

A.I.L. THEORY AND THE AILING PHILLIPS CURVE:
A CONTRACT BASED APPROACH TO AGGREGATE SUPPLY.

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A.I.L. Theories of Aggregate Supply

Abstract

This paper presents empirical evidence from U.S. data of a structurally stable aggregate supply relationship between real and nominal rates of interest and the rate of unemployment. The paper reviews theories of contracts that are based on the twin assumptions of asymmetric information and limited collateral and it argues that these theories (referred to as A.I.L. theories) provide a strong theoretical foundation for a contract-based theory of aggregate supply. It is suggested that the original Phillips curve estimates should be reinterpreted in the light of A.I.L. theories which represent alternatives to the Phelps-Friedman interpretation of the Phillips relationship.

1. Introduction

My focus in this paper is the role of certain recent microeconomic contract-based theories in helping us to understand the theory of aggregate supply. Typically, these theories are viewed as part of a search for the underpinnings of Keynesian explanations of the Phillips curve. Contract theories are supposed to explain why prices are sticky and thereby help us understand why unemployment may temporarily deviate from its 'natural rate'. I shall argue that this view of the role of contract theories is fallacious. Contract theories do not justify the status quo; instead they provide a powerful alternative to both Neo-Keynesian and New-Classical theories of aggregate supply.

The group of theories that I am referring to is a subset of the class of all contract theories that takes, as its starting point, two important premises. The first of these premises is that contracts are written between parties who are asymmetrically informed about the state of the world. The second premise is that agents have limited access to collateral. To differentiate the members of this class of theories from more familiar insurance-based approaches to contract theory I shall refer to them as Asymmetric Information limited

Liquidity theories or A.I.L. theories in short.¹

The most prominent feature that separates A.I.L. theories from both Neo-Keynesian and New-Classical theories of aggregate supply is that A.I.L. theories deny the utility of the concept of the natural rate of unemployment. According to standard popular approaches to macroeconomics, cyclical variability of the level of economic activity is due either to inter-temporal substitution of leisure or to sticky prices of one kind or another. In either case, short run fluctuations in employment occur mainly as a result of the failure of agents to perfectly forecast future economic conditions. The long run upward movements in unemployment rates that have occurred in both the U.S. and Europe in recent years are perceived to be due to structural adjustment problems or as due to hysteresis effects that have altered the natural rate. The A.I.L. contract-based alternative, on the other hand, explains both cyclical and long-run movements in the unemployment rate as rationally anticipated fluctuations in an equilibrium rate of unemployment that are caused by movements in real and nominal interest rates. The advantage of this approach is that it unifies a theory of short run fluctuations in employment with a

¹. Some of the more recent approaches to contract theory combine asymmetric information with an insurance based approach. The Q.J.E. supplement, vol. 98 1983, edited by Azariadis and Stiglitz contains a number of such papers. This volume goes only part way to providing the kind of alternative theory of supply that I am referring to and, for the most part, it is oriented to the task of explaining the Neo-Keynesian assumption of sticky prices. A.I.L. theories require the additional assumption of limited collateral.

theory of long term movements in the level of economic activity.

I have argued elsewhere² that a contract theory based on asymmetric information and limited collateral has strong theoretical claims to be given serious consideration as a replacement to the Phelps-Friedman theory of the expectations-augmented Phillips curve. I briefly review this argument in section (3) of this paper. The main contribution of this work is, however, empirical. In section (6) I present estimates of an A.I.L. based theory of supply from U.S. annual time series data. The relationship not only fits well- it also remains structurally stable over the entire post-war sample period. A researcher who had estimated an A.I.L. based equation using only pre-war data would not go far wrong if he or she applied the same parametric model to post-war data from 1946 up to the present day.

2. The Stylized Facts.

In this section of the paper I summarize three stylized facts that concern the relationship between inflation, the rate of interest and employment. I then offer an interpretation of these facts in terms of an A.I.L. based theory of aggregate supply.

FACT NUMBER 1.

In the United Kingdom there was a marked and fairly stable inverse

². Roger E.A. Farmer, "A New Theory of Aggregate Supply" (1984). Also see "Money and Contracts", (1988a) which discusses the effect of nominal interest rates on aggregate supply in a general equilibrium model.

relationship between unemployment and the rate of wage inflation from 1861 well into the 1960's. Beyond this date the relationship appears to have broken down and parts of the 1970's and 1980's have been characterized by the simultaneous occurrence of both high inflation and high unemployment.

EXPLANATION.

The traditional explanation for the Phillips curve relationship is as a wage adjustment equation. According to this interpretation, high unemployment causes wages to fall as part of a disequilibrium adjustment process.

The A.I.L. based theory reverses the direction of causation. Under the A.I.L. interpretation, a high rate of inflation is associated with a low realized rate of interest. When the real rate of interest is low, the equilibrium frequency of contract failures is low. These contract failures may manifest themselves as bankruptcies or as layoffs. In either case, contract terminations are rationally anticipated outcomes of negotiations between asymmetrically informed parties; that is, the form of the contract as **explained** not **assumed** as in more traditional ad-hoc contract based theories that have been advanced as possible justifications for sticky-price Keynesian theories of supply.³

³. It should be pointed out that the implications of A.I.L. based theories of aggregate supply are distinct from New-Classical Inter-Temporal-Substitution (I.T.S.) theories which also stress the role of real interest rates. In I.T.S. theories agents supply more labor today if the currently anticipated real rate of interest is high. In

The Phelps-Friedman explanation of the disappearing Phillips curve relies on the idea that original estimates of the relationship neglected to take account of the influence of expectations on the wage formation process. The A.I.L. interpretation of the facts also relies on an omitted variable problem but in A.I.L. theory it is the influence of the rate of interest that has been omitted and not the effect of (un-observable) inflationary expectations. Until the mid 1960's the nominal rate of interest exhibited very little movement relative to its more recent fluctuations (see figure (IV) which documents this assertion for U.S. data). Failure to take account of the interest rate as an explanatory variable in the aggregate supply equation caused the estimated Phillips curve to shift in the 1970's when a high and volatile rate of interest became part of the background of central bank monetary policy.

FACT NUMBER 2.

In post-war U.S. time series data there is a strong correlation between lagged values of the rate of interest and values of the unemployment rate. The mean lag is about nine months. If the

contrast, A.I.L. theories predict that employment will be high today if the rate of return that is realized today is low. Both the timing and the sign of the relationship differ between the two theories. A.I.L. theories are also eclectic on the distinction between the effects of the anticipated real rate of interest and the realized rate. Which of these variables is important depends on whether contracts are indexed to the observable rate of inflation. This in turn depends on agents attitudes to risk sharing which in A.I.L. theories are seen as second order effects. Section (4) discusses the indexation issue in more depth.

influence of expected inflation is removed from the series, the role of the nominal interest rate is still significant; that is, the nominal interest rate exerts an influence on the level of aggregate economic activity that is independent of the expected real rate of return.⁴

EXPLANATION.

The role of the nominal interest rate fits naturally into A.I.L. based theories in which a lack of liquidity is an important factor that contributes to a high incidence of layoffs. The nominal rate of interest represents the opportunity cost of holding money and an optimal contract balances this opportunity cost against the benefit of additional liquidity. In A.I.L. theories this benefit arises from the fact that a high cushion of liquidity allows firms to offer a more stable wage. Ex-post stability of the contracted wage, in the presence of fluctuations in the marginal productivity of labor, allows the firm to make more efficient employment decisions. If a firm had to raise the wage every time that it wished to expand output, then it would be less likely to expand in times of high productivity.

⁴. C. A. Sims, "Comparison of Interwar and Postwar Cycles: Monetarism Reconsidered" American Economic Review vol. 70, 1980. Sims documents this assertion for small vector auto-regressions. Evidence for the effect of nominal interest rates after correcting for anticipated inflation is found in Litterman and Weiss, "Money Real Interest Rates, and Output: A Reinterpretation of Postwar U.S. Data", Econometrica vol. 53, number 1 January 1985.

The simplest way to think of the chain by which the nominal rate of interest affects employment is to view money as a productive asset; money enters the production function and directly affects aggregate supply. If the opportunity cost of holding money rises then firms will use less of it. Since money is a complement to labor, the net effect is that high interest rates are associated with less employment in equilibrium.

FACT NUMBER 3.

The unemployment rate in the United States exhibits a significant degree of persistence. An A.R.I.M.A. (1,1,0) process fits reasonably well to twentieth century annual data with an auto-regressive coefficient of approximately 0.5.

EXPLANATION.

It has recently become common practice to explain the persistence of unemployment in terms of hysteresis effects.⁵ Under this interpretation, unemployment has remained high in recent years because workers remain out of the labor force in the face of persistent

⁵. See, for example, the paper by Blanchard and Summers, "Hysteresis and the European Unemployment Problem," in the 1986 NBER Macroeconomics Annual. A number of authors have recently begun to question the natural rate hypothesis in the light of recent European experience. Several papers on the issue are collected in the American Economic Review May 1988 papers and proceedings. Most writers on the topic, however, maintain the distinction between a theory of short run fluctuations and a theory of movements in the natural rate. It is my contention that this distinction is artificial and anachronistic.

spells of demand induced unemployment. This effect causes an increase in the natural rate. Under A.I.L. theories, on the other hand, unemployment is highly auto-correlated because the lagged value of the unemployment rate serves as a proxy for the effects of financial structure on the efficiency of labor contracts. I provide evidence in section (6) of this paper that the value of previous periods profits is a more appropriate regressor, in an aggregate supply equation, than is the lagged value of the unemployment rate. The real value of last periods profits is an important explanatory variable because when profits are high entrepreneurs do not need to borrow as much from external sources in order to finance their activities. High profits reduce the dependence of the entrepreneur on outside funding and, by so doing, reduce the production inefficiencies that are induced by contracts between asymmetrically informed parties.

3. A Review of A.I.L. Theory.

In this section I review the structure of A.I.L. based theories. The presentation is broken into three parts each of which is designed to explain the role of three explanatory variables in the A.I.L. theory of aggregate supply. These variables are the real rate of interest, the nominal rate of interest and the profits that are earned by entrepreneurs.

Throughout this section, I maintain the simplifying assumption that future prices are perfectly foreseen. Although uncertainty is important in A.I.L. theory it is uncertainty about the productivity

of individual enterprises that provides the motive for agents to write contracts. The basic theory does not differentiate between the anticipated real rate of interest and the realized real rate of interest and it is eclectic on which of these variables should enter the aggregate supply function. This important issue is treated in section (4) in which I discuss the question of the indexation of nominal contracts to observed prices.

I. THE ROLE OF THE REAL RATE OF INTEREST.

The most direct way of explaining why the real rate of interest is a key variable in A.I.L. theories of supply is by means of a parable. Think of a simple economy in which all output is produced by one-person-firms. These firms are owned and operated by self-employed risk-neutral entrepreneurs each of whom may combine a single unit of his own labor with a single unit of capital. Nothing of substance hinges on the assumption that the technology is of this rather simple form although it is important that there should be at least two inputs. The second input introduces a role for a second individual and provides a motive for a contract. I refer to the second individual as a banker and to stress the fact that risk-sharing does not play a role in A.I.L. theories I assume that this second individual is also risk-neutral. The role of the banker is to provide sufficient funds to the entrepreneur to enable him to purchase a machine.

The process of production yields an uncertain future return and the distribution of this return is known by both the entrepreneur and

the banker. These two individuals must write a contract that specifies how the proceeds of the enterprise will be divided up between them. At this point A.I.L. theories introduce a key assumption:

ASYMMETRIC the entrepreneur has better information
INFORMATION about the productivity of his own business
than does the banker.

This assumption is an important ingredient of theories that rely on informational asymmetries and it is a feature that is missing in more familiar insurance based approaches to contract theory. The role of the assumption is to limit the set of contracts that can be written to those that are indexed to common verifiable information. Its effect is to link together the employment rule and the loan repayment schedule in any contract that is acceptable to both parties. This linkage is achieved by the principle that a contract will be acceptable to the banker if it provides the entrepreneur with an incentive to truthfully reveal the productivity of the enterprise.⁶ Any contract that has this property must take account of the fact that, ex-post, the entrepreneur will make the employment decision that is in his own best interests. Since the entrepreneur will make this

⁶. A contract that has this property is said to be incentive compatible and the principle is usually referred to as the revelation principle. See the paper by Roger Myerson, "Incentive Compatibility and the Bargaining Problem", Econometrica vol. 47, 1979 pp. 61-74.

decision by comparing the marginal product of employment with the marginal amount that he must pay to the banker, it follows that the loan repayment schedule and the employment level cannot be separated from each other.

At this point A.I.L. theories introduce a second key assumption:

LIMITED the collateral of the entrepreneur is limited
COLLATERAL by his own wealth.

This assumption limits the amount that the entrepreneur can pay to the banker in the worst possible state of nature.

In order to clearly explain the combined implications of these two assumptions I make the simplifying assumption that the technology permits only two possible employment decisions. The entrepreneur may decide either to work or to lay himself off. Further assume that the banker observes whether or not the entrepreneur decides to work but that he cannot observe either the productivity of the enterprise or ex-post profits. These assumptions imply that the set of acceptable contracts consists of those that make one payment to the banker if production takes place and a different payment if it does not.

It is at this point that the real rate of interest enters the picture. The expected real rate of interest represents the value of the banker's opportunity cost of funds. The higher is this ex-ante expected return, the higher must be the expected value of the banker's

share of the enterprise. Since the payment received by the banker in the event of bankruptcy is limited by the wealth of the entrepreneur, an increase in the rate of interest must be accompanied by an increase in the payment that is promised to the banker in the event that production takes place. But herein lies the essence of the A.I.L. approach to aggregate supply. The entrepreneur's ex-post employment decision is itself a function of the amount that must be paid to the banker. Once a contract has been written and the state of nature is revealed to the entrepreneur he will decide whether or not to declare bankruptcy by comparing his ex-post utility under two alternative employment decisions. In order to induce the entrepreneur to work, the marginal product of employment must exceed his disutility of effort: in addition it must be sufficiently high to cover the marginal increment in the loan-repayment-schedule. If the ex-ante real interest rate increases then the increment in the loan-repayment-schedule must also increase and, ex-post, there will be fewer states of nature in which the entrepreneur finds it worthwhile to employ himself.

In an economy that consists of a large number of self-employed entrepreneurs, each of whom receives an idiosyncratic productivity shock, the aggregate quantity of output that is produced will be a decreasing function of the real rate of interest because a higher real interest rate induces a higher equilibrium frequency of contract failures. This is the basic mechanism that underlies A.I.L. theories of aggregate supply.

II. THE ROLE OF THE NOMINAL RATE OF INTEREST.

A slight modification to the above story will serve to illustrate the role that money may play in the productive process. Consider a scenario in which an entrepreneur must write a contract with a single worker. In order not to complicate this picture unnecessarily let us assume that the entrepreneur has no need of a banker since he has sufficient collateral to purchase his own capital equipment. As in the previous discussion, assume that there are only two possible employment states - the worker may work or he may be laid off. Unlike the previous story however it is now the worker, and not the entrepreneur, who supplies his labor time to the enterprise. The worker observes his own ex-post labor supply whereas the entrepreneur observes the random productivity of the enterprise.

The way that one may introduce money into this story is by requiring that the worker should be paid in cash. The entrepreneur may invest his wealth in the form of productive capital in the enterprise, but in so doing this capital is tied up and becomes unavailable for use in making wage payments to the worker. He must decide, ex-ante, how much of his wealth to retain in the form of liquid assets and how much of it to sink into more productive, but less available, capital.⁷

⁷. One might argue that a theory that relies on an assumption that workers are paid in cash does not fit well with recent experience. However, the critical feature of the A.I.L. explanation is that the opportunity cost of liquidity is an increasing function of the nominal rate of interest. In U.S. time series data the gap between the loan rate of interest and the deposit rate is a stable linear function of the level of the three month T-bill rate. It

The worker and the entrepreneur must negotiate a contract that offers the worker a sufficiently high ex-ante expected return to induce him to forego his next best alternative. But, as in the situation that we discussed above, the set of acceptable contracts is limited to those that make one payment to the worker if he is employed and another payment if he is laid off. The payment that the worker receives if he is laid off is limited by the liquid assets of the entrepreneur. It follows that the lower the liquidity position that is taken by the entrepreneur the larger must be the wage that is paid to the worker if he is employed; that is, a low level of liquidity will be associated with a high degree of variability in the contracted-wage-schedule. But the degree of variability of the contracted-wage-schedule will itself affect the probability that the entrepreneur will decide to employ the worker. In making an ex-post employment decision the entrepreneur will compare the worker's marginal product to the marginal increment in his wage-schedule. The larger is the gap between the layoff payment and the employment payment the lower is the probability that the worker will be employed.

It is at this point that the role of the nominal interest rate enters the picture. The money rate of interest represents the opportunity cost of holding cash and the entrepreneur must balance

follows that even if firms hold their liquid assets in the form of interest bearing deposits they will still face a cost of liquidity that increases systematically with the rate of interest. The papers by Farmer (1988a, 1988b) discuss this issue in more depth and provide evidence of the relationship between loan rates and deposit rates for post-war U.S. time-series data.

this opportunity cost against the benefit that is afforded by a less volatile employment-schedule. If the interest rate rises then the entrepreneur will hold less cash. To compensate the worker for the fact that he will be paid less if he is laid off, the contracted-wage-schedule must promise to pay more to the worker if he is employed. But this additional variability in the wage-schedule will cause the entrepreneur to be less likely, ex-post, to decide to employ the worker. Across the whole economy a higher rate of interest will be associated with a lower level of liquidity and with a higher frequency of layoffs. It is this basic mechanism that causes the nominal rate of interest to be an important explanatory variable in A.I.L. theories of aggregate supply.

III. THE ROLE OF PROFITS.

In A.I.L. theory contracts will be more efficient if entrepreneurs are able to finance a higher proportion of their activities with internally generated sources of funds. Take a simple example in which all output is produced by entrepreneurs who face a set of identical projects of the type that I discussed in part (I). If all projects are of given size then the most efficient way of organizing production is for each entrepreneur to own a single plant that is purchased with his own funds. A social organization of this type will maximize the social product since it eliminates the efficiency distortions that are introduced by contracts between asymmetrically informed agents. Whether or not such an organization will arise in a competitive

economy depends on the relationship between the technology, which dictates efficient plant size, and the wealth distribution, which determines the extent to which production requires individuals to share the entrepreneurial role. Those individuals who are wealthier are more likely to become entrepreneurs because they will need to borrow less from other individuals in order to set up a firm. Wealth bestows a comparative advantage in the role of entrepreneurship because it permits the individual to make more efficient production decisions. As an economy evolves over time, the distribution of income between entrepreneurs and other members of society will itself affect the efficiency with which productive activity is organized. If entrepreneurs receive a large share of national income then these individuals will need to borrow less in future periods from other members of society. A high current level of profit will be associated with a high future level of economic activity because it reduces the dependence of entrepreneurs on less efficient sources of outside funding. It is this basic mechanism that explains why profits are included as an explanatory variable in A.I.L. theories of aggregate supply.

4. The Indexation of Contracts.

One of the issues that has caused problems for Neo-Keynesian contract theories concerns the indexation of contracts. According to these theories, firms offer contracts to workers in which wages are stable because workers are risk averse and, *ceteris-paribus*, they

would prefer a stable income stream to one that fluctuates. But this explanation is widely recognized to be flawed. The Neo-Keynesian theory of aggregate supply relies on an assumption that agents write contracts in which money wages are predetermined. Stable money wages do not insure workers against fluctuations in the value of the monetary unit; indeed quite the opposite is the case. Predetermined money wages expose workers to the risk of income fluctuations in the face of demand disturbances that presumably these individuals would prefer to avoid.

A.I.L. theories do not face this problem. In the basic theory that I outlined in section (3) I made the strong assumption that there was no aggregate uncertainty. This assumption is clearly counter-factual and it must be modified if the theory is to be applied to the data. The most straightforward way in which to introduce aggregate uncertainty is to assume that the price level fluctuates randomly and that this fluctuation is independent of the idiosyncratic production uncertainty that is faced by any particular entrepreneur. This would be the case, for example, if all aggregate fluctuations arose as a result of random policy actions on the part of the central bank. In this situation it is meaningful to distinguish between the ex-ante expected real rate of interest and the ex-post realized real rate. Which of these two variables is the appropriate regressor in an A.I.L. theory of aggregate supply? The answer to this question is that, if both parties are risk-neutral, then they will be indifferent to a contract in which the money wage rate is indexed to the observable

price level and one in which it is not. If one party is more risk averse than the other then the details of the employment contract and, in particular, the degree to which the contract is indexed to the price level, will depend on the relative curvature of the utility functions of the entrepreneur and of the worker. In A.I.L. theory unanticipated shocks do not play a central role in explaining employment fluctuations and consequently the issue of contract indexation is secondary. When applying this theory to U.S. data I have taken account of the fact that most contracts seem to contain only limited indexing provisions and I shall therefore interpret the real interest rate variable as an ex-post rate. The details of estimating an A.I.L. theory of supply are explored in the next section.

5. From Theory to Evidence.

In the next two sections of the paper I explore the statistical evidence for an A.I.L. based theory of supply. My data consists of annual time series on four basic explanatory variables for the period from 1929 to 1986. These variables are:

prate 1 the period $t-1$ interest rate on six month
commercial loans,

DLprice the logarithmic difference of the period t and
period $t-1$ values of the GNP deflator,

unem the period t unemployment rate,

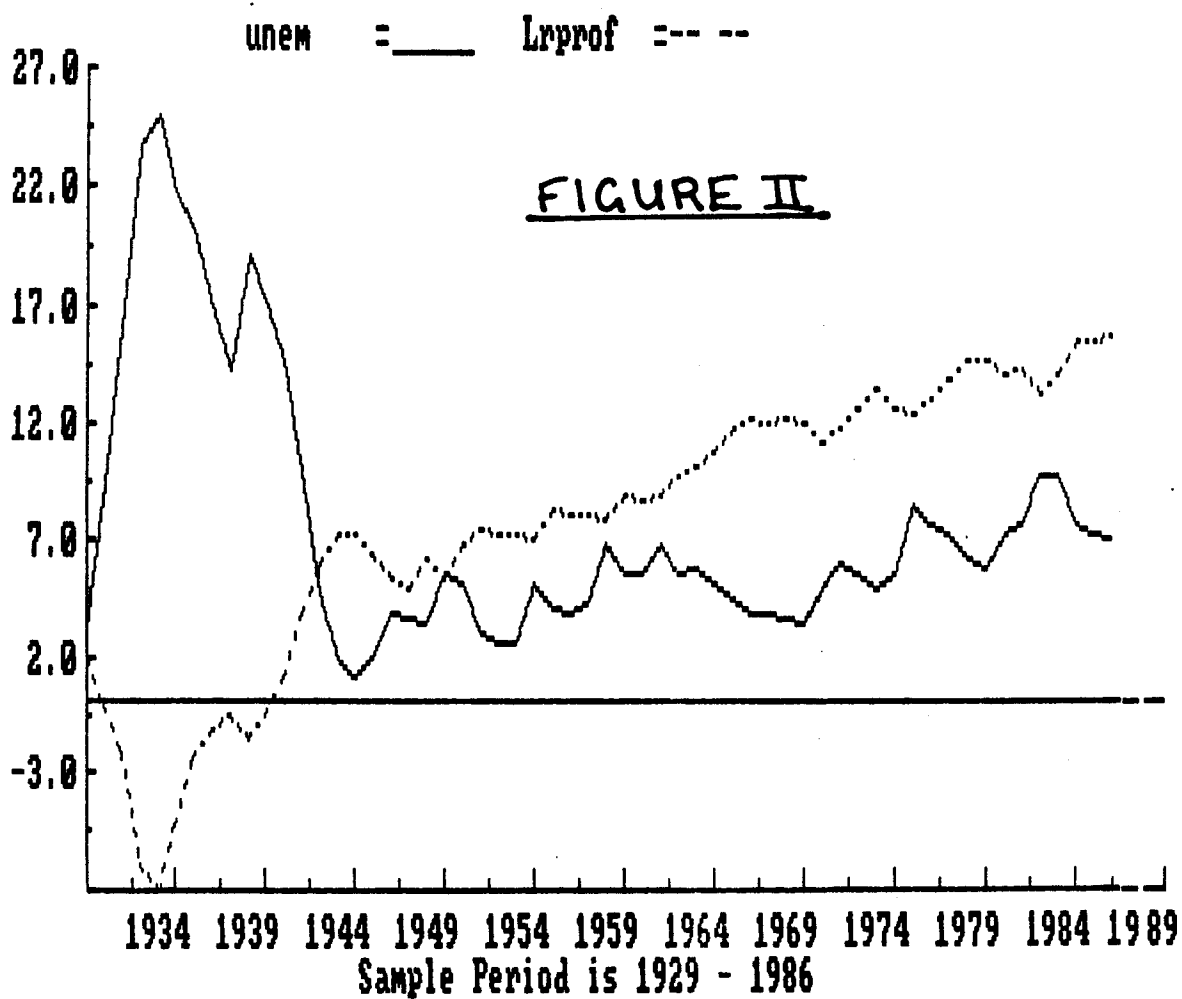
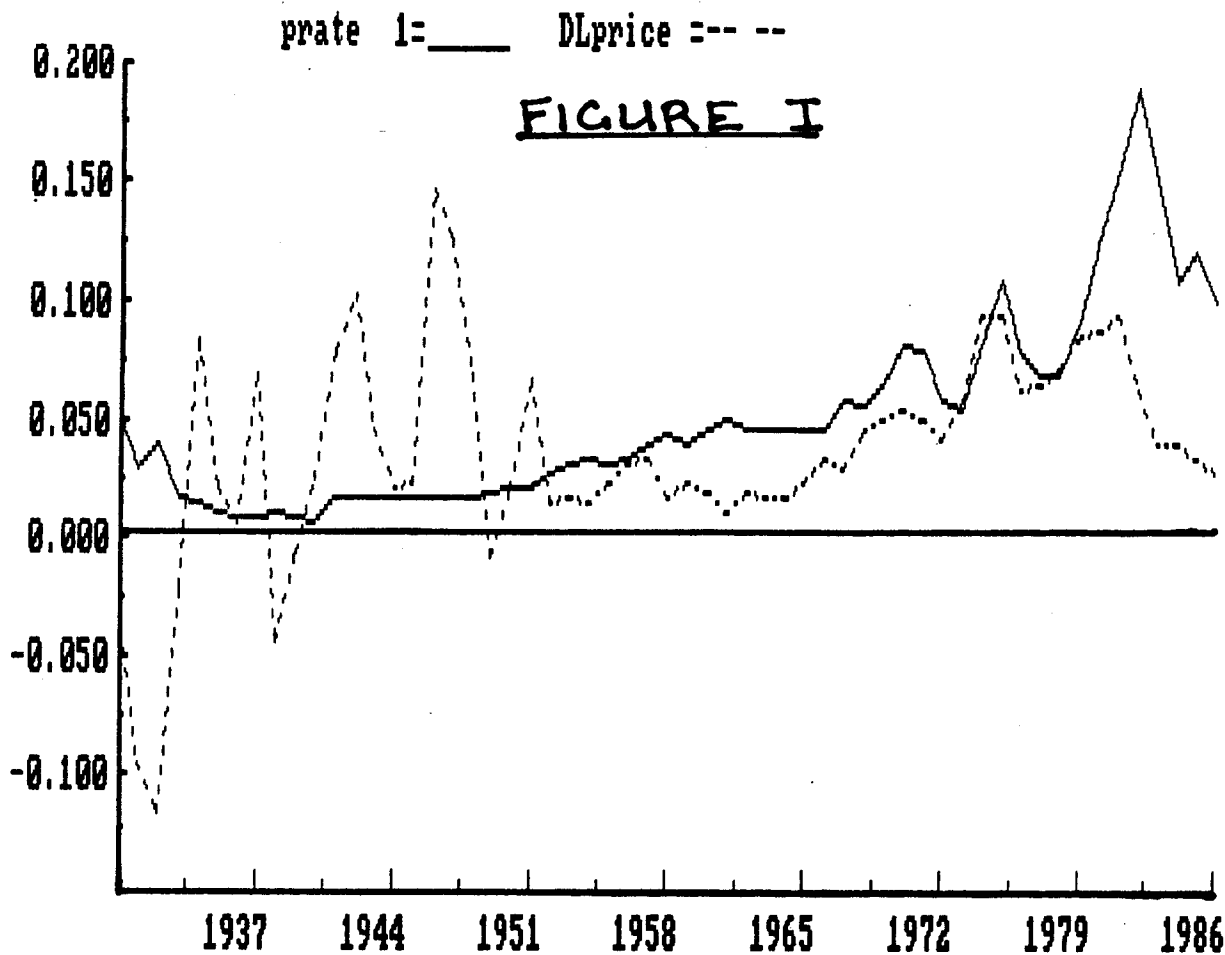
Lrprof 1 ... the logarithm of the period t-1 value of real national income, net of real compensation to employees.

These variables are graphed in figures (I) and (II) from which it is apparent that each of these variables has experienced a marked upward trend over the sample period. The Durbin-Watson statistics for the residuals of a regression of each of these series on a constant are presented below:

prate = .13	DLprice = .78
unem = .18	Lrprof = .04

J. D. Sargan and Alok Bhargava present a test for stationarity of a time series that is based on the Durbin Watson statistic. The critical value of this test for a simple random walk with a sample size of 57 is approximately .49 and hence three of these series (the inflation series is the exception) do not seem to be stationary. Since standard asymptotic theory does not apply to non-stationary data the regression results that I report below are based on first differences.⁸ The data in first difference form is presented in figures (III) and (IV) and the corresponding Durbin Watson statistics are given by:

⁸. J. D. Sargan and Alok Bhargava (1983). The Sargan-Bhargava test is uniformly most powerful against the alternative of a first order stationary Markov process and seems to be preferable to the alternative Dickey-Fuller (1981) test which is not invariant to whether the alternative hypothesis is a pure random walk or a random walk with drift.



$$\text{Dprate 1} = 1.57$$

$$\text{DDLprice} = 2.02$$

$$\text{Dunem} = .93$$

$$\text{DLrprof} = 1.02.$$

The profits variable that I have chosen to work with consists, essentially, of the sum of proprietor's incomes, rental income, corporate profits and net interest as reported in the national income and product accounts of the United States. This is a very broad interpretation of entrepreneurial income but has the advantage of avoiding the problem that the category in which profits are reported depends in an arbitrary way on the tax laws.

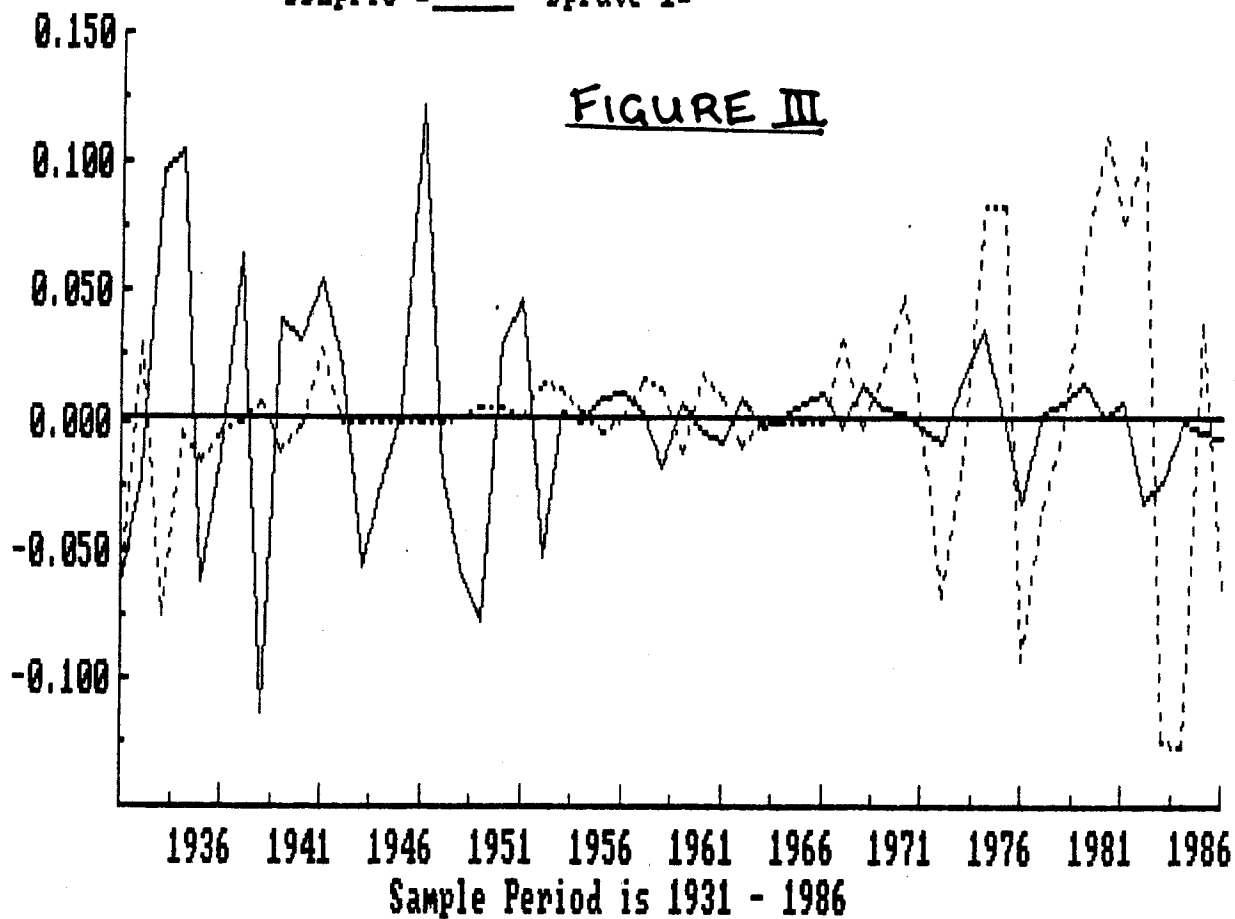
In addition to the four basic variables I have also used annual data on the real values of consumption, G.N.P. and the stock of high powered money as instruments in instrumental variables estimation of aggregate supply. The consumption and GNP data is taken from the national income and products accounts: the series on high powered money for earlier years is assembled from various Federal Reserve publications and for the post-war period it is taken from the Economic Report of the President.

6. The Evidence For A Stable Supply Relationship

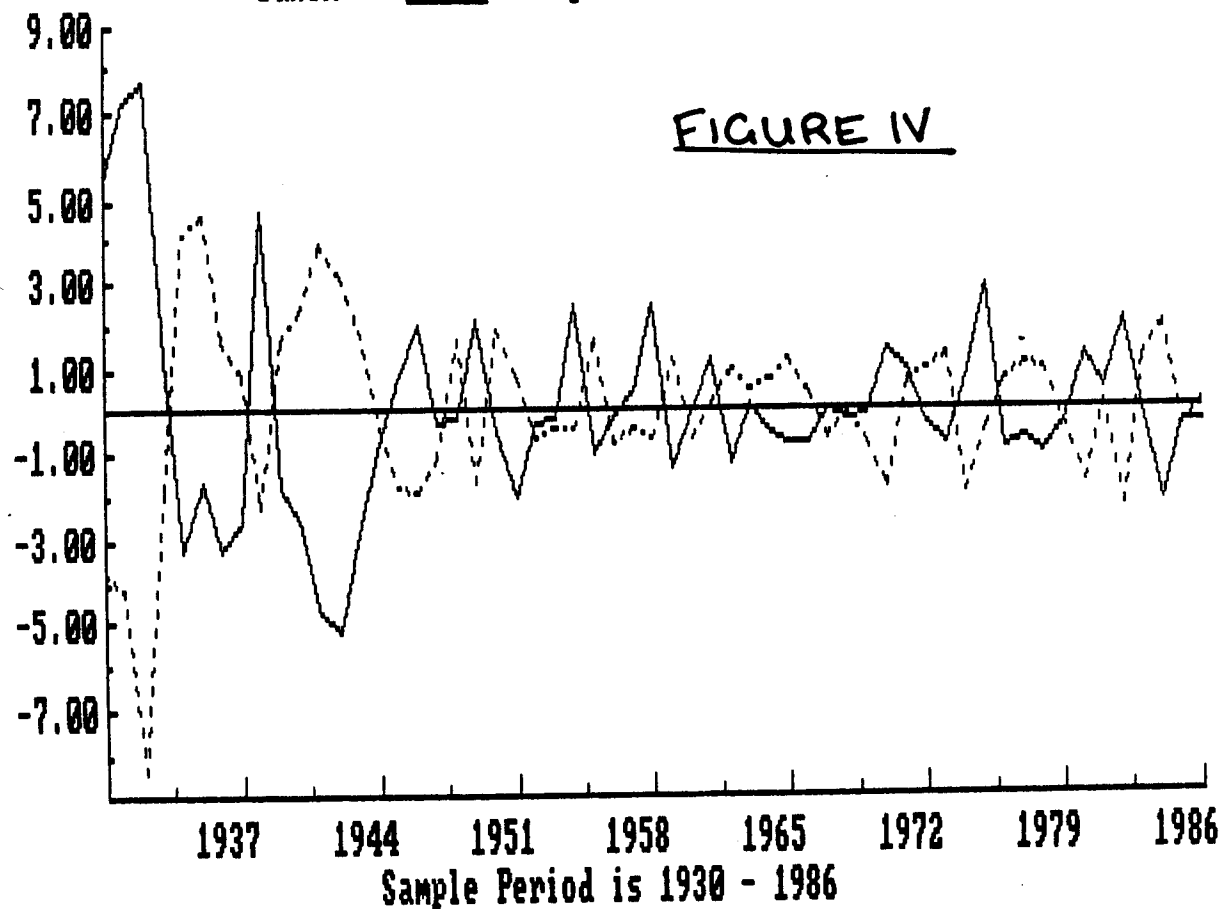
The regression equation that I have estimated for these data series takes the form:

$$[1] \quad \text{Dunem} = \underset{(5.5)}{-19.5} * \text{DDLprice} + \underset{(11.4)}{42.7} * \text{Dprate 1} - \underset{(1.6)}{10.7} * \text{DLrprof 1},$$

DDLpric = _____ Dprate 1:-- --



Dunem = _____ dirprf =-- --



where standard errors appear in parentheses. The equation was estimated for the entire sample period and for various sub-periods to check stability across pre-war and post-war samples. Equation [1] reports the results that I obtained for the full sample using a recursive instrumental variables estimator.⁹ I used instrumental variables because the current value of the price level appears as a regressor on the right hand side of the equation and one would expect that this variable would also enter an aggregate demand equation in a complete system. I used a recursive estimator as a means of checking the stability of the parameter estimates over the sample period.

The instruments were chosen by picking lagged values of variables that one would expect to appear in the reduced form of a small econometric model. The complete set of instruments that was used to estimate equation [1] is listed below:

DDLprice 1 the lagged difference in the inflation rate

DLprice 1 the lagged value of the logarithmic inflation
rate

DLhmon 1 the lagged value of the logarithmic money
growth rate

DDLrgnp 1 the difference in the real logarithmic growth
rate of G.N.P., lagged once

⁹. All regressions were run using David Hendry's program G.I.V.E..

TABLE I

The Present Sample is : 1933 to 1986 less 0 Forecasts

Modelling R.F. for Dunem

VARIABLE	COEFFICIENT	STANDARD ERROR	t-Value
Dprate 1	30.86013	13.55965	2.2759
dlrprf 1	-8.62344	3.33673	-2.5844
DDLpric1	-6.02328	5.40822	-1.1137
DLprice1	11.32267	5.11099	2.2154
DLrcons1	3.03328	7.86273	.3858
DLhmon 1	-9.44258	2.94940	-3.2015
Ddlrgnp1	-5.58095	4.58824	-1.2164
DDLhmon2	.62968	4.84670	.1299
Ddlrgnp2	4.67657	4.32808	1.0805

REDUCED FORM σ = 1.3797980 RSS = 85.6729126
 R^2 = .50888 F(9, 45) = 5.18089 DW = 2.52

The Present Sample is : 1933 to 1986 less 0 Forecasts

Modelling R.F. for DDLpric

VARIABLE	COEFFICIENT	STANDARD ERROR	t-Value
Dprate 1	.39698	.24265	1.6360
dlrprf 1	-.22701	.05971	-3.8019
DDLpric1	.28557	.09678	2.9507
DLprice1	-.57685	.09146	-6.3070
DLrcons1	.64766	.14070	4.6030
DLhmon 1	.17976	.05278	3.4059
Ddlrgnp1	.16045	.08211	1.9542
DDLhmon2	.01495	.08673	.1724
Ddlrgnp2	-.06147	.07745	-.7936

REDUCED FORM σ = .0246917 RSS = .0274355
 R^2 = .67899 F(9, 45) = 10.57576 DW = 2.01

The Present Sample is : 1933 to 1986 less 0 Forecasts

EQ(S1) Modelling Dunem by IVE

G. I. V. E.

1 ENDOGENOUS and 2 EXOGENOUS Variables With 9 INSTRUMENTS

VARIABLE	COEFFICIENT	STANDARD ERROR	t-VALUE
DDLpric	-19.50165	5.54802	-3.5151
Dprate 1	42.73199	11.41742	3.7427
dlrprf 1	-10.68548	1.64866	-6.4813

INSTRUMENTS USED :

DDLpric1	DLprice1	DLrcons1	DLhmon 1	Ddlrgnp1	DDLhmon2	Ddlrgnp2
RSS =	77.831906990	σ =	1.2353606	DW =	2.033	1.89
Reduced Form σ =	1.37979799	Specification CHI ² (6) / 6 =				
CHI ² (3) / 3 Testing β = 0 :		16.95				

- DDLrgnp 2 the difference in the real logarithmic growth rate of G.N.P., lagged twice
- DDLhmon 2 the difference in the logarithmic money growth rate, lagged twice.

The reduced form equations for Dunem and for DDLprice are presented in table I, which also reports some additional statistics for the instrumental variable regression. The choice of instruments does not make a great deal of difference to the I.V. estimates and I experimented with a number of alternatives including lagged values of investment, of government expenditure and various lags of the first and second differences of the logarithm of the price index and of the money stock.

Equation [1] is typical of the results that I obtained using a number of different sample periods and a number of different instrument sets.¹⁰ I have not restricted the co-efficient on DDLprice to be equal and of opposite sign to the co-efficient on Dprate 1 and it is clear from the precision with which these co-efficients are

¹⁰. The residuals of the regression do not show evidence of auto-correlation although I did find evidence of heteroscedasticity and they do not pass tests for normality. There is no evidence of A.R.C.H. effects. There is some evidence of mis-specification of the functional form although I did not manage to find a parsimonious representation of the relationship that performed better than the equation that is reported. A functional form in which the logarithmic difference of the unemployment rate appears on the left hand side does significantly worse. A collection of additional test statistics is reported in appendix 1.

TABLE II

① PERIOD 1933 - 45

G. I. V. E.				
1 ENDOGENOUS and VARIABLE	2 EXOGENOUS Variables With	6 INSTRUMENTS		t-VALUE
	COEFFICIENT	STANDARD ERROR		
DDLpric	-32.00162	8.68435		-3.6850
Dprate 1	48.55340	116.41942		.4171
dlrprf 1	-14.88498	2.56745		-5.7976
INSTRUMENTS USED :				
DDDirgn2	DDLrcon1	DDLhmon2	DDLpric1	
RSS =	16.157650115	σ =	1.3398860	DW = 1.763
Reduced Form σ =	2.85964940		Specification CHI^2 (3) / 3 =	.89
CHI^2 (3) / 3	Testing $\beta = 0$:	12.47		

② PERIOD 1946 - 86

G. I. V. E.				
1 ENDOGENOUS and VARIABLE	2 EXOGENOUS Variables With	6 INSTRUMENTS		t-VALUE
	COEFFICIENT	STANDARD ERROR		
DDLpric	-7.14713	9.70822		-.7362
Dprate 1	39.03005	9.22832		4.2294
dlrprf 1	-6.29407	2.32061		-2.7122
INSTRUMENTS USED :				
DDDirgn2	DDLrcon1	DDLhmon2	DDLpric1	
RSS =	35.137310873	σ =	.9615956	DW = 2.371
Reduced Form σ =	.95093673		Specification CHI^2 (3) / 3 =	1.70
CHI^2 (3) / 3	Testing $\beta = 0$:	7.95		

③ FULL: SAMPLE PERIOD

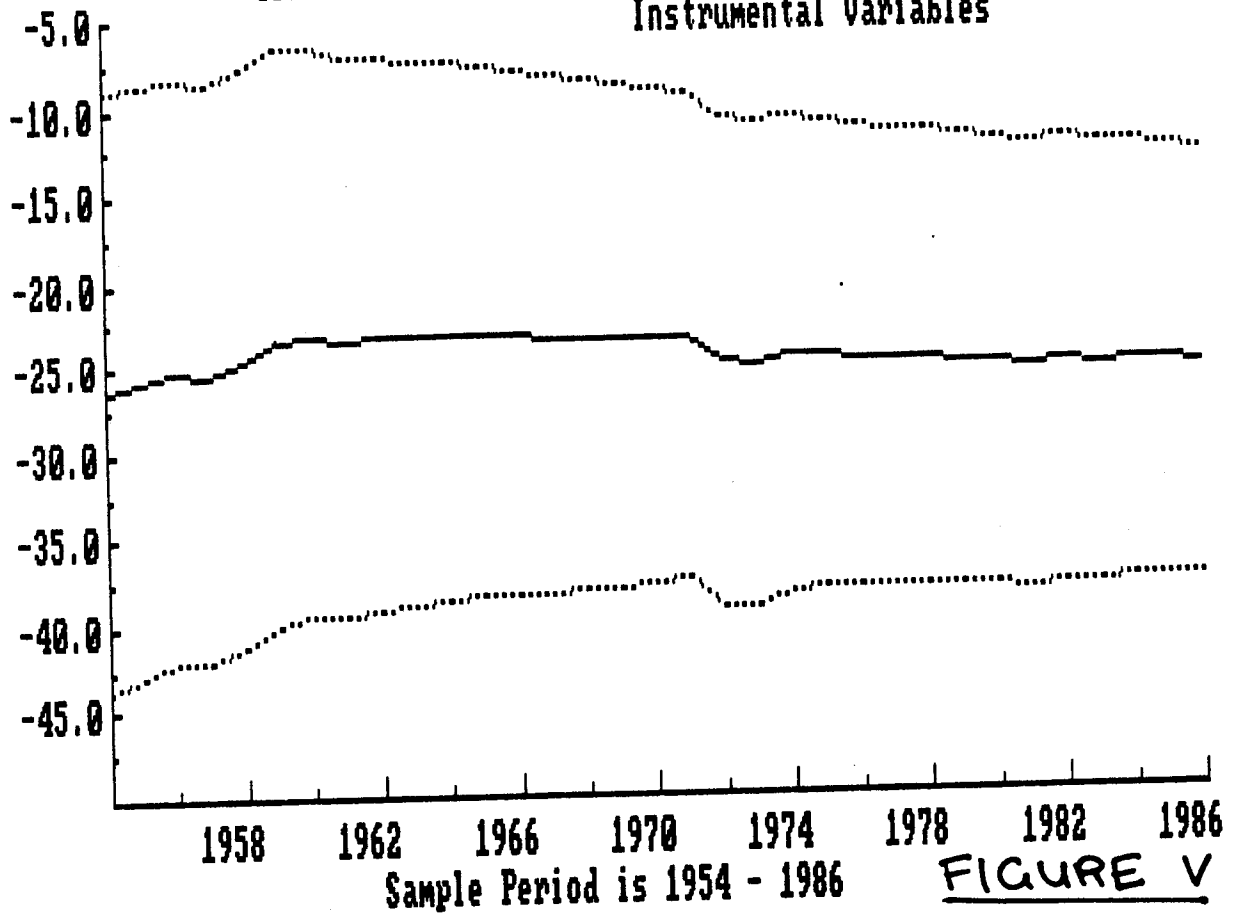
G. I. V. E.				
1 ENDOGENOUS and VARIABLE	2 EXOGENOUS Variables With	6 INSTRUMENTS		t-VALUE
	COEFFICIENT	STANDARD ERROR		
DDLpric	-21.59181	7.33891		-2.9421
Dprate 1	42.19304	11.67587		3.6137
dlrprf 1	-11.30842	1.85985		-6.0803
INSTRUMENTS USED :				
DDDirgn2	DDLrcon1	DDLhmon2	DDLpric1	
RSS =	76.435856954	σ =	1.2364130	DW = 2.054
Reduced Form σ =	1.48459869		Specification CHI^2 (3) / 3 =	.24
CHI^2 (3) / 3	Testing $\beta = 0$:	15.98		

estimated that a restriction of this nature would be rejected by the data with high probability. That is, one cannot accept the proposition that it is only the real rate of interest that belongs in the aggregate supply equation rather than real and nominal rates of interest separately. This statement does, however, deserve some qualification since the effects of the nominal interest rate and of the inflation rate are being picked out by the data over very different sample periods.¹¹

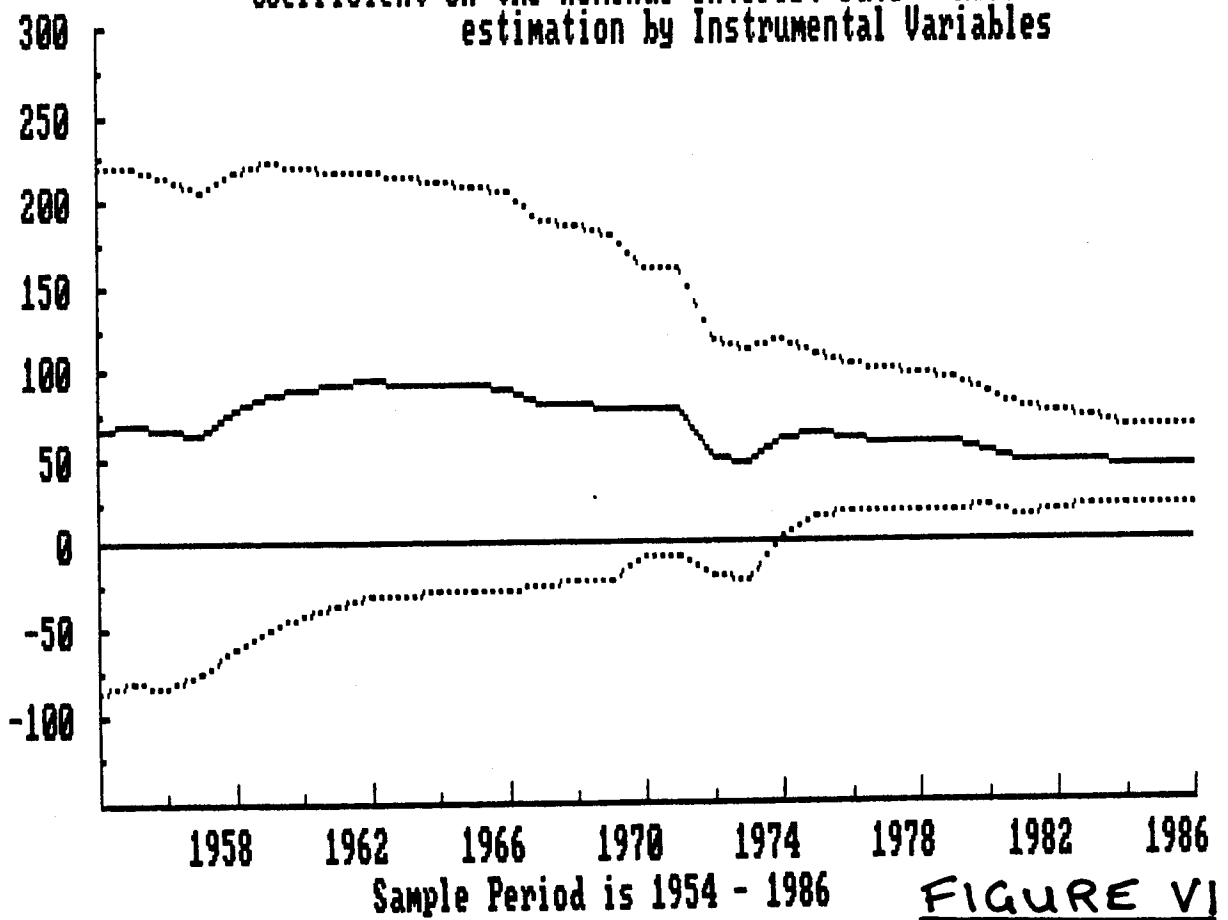
Figure (III) graphs the difference in the inflation rate and the difference in the nominal interest rate over the period from 1931 to 1986. Notice that for the initial part of the sample period there is a great deal of variability in the inflation rate but not much movement at all in the rate of interest. In the latter part of the sample period this situation is reversed. One might suspect that the data will be unable to identify the coefficient on the interest rate in pre-war data and that it will similarly be unable to identify the separate effect of the inflation rate in post-war data. This suspicion is born out in table (II) in which I present separate estimates for pre 1945 and post-war samples. Since there are only 12 observations in the pre 1945 sample I was forced to use a restricted

¹¹. Since there is some reason to believe that the methods of data collection differ between pre-war and post-war samples (see the article by Christina Romer (1986)), it is possible that the hypothesis that only the real rate of interest is important would not be rejected if one had access to a consistently collected sample in which there was substantial variation in both variables.

Coefficient on inflation -- Recursive estimation by
Instrumental Variables



Coefficient on the nominal interest rate-- Recursive
estimation by Instrumental Variables

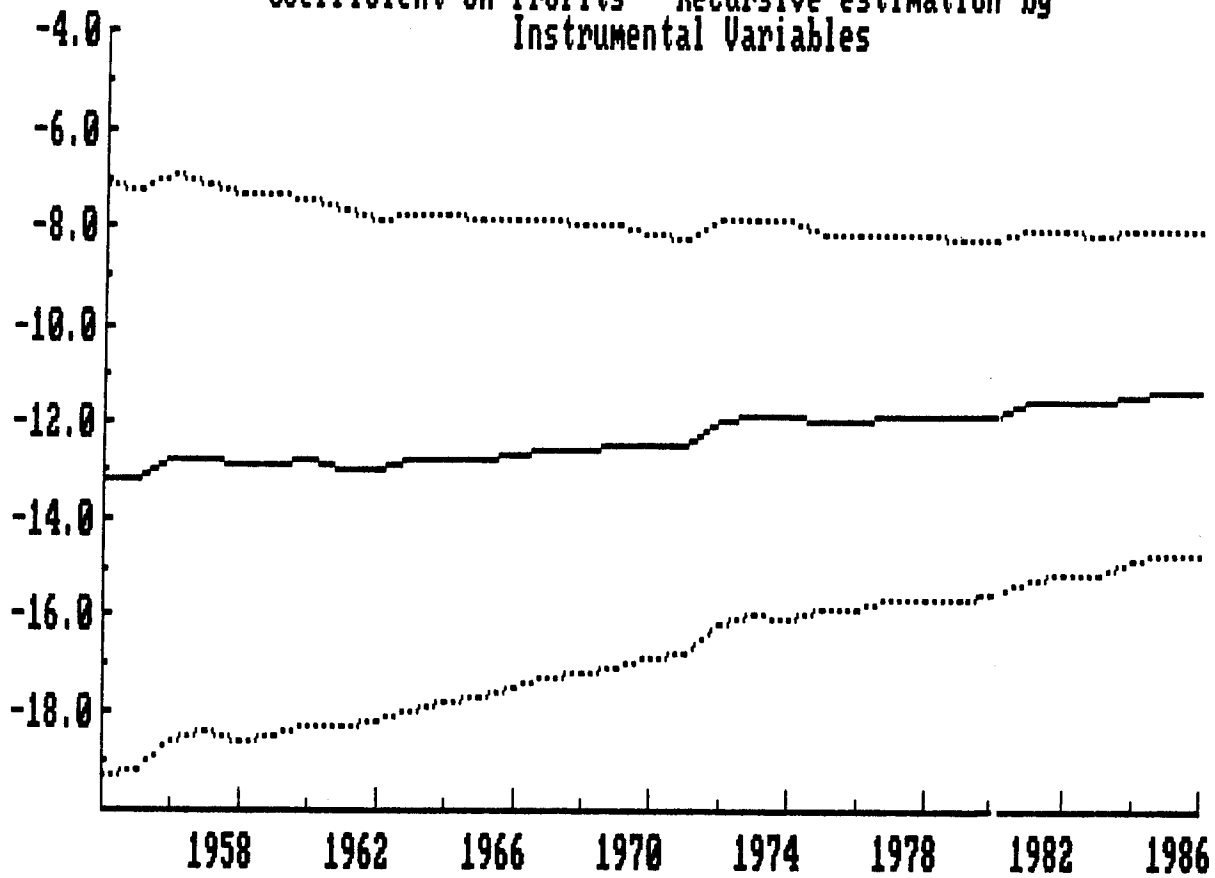


instrument set that drops DDLrgnp 1, DLhmon 1 and DLprice 1 as a way of increasing the number of degrees of freedom. Table (II) also reports estimates for the pooled sample using the restricted instrument set.

The remarkable feature of all of the estimates that I obtained is that they remain stable over the entire post-war sample period. Figures (V), (VI) and (VII) present recursive estimates of the co-efficients on the realized inflation rate, on the lagged interest rate and on profits, for sequential sample periods beginning with the period 1933 to 1954 and ending with the sample period 1933 to 1986. The dashed lines are 5% standard error bounds. As an indication of the stability of this relationship in post-war data, figure (VIII) presents a graph of fitted versus actual values of Dunem for the period from 1933 to 1986. This equation is estimated using data from 1933 to 1958 but it is graphed for the entire sample period. Although there is some evidence of a break between pre-war and post-war samples, a researcher who had estimated equation [1] using data from 1929 up until 1945 would not have gone far wrong in applying these estimates to the post-war period.¹²

¹². There is no evidence of a structural break in the data at any point beyond 1947. The pre-1946 and post-war samples do show some evidence of structural instability but this result is highly sensitive to the single observation for 1946 which corresponds to the removal of war-time price controls. If 1946 is included in the post-war sample, it dramatically reduces (in absolute value) the magnitude of the post-war inflation co-efficient. If 1946 is excluded from the post-war data, the effect of inflation in the post-war sample is much closer to the pre-1946 value although it is still estimated very imprecisely.

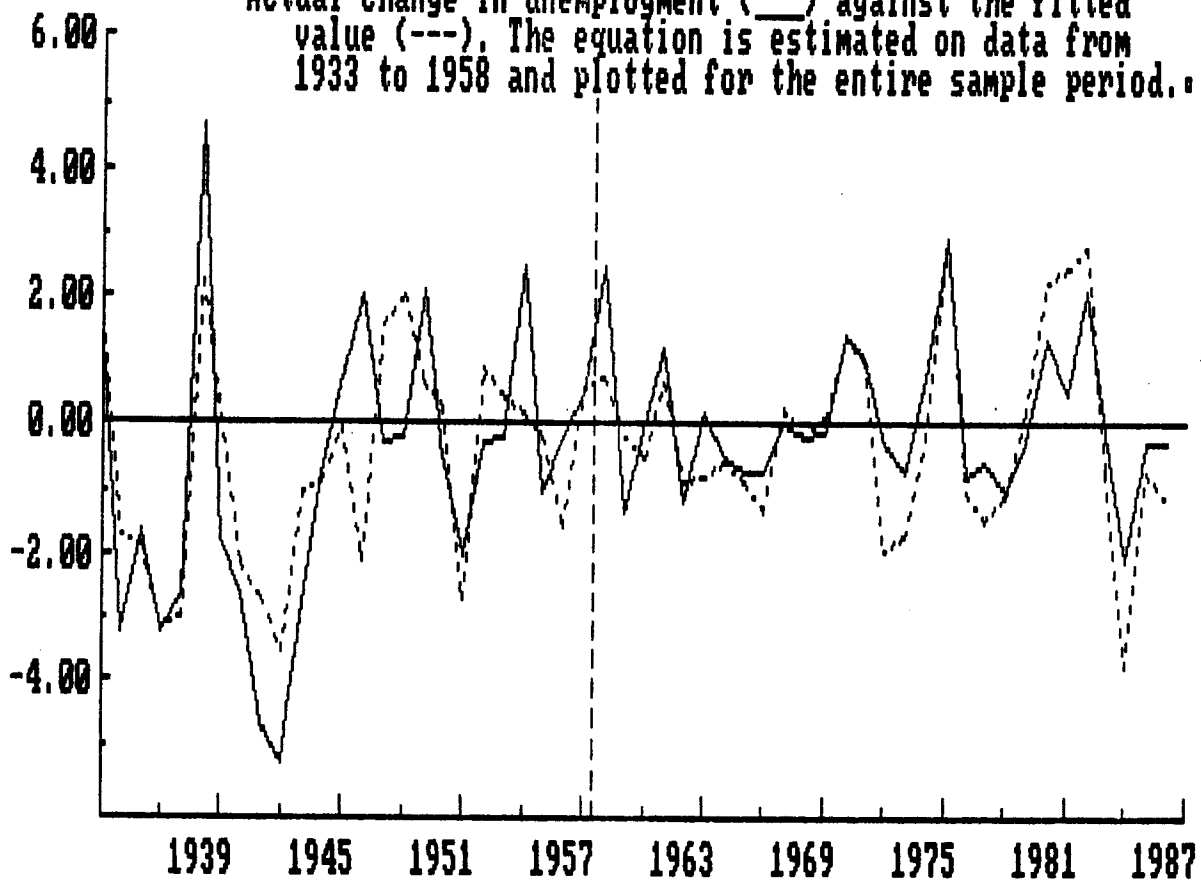
Coefficient on Profits-- Recursive estimation by Instrumental Variables



Sample Period is 1954 - 1986

FIGURE VII

Actual change in unemployment (___) against the fitted value (---). The equation is estimated on data from 1933 to 1958 and plotted for the entire sample period.



Sample Period is 1933 - 1986

FIGURE VIII

In section (3) of the paper I discussed the issue of the persistence of unemployment. As a test of whether lagged profits is an appropriate explanatory variable in an aggregate supply equation I ran a number of encompassing tests in which various additional explanatory variables were tested as alternatives to lagged profits. In all of the equations that I tested the functional form that includes only $DLrprof$ 1, $DDLprice$ and $Dprate$ 1 performed significantly better than the joint model and the alternative model that did not include lagged profits was rejected. Table (III) reports the outcome of two of these tests. The top panel of the table tests an alternative model in which lagged profits is replaced by the lagged unemployment rate. Notice that this alternative model is overwhelmingly rejected against the joint model which includes both $DLrprof$ 1 and $Dunem$ 1 as regressors—the F statistic of 27.425 is well outside the 5% error bound, under the null, of 4.034. The model that drops lagged unemployment and includes only lagged profits, however, cannot be rejected with an F statistic of .096. The second panel of table (III) presents similar results for a test of the model that replaces lagged profits with the lagged value of compensation to employees. This model is again overwhelmingly rejected in favor of the A.I.L. specification.

7. Conclusion.

I hope to have persuaded the reader that the statistical evidence that I have presented lends qualified support to A.I.L. theories of aggregate supply and that these theories offer a more promising

TABLE III

Sample from 1933 - 1986 less 0 forecasts

ENCOMPASSING TEST STATISTICS

M1 is: Dunem on DDLpric Dprate 1 dlrprf 1

M2 is: Dunem on DDLpric Dprate 1 Dunem 1

INSTRUMENTS used :

Dprate 1 dlrprf 1 DDLpric1 DLprice1 DLrcons1 DLhmon 1 Ddlrgnp1
DDLhmon2 Ddlrgnp2 Dunem 1

Due to including ENDOGENOUS regressors, the COX-statistic is INVALID

$\sigma_1 =$ 1.235459 $\sigma_2 =$ 1.609384 $\sigma[\text{Joint}] =$ 1.244948

Model 1 v Model 2	Form	Test	Form	Model 2 v Model 1
.309	N(0,1)	Cox	N(0,1)	-9.686
-.303	N(0,1)	Ericsson IV	N(0,1)	7.629
10.717	Chi ² (7)	Sargan	Chi ² (7)	22.669
.096	F(1, 50)	Joint Model	F(1, 50)	27.425
4.034	FI 1, 50]	Crit Vals	FI 1, 50]	4.034

Sample from 1933 - 1986 less 0 forecasts

ENCOMPASSING TEST STATISTICS

M1 is: Dunem on DDLpric Dprate 1 dlrprf 1

M2 is: Dunem on DDLpric Dprate 1 dlrcmp 1

INSTRUMENTS used :

Dprate 1 dlrprf 1 DDLpric1 DLprice1 DLrcons1 DLhmon 1 Ddlrgnp1
DDLhmon2 Ddlrgnp2 dlrcmp 1

Due to including ENDOGENOUS regressors, the COX-statistic is INVALID

$\sigma_1 =$ 1.235384 $\sigma_2 =$ 1.402708 $\sigma[\text{Joint}] =$ 1.240135

Model 1 v Model 2	Form	Test	Form	Model 2 v Model 1
-.590	N(0,1)	Cox	N(0,1)	-5.350
.561	N(0,1)	Ericsson IV	N(0,1)	4.427
10.716	Chi ² (7)	Sargan	Chi ² (7)	19.439
.291	F(1, 50)	Joint Model	F(1, 50)	14.526
4.034	FI 1, 50]	Crit Vals	FI 1, 50]	4.034

research agenda for macroeconomics than the Phelps-Friedman alternative. In concluding I should add that if this view is correct then it will be necessary to reassess a number of recent ideas that concern the channels by which macroeconomic policy variables may affect unemployment and inflation. In particular, A.I.L. theories imply that expectational surprises play, at best, a secondary role in the business cycle. If A.I.L. is right then a high level of unemployment is caused by the same factors that cause high real and nominal interest rates and it is likely that traditional monetary and fiscal instruments will prove to be far more effective in influencing the level of economic activity than has recently been thought to be the case.

In closing, it is worth noting that there is still much work to be done. A pessimist might conclude that we have not come much further in 1988 than we had in 1958 when A.W. Phillips closed his paper with the lines:

"These conclusions are of course tentative. There is need for much more detailed research into the relations between unemployment, wage rates, prices and productivity."

This statement is as true today as it was then.

APPENDIX I

The Present Sample is : 1933 to 1986 less 0 Forecasts

Dunem = -25.393 DDLpric + 43.460 Dprate 1 -11.366 dlrprf 1
Mean = -.309259 S.D. = 1.814228 σ = 1.2235248
Chow F [0., 0.] = .00 Normality Chi²(2) = 7.54
Xi**2 F [6., 44.] = 7.45 ARCH F [3., 45.] = .68
Xi*Xj F [9., 41.] = 5.35 AR F [3., 48.] = .22

The Current Set of Instruments is :

5) DDLrcon1 6) DDLhmon2 7) DDLpric1 8) Ddlrgnp2 9) DLhmon 1
10) DLpric1 11) Ddlrgnp1

DIAGNOSTIC-TEST M E N U

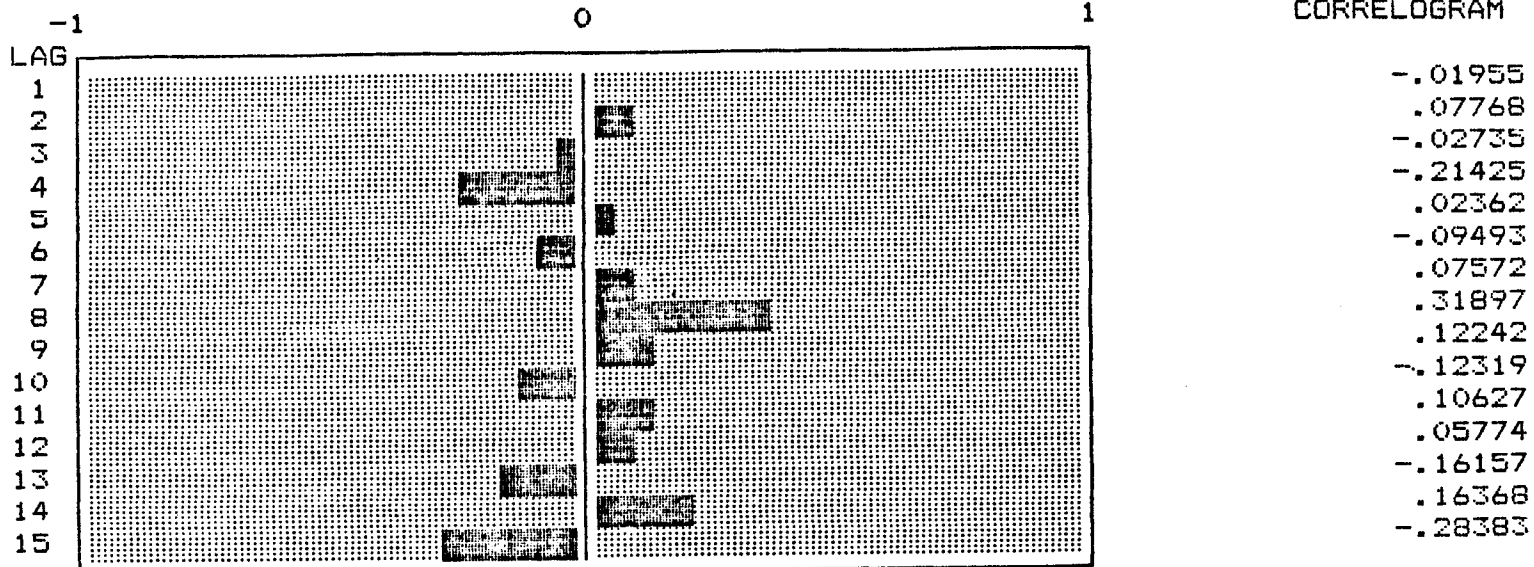
- | | |
|---|-----------------------------------|
| 1. RESIDUAL CORRELOGRAM | 2. Test for ERROR AUTOCORRELATION |
| 3. A.R.C.H. | 4. NORMALITY |
| 5. HETEROSCEDASTICITY [Due to SQUARES of the Regressors] | |
| 6. FUNCTIONAL FORM MIS-SPECIFICATION Test | |
| 7. L-M OMITTED VARIABLES Tests | |
| 8. ENCOMPASSING Tests | |
| 9. ** CONTINUE to the ACTION MENU ** | |

Choose an Option :

RESIDUAL CORRELOGRAM

54*(Sum of 15 Squared Residual Autocorrelations) =

18.811

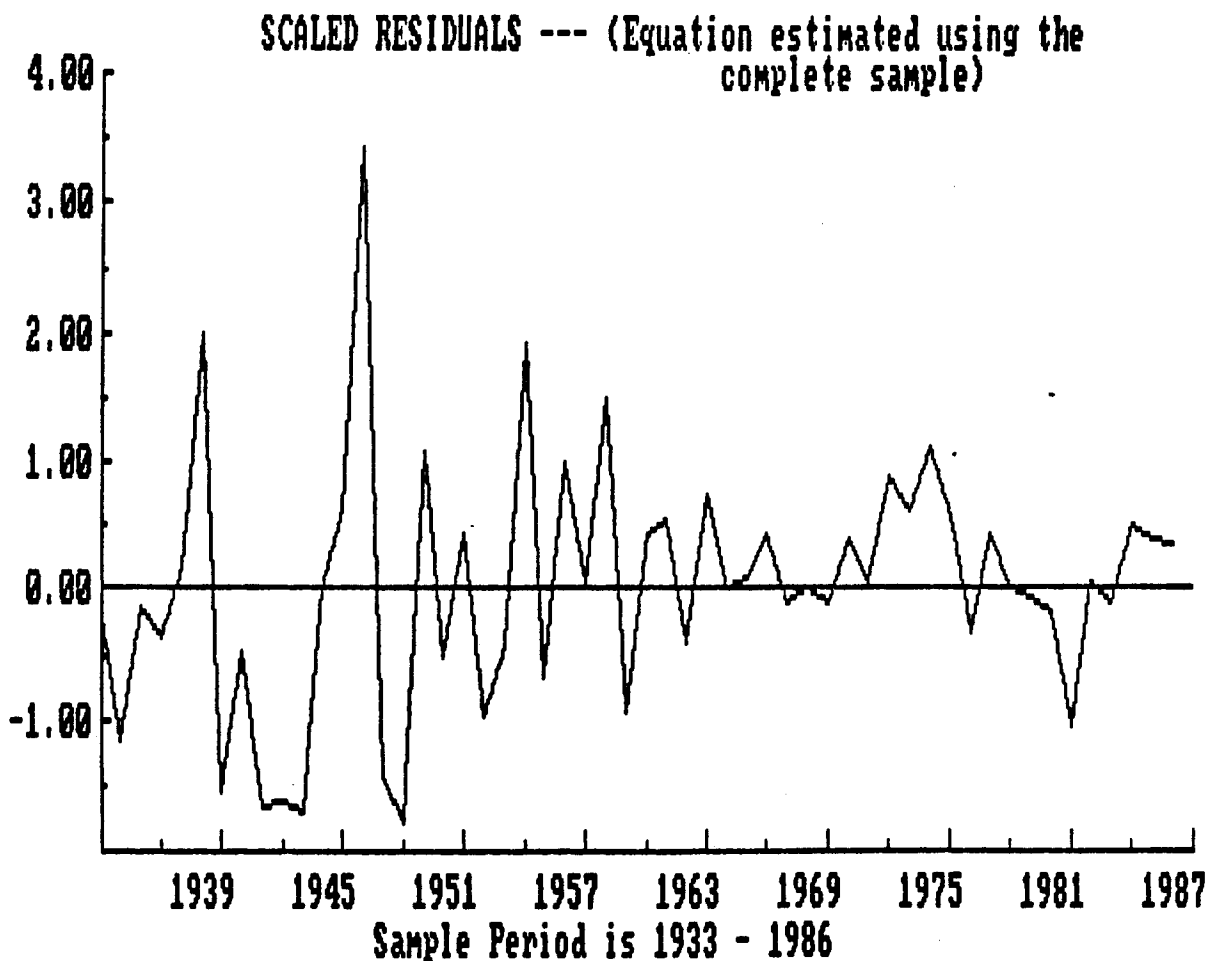


Press the RETURN Key to Continue

RESIDUAL AUTOREGRESSION of Order 5

LAG	1	2	3	4	5
COEFF.	-.0336	.0801	-.0432	-.2195	.0147
S.E.'s	.1562	.1524	.1531	.1488	.1523

RESID SUM SQS = .691467D+02 σ = 1.29866 F[5, 41] = .45
 F[5, 41] Crit Val = 2.44



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