FARM SECTOR REAL ASSET DYNAMICS

by

Allen M. Featherstone
and
Timothy G. Baker*

*Featherstone is a Graduate Research Assistant, Purdue University, Timothy G. Baker is an Associate Professor, Department of Agricultural Economics, Purdue University, W. Lafayette, IN 47906.

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ABSTRACT

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A vector autoregression is estimated to explore the dynamics of the real asset market using real asset values, real returns to assets, and real interest rates. Results indicate that a significant portion of the hardship faced by farmers today can be explained by the dynamics of the farm asset market.

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Much interest has again been generated in land prices and the determinents of land prices. Past research has generated a number of explainations for the level of land values.

Pope, Kramer, Green, and Gardner reviewed and reestimated a number of land value studies using more recent data. They concluded that these models were inappropriate for explaining the divergence between farm income and land values of the 1970's.

More recent research done by Castle and Hoch conclude that two components are critical in the determination of farm land price; expected capitalized rent and capitalized capital gains. They conclude that expected capital gains are driving land prices without realizing that the capital gains themselves result from capitalizing a growing rent stream in the theory of rent capitalization. Shalit and Schmitz conclude that savings (farm income minus consumption) and accumulated real estate debt are important determinants of farmland prices.

Phipps concludes that farm-based returns undirectionally cause farmland prices. He does little to explain the dynamic movement of land prices.

Burt examines at the dynamic structure of farmland prices. The structure is approximated by a second order rational distributed lag on land rents. He uses this model to forecast land prices and forecasts declines until 1988. Burt's theroretical model is the familiar capitalization model; price equals real rents over real interest rate. He assumes that decision makers perceive that the equilibrium real rate of interest is fairly constant over time based on the work of Irving Fisher.

Observing ex-post real interest rates (Figure 3) one notices that these interest rates have no significant trend over time. However, there have been periods of time where real rates have been unusually high or low for a number of consecutive years. This may change the expectations of investors, at least in the short run, which could cause some of the dynamics in the land market.

The purpose of this paper is to report results from a study of the dynamics in real farm asset values.

The Model

Based upon the theoretical concepts of rent and the capitalization of rent, the equilibrium model of land value might look like

$$A_* = I_*/r_*$$

where, A_* is the equilibrium land value, I_* is the equilibrium residual return to that land, and r_* is the real equilibrium interest rate. Thus, land values, real interest rates, and real rent are related. However, equilibrium is an idealized concept and real interest rates, rents, and land values are probably never observed in long-run equilibrium.

The expectations processes and the absence of instantaneous market adjustment lead to dynamics in markets for assets, rents, and real interest rates.

Vector autoregression (VAR) is a tool that has been useful for the analysis of dynamic systems. VAR offers the advantage of incorporating several time series which seen theoretically appropriate for inclusion in a model without forcing the researcher to determine explicit dynamic relationships between the series. Identification is achieved by letting every variable in a multivariate system influence every other variable in the system with lags. The estimated VAR is converted to a moving average representation to use three technical operations to study the dynamics of the system. The impulse response function allows one to simulate the effect of a one-time shock of a series on itself and on other series in the system. Decomposition of variance allows the researcher to infer the strength and timing of shocks in each series of the system. Historical decomposition allows the researcher to decompose a cycle into its component causes, thereby allowing one to study the historical causes of a cycle. For a complete mathematical treatment of VAR see Bessler, Burbidge and Harrison, or Sims.

The Data

One must find measures for the asset value, the return to assets and the real interest rate. Good measures of the returns to land for periods long enough to estimate a VAR are not easily found. Emanuel Melichar has developed an aggregate series of imputed returns to assets for the farm sector dating back to 1910 which were used along with farm sector assets values in this study. Commerical paper rates converted into ex-post real interest rates using the PCE deflator were used as the third variable in a VAR. The PCE deflator is the personal consumption and expenditures part of the implicit GNP deflator.

Descriptive Analysis

Real farm sector asset values have been increasing with periodic cycles in both nominal and real terms since 1910. A peak in real asset values occurs at the end of 1915 (Figure 1). Real asset values then decline until 1932. From 1932 to the end of 1980 real asset value increased in most years. The peak real asset value in 1980 was about 2.5 times larger than the peak in 1915.

Real returns to assets have been quite variable from year to year (Figure 2). The best return in real terms was in 1973 with the next previous high occuring during 1917. The lowest real income to asset from 1910 to 1984 was in 1932. The return to assets exhibit a slight upward trend from 1910 to 1984.

Contrary to popular belief, ex post real interest rate in 1970's and 80's have not been extremely variable by historical standards (Figure 3). The rates during the 1950's and 1960's were extremely stable. The ex post real interest rate does have periods which are significantly different from the center of the distribution which seems to occur at about 3% for commercial paper. The real interest rate does not seem to have a significant trend over time.

VAR Results

In order to estimate a system of equations using VAR the order of the model (number of lagged variables) must be determined. One to ten lags were tested. A fifth order model was chosen using a likelihood ratio test suggested by Sims. The only deterministic components in the VAR's were a constant and a linear time trend. The linear time trend was included to obtain stationarity.

The estimated VAR system can be found in Table 1. Granger causality testing using the estimated VAR indicates that returns unidirectionally affects assets (Table 1). Interest rates were found to unidirectionally cause returns and then assets via returns causing assets. Assets do not affect either interest rates or returns.

Only the linear time trend is significant from a statistical point of view in the asset equation. This linear trend explains 24.5% of the increase in asset values from 1910 to 1984. The linear time trend may account for the growth of nonreal estate assets over time.

The stability of the model was checked using the method proposed by Sargent. Examination of the eigenvalues suggest that the model is stable as each modulus is less than one in absolute value. Because some roots are complex and some moduli are near to one in absolute value, a shock to the system will cause an oscillating pattern for a number of periods before the system returns to equilibrium.

Impulse Response

The impulse response function is calculated using the moving average representation of the VAR. Innovations were orthogonalized in the following order interest rate, returns to assets and assets. Interest rates are allowed to affect all other variable contemporaneously, but no other variables are allowed to affect interest rate. Returns to assets are allowed to contemporaneously affect asset values, but not interest rates. Any innovation in assets is not allowed to influence another variable contemporaneously.

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[1]All of the empirical work report in this paper was performed with the RATS packagae of Doan and Litterman (1981).

Table 1. Estimated VAR for Real Interest Rate, Income to Assets, and Real Asset Value.[a]

	Interest Rate Equation	Income Equation	Asset Equation
R-square	.742	.582	.991
Q-statistic[b]	16.00	9.99	17.89
Dependent Variable	r_t	I_t	A_t
Intercept	-.691	2511.620	-11539.21
Time trend	-.148	- 80.566	671.193*
r_{t-1}	1.308*	-604.980*	-365.935
r_{t-2}	-.986*	474.334	-157.852
r_{t-3}	.683*	-364.932	898.600
r_{t-4}	-.464*	288.648	-558.131
r_{t-5}	.198	-178.927	1231.515
I_{t-1}	-.694 E-4	.278	-.855
I_{t-2}	.248 E-4	-.023	1.403*
I_{t-3}	.273 E-3	-.065	-.129
I_{t-4}	-.350 E-3*	.094	1.221
I_{t-5}	.101 E-3	-.219	.866
A_{t-1}	.118 E-4	.042	1.449*
A_{t-2}	.117 E-4	.004	-.653*
A_{t-3}	-.697 E-4	-.032	.386
A_{t-4}	.617 E-4	-.100	-.594*
A_{t-5}	-.820 E-5	.122*	.283
F-value[c]	19.28*	3.51*	1.68
F-value[d]	1.28	1.33	3.69*
F-value[e]	.43	2.23	90.65*

[a]r, I and A represent interest rate, returns to assets and real asset values respectively.

[b]Reject H_o: White Noise Residuals at the 10 percent level if the test statistic is greater than 33.20

[c]H_o: Coefficients on all r_{t-i}'s = 0.

[d]H_o: Coefficients on all I_{t-i}'s = 0.

[e]H_o: Coefficients on all A_{t-i}'s = 0.

*Significant at the 5 percent significance level.

The impulse function measures the response to a one standard deviation shock in a variable on other variables over time. In response to a shock in real returns to assets (2.77 billion dollars), asset values immediately increase by about 4.2 billion dollars (Figure 4). Assets continue to increase for another six years until they have increased in value by 16.1 billion dollars in response to the one time shock in rèturns. Full recovery takes about 12 years.

It was found that in response to a one standard deviation shock in real interest rates (2.6 percentage points), farm sector real asset values immediately decline by about 4.0 billion dollars (Figure 5). Asset values continue to decline for another three years after the shock before they begin to recover. After three years asset values have fallen a total of 8.0 billion dollars. Full recovery takes about 10 years.

In response to a shock in asset values (8.76 billion dollars), asset values continue to increase another year to 12.6 billion dollars (Figure 6). In all cases asset values tend to feed on asset values for several years before the effects of a shock dies out. Asset values have a period of 14 years. Interest rates and return to assets variables lose memory of a shock rather quickly, as these variables return towards the original pre-shock levels in a few years.

<u>Decomposition of Variance</u>

Decomposition of variance allocates in sample forecast error to innovations in respective series for alternative forecast time horizons. This analysis is useful in describing whether certain variables are exogenous along with describing the strength of causality that other variables imply. The standard error of the within sample forecasts increase as the number of periods forecasted ahead increases (see Table 2). The interest rate forecasts and the returns to assets forecast standard errors increase more rapidly towards an upper bound than do the forecasts of asset values.

Examination of the interest rate decomposition reveals that for all practical purposes interest rate is exogenous to the model, as errors in the interest rate can only be attributed to it's own innovations.

Examination of the returns to assets decomposition reveals that in the initial period, return innovations are almost entirely responsible for any forecast error. However, after the initial period, interest rate innovations account for almost as much of the forecast error as does return innovations. If one had perfect foresight with respect to interest rates through the period being forecasted, one would be able to improve return to assets long-term forecasts by about forty-five percent.

In the short-run, interest rate innovations are as important in explaining forecast error as return innovations. Together in the short term only about thirty percent of forecast error can be attributed to these two series. In the long run, returns to assets explain about half of the forecast error. Interest rates explain about one third as much of asset forecast error as does returns. Interest rate and return innovations combined explain almost seventy percent of asset forecast error in the long run.

Table 2. Proportions of Forecast Error Variances K years Ahead Allocated to Innovations in Respective Series.

	k	Standard error	r	I	A
r	1	2.62	1.00	.00	.00
	3	4.76	.99	.00	.01
	5	4.88	.97	.02	.01
	7	4.90	.97	.02	.01
	10	4.96	.96	.02	.02
	20	5.06	.93	.04	.03
	30	5.10	.92	.05	.03
I	1	2866	.07	.93	.00
	3	4040	.43	.54	.03
	5	4229	.46	.49	.05
	7	4248	.46	.49	.05
	10	4336	.45	.48	.07
	20	4492	.43	.49	.08
	30	4557	.43	.49	.09
A	1	10484	.14	.16	.70
	3	23375	.19	.11	.70
	5	33131	.21	.31	.48
	7	42008	.19	.39	.42
	10	47728	.16	.51	.33
	20	53243	.16	.48	.36
	30	56996	.16	.52	.32

Historical Decomposition of Variance

Historical decomposition can be a useful tool in describing the movements in series over time. Errors in model forecasts are attributed to innovations in respective series. The first period examined was the 1920 to 1940 asset bust. Asset values fell dramatically until 1933 and then began to slowly recover. The real interest rate accounts for most of the fall in asset values. Income also exerted a downward pressure on asset values. Asset values did not fall as much as innovations in the interest rate and income suggest. Because agriculture was coming off it's "golden era", market participants may have been slow to adjust expectations to current return and interest rate signals. As returns and interest rates recovered in the late 1930's, asset values were again slow to adjust to market signals.

Historical decomposition of variance reveals the record high income received in 1973 is largely responsible for the asset boom bust cycle from 1973 to the present. However, income can not account for all of the cycle. Actual asset values were higher than can be attributed to income. Again a phenomena exists, where asset values seem to feed on assets. The market over reacted to income and interest rate signals.

Summary and Conclusions

Real asset values are substantially higher in the 1980's than any other previous period since 1910. Real returns to assets have been highly variable since 1910 without exhibiting any significant trend. Real returns to assets reached a historical high in 1973, topping the previous high in the year 1917. The ex post real interest rate series exhibits no significant trend. The real interest rate seems to fluctuate around three percent. The real interest rate was much more variable before 1953 than after.

A shock in any variable, asset value, return to assets, or the real interest rate, all lead to a process where assets seem to feed on assets. In the initial period, a reaction from a shock occurs followed by a process where asset values continue to grow (fall) for up to six years until finally the effect of the transitory shock begins to die out.

In the shorter run, interest rates explain as much of the asset value forecast error as does returns. However, in the long run, returns seem to be three times as important as interest rate in explaining asset values.

The asset bust of the 1920's and early 1930's was primarily an interest rate phenomena while the asset boom-bust cycle in the late 1970's and early 1980's is a return to assets phenomena. In both periods, however, asset values seemed to feed on past values and did not adjust quickly to the level that returns to asset and interest rate would have suggested.

In conclusion at least part of the hardship faced by farmers today can be explained by the dynamics of the farm asset market. A single shock in income can set off a boom-bust cycle whose effects are felt for many years.

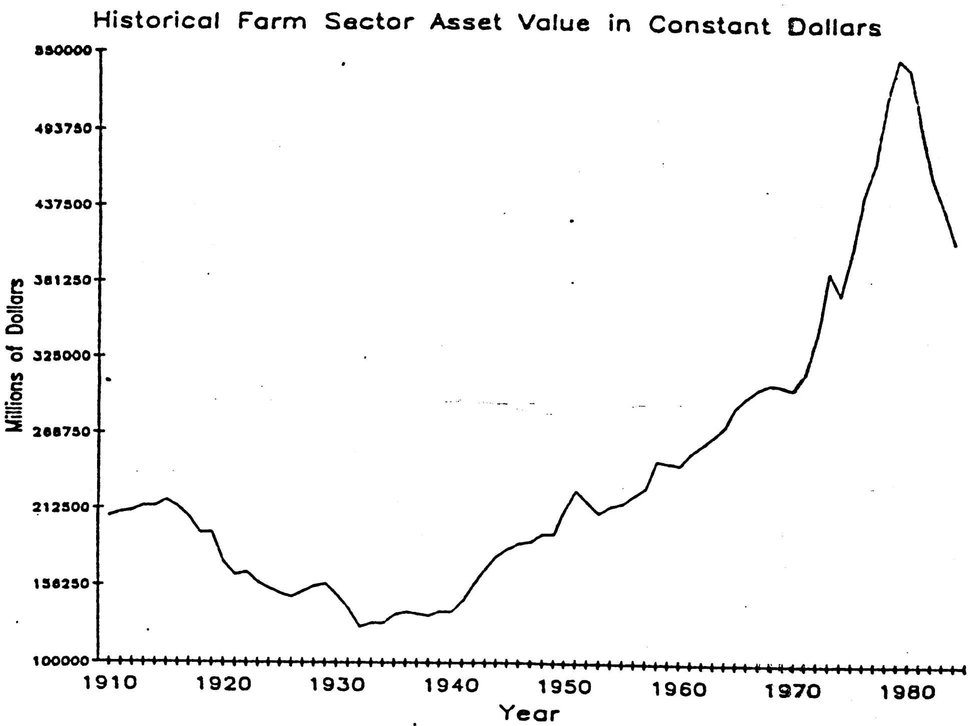

Figure 1

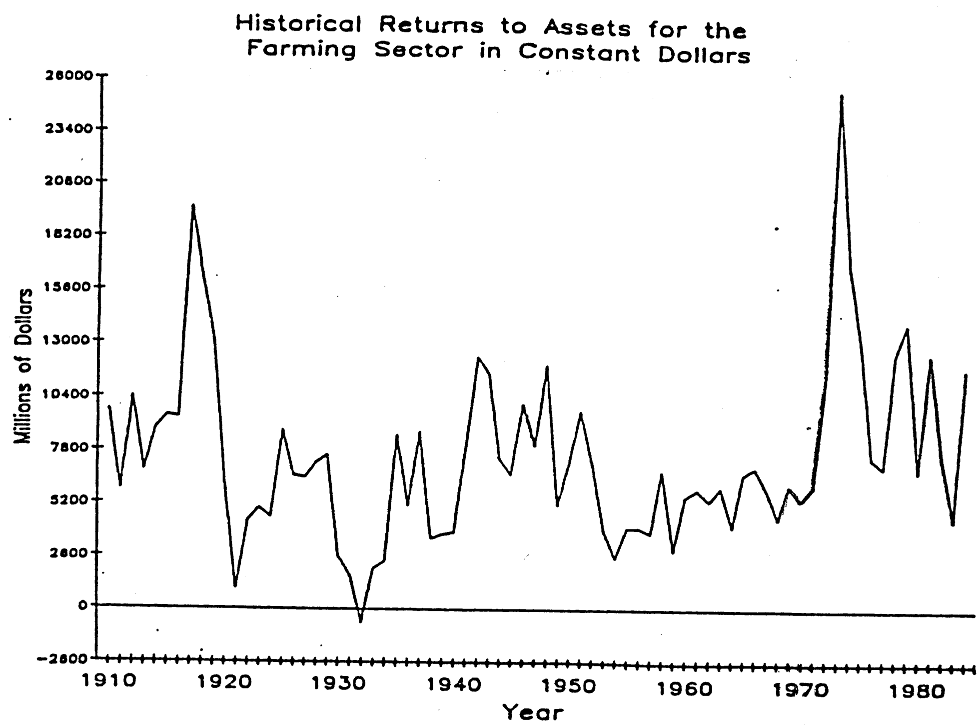

Figure 2

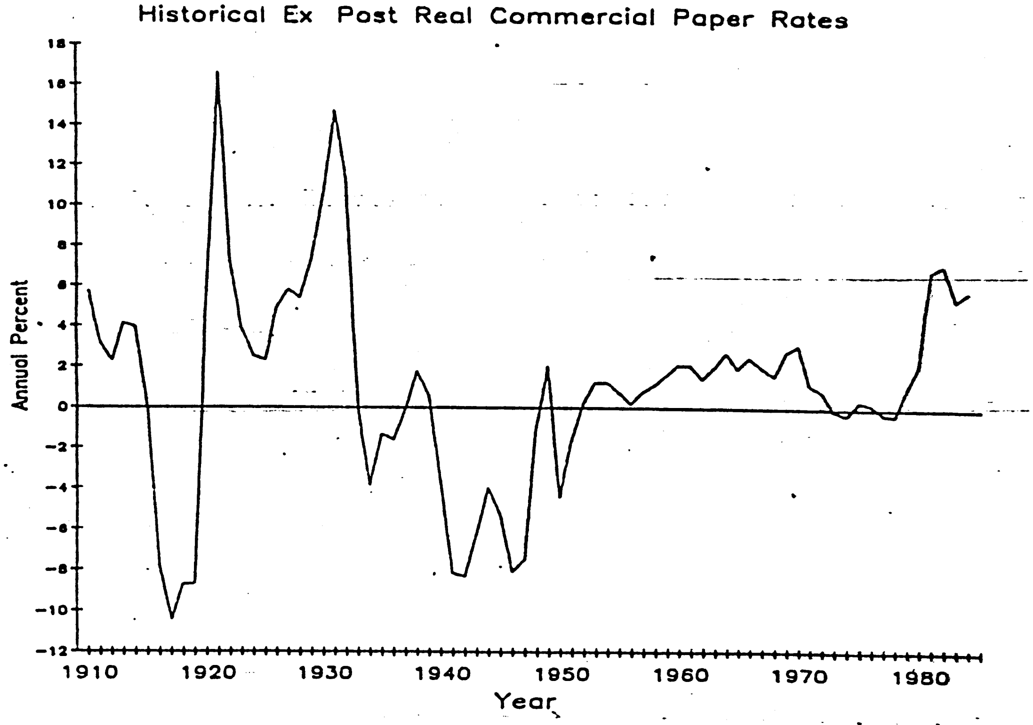

Figure 3

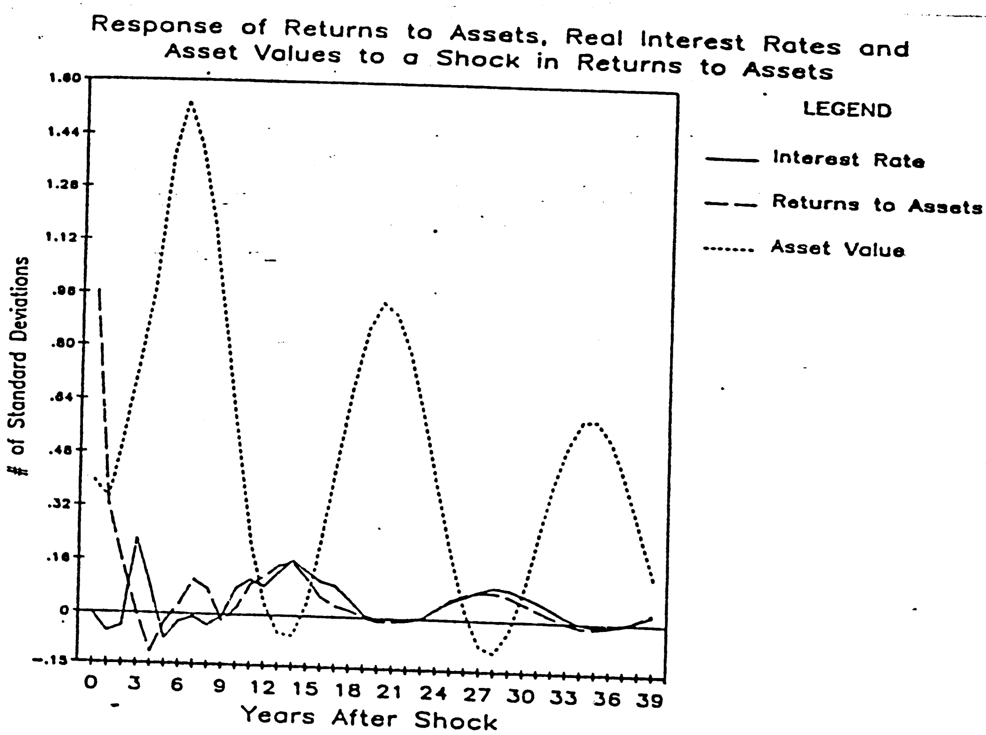

Figure 4

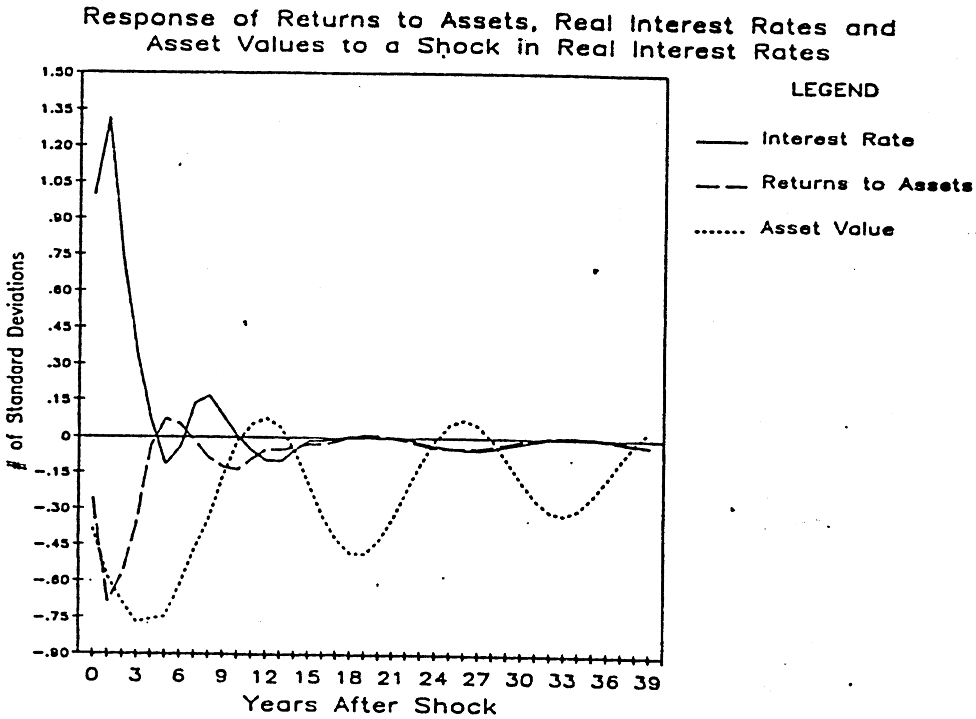

Figure 5

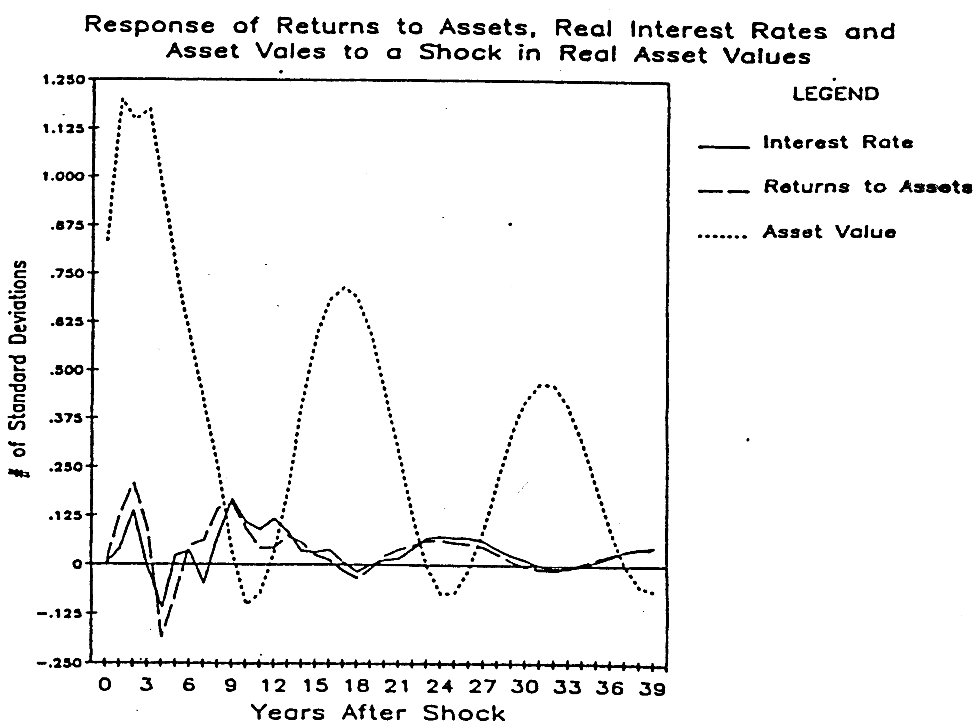

Figure 6

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