

This PDF is a selection from an out-of-print volume from the National Bureau of Economic Research

Volume Title: Asymmetric Information, Corporate Finance, and Investment

Volume Author/Editor: R. Glenn Hubbard, editor

Volume Publisher: University of Chicago Press, 1990

Volume ISBN: 0-226-35585-3

Volume URL: <http://www.nber.org/books/glen90-1>

Conference Date: May 5, 1989

Publication Date: January 1990

Chapter Title: AIL Theory and the Ailing Phillips Curve: A Contract-Based Approach to Aggregate Supply

Chapter Author: Roger E. A. Farmer

Chapter URL: <http://www.nber.org/chapters/c11473>

Chapter pages in book: (p. 207 - 230)

---

# AIL Theory and the Ailing Phillips Curve: A Contract-Based Approach to Aggregate Supply

Roger E. A. Farmer

## 8.1 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 *AIL theories*.<sup>1</sup>

The most prominent feature that separates AIL theories from both neo-Keynesian and New-Classical theories of aggregate supply is that AIL 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 intertemporal substi-

Roger Farmer is an associate professor at the University of California, Los Angeles.

This work was supported by NSF grant SAS-8722432. The author thanks Glenn Hubbard for his comments.

tution 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 United States and Europe in recent years are perceived to be due to structural adjustment problems or hysteresis effects that have altered the natural rate. The AIL 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 theory of long-term movements in the level of economic activity.

I have argued elsewhere 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.<sup>2</sup> I briefly review this argument in section 8.4 of this paper. The main contribution of this work is, however, empirical. In section 8.7 I present estimates of an AIL-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 postwar sample period. A researcher who had estimated an AIL-based equation using only prewar data would not go far wrong if he or she applied the same parametric model to postwar data from 1946 up to the present day.

## 8.2 Related Literature

A number of authors have been concerned with the effects of collateral on macroeconomic theory and with the role of informational asymmetries in the theory of financial intermediation. I view the present work as complementary to this literature. One of the earliest theoretical pieces on the theory of financial intermediation is the work by Stiglitz and Weiss (1981) on credit rationing. Ben Bernanke and Mark Gertler (1987) have made a number of important contributions, and papers by Bruce Smith (1983), Steve Williamson (1986), Greenwald and Stiglitz (1986), and Fazzari, Hubbard, and Petersen (1987) have explored both theoretical and empirical implications of theories of imperfect financial intermediation. This literature is comprehensively surveyed in the paper by Mark Gertler (1988).

My difference is one of emphasis. Most of the work that I cite above is concerned with the implications of informational asymmetries for the theory of aggregate demand, and it is my impression that these authors have in mind a fairly standard transmission mechanism, from demand fluctuations to output, that operates through price inflexibility on the supply side. It is my contention, in this paper, that the same set of theories that offers a potential explanation of, for example, the Keynesian investment multiplier also suggests a

very different mechanism for the transmission of policy shocks to aggregate supply. It is the theory of supply that I concentrate on below.

### 8.3 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 AIL-based theory of aggregate supply.

*Fact number 1.* In the United Kingdom there was a marked and fairly stable inverse relationship between unemployment and the rate of wage inflation from 1861 well into the 1960s. Beyond this date the relationship appears to have broken down, and parts of the 1970s and 1980s 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 AIL-based theory reverses the direction of causation. Under the AIL 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 is *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.<sup>3</sup>

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 AIL interpretation of the facts also relies on an omitted variable problem, but in AIL theory it is the influence of the rate of interest that has been omitted and not the effect of (unobservable) inflationary expectations. Until the mid 1960s the nominal rate of interest exhibited very little movement relative to its more recent fluctuations (see fig. 8.3 below, which demonstrates 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 1970s when a high and volatile rate of interest became part of the background of central bank monetary policy.

*Fact number 2.* In postwar 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 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.<sup>4</sup>

*Explanation.* The role of the nominal interest rate fits naturally into AIL-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 AIL 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.

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 ARIMA (1,1,0) process fits reasonably well to twentieth-century annual data with an autoregressive coefficient of approximately 0.5.

*Explanation.* It has recently become common practice to explain the persistence of unemployment in terms of hysteresis effects.<sup>5</sup> Under this interpretation, unemployment has remained high in recent years because workers remain out of the labor force in the face of persistent spells of demand-induced unemployment. This effect causes an increase in the natural rate. Under AIL theories, on the other hand, unemployment is highly autocorrelated 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 8.7 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-period 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.

## 8.4 A Review of AIL Theory

In this section I review the structure of AIL-based theories. The presentation is broken into three parts, each of which is designed to explain the role of three explanatory variables in the AIL 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 AIL 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 8.5, in which I discuss the question of the indexation of nominal contracts to observed prices.

### 8.4.1 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 AIL 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 AIL 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 AIL theories introduce a key assumption: *asymmetric information*—the entrepreneur has better 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 truth-

fully reveal the productivity of the enterprise.<sup>6</sup> 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 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 AIL theories introduce a second key assumption: *limited collateral*—the collateral of the entrepreneur is limited 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 bankers'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 AIL 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 AIL theories of aggregate supply.

### 8.4.2 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 workers. 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.<sup>7</sup>

The worker and the entrepreneur must negotiate a contract that offers the worker a sufficiently high *ex ante* expected return to induce him to forgo 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 the gap is 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 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 AIL theories of aggregate supply.

#### 8.4.3 The Role of Profits

In AIL 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 section 8.4.1. 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 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 AIL theories of aggregate supply.

### 8.5 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.

However, AIL theories do not face this problem. In the basic theory that I outlined in Section 8.4, I made the strong assumption that there was no aggregate uncertainty. This assumption is clearly counterfactual, 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 AIL 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, 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 AIL theory, unanticipated shocks do not play a central role in explaining employment fluctuations, and, consequently, the issue of contract indexation is secondary.

Although from a theoretical point of view one might be happy with this approach, it does lead to a number of difficulties in empirically testing the theory. It is clearly not a good description of the real world to assume that future prices are perfectly foreseen, and it is almost certainly true that one of the roles of liquid assets (a role that is not captured by the theory that I have discussed) is to provide a guarantee of payment against *aggregate* fluctuations in income. By neglecting to model the role of aggregate uncertainty it is likely—to the extent that aggregate uncertainty is important in the real economy—that the theories that I have described above will generate predictions that are at odds with the facts. One place in which this problem is likely to manifest itself is in the counterfactual implication, of the simple AIL theory, that the business cycle is symmetric. Upswings are predicted to last for just as long, and to be just as severe, as downswings,<sup>8</sup> although we know that this is not the case at least in the United States.

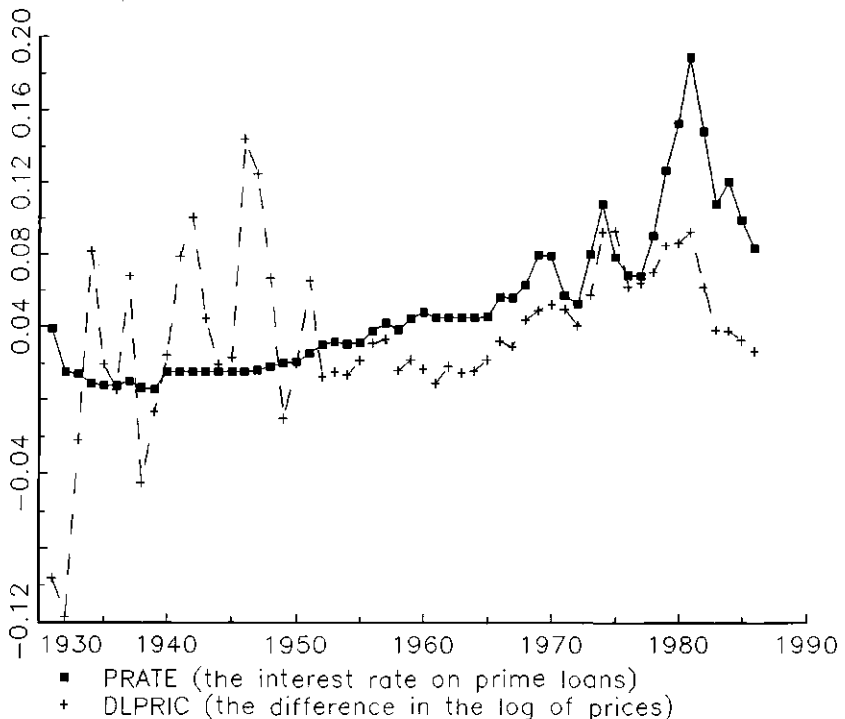
In applying the theory to U.S. data I have taken account of the fact that most contracts seem to contain only limited indexing provisions, and I shall therefore interpret the real interest rate variable as an *ex post* rate. This approach sidesteps the issue of aggregate fluctuations, and it does not offer a satisfactory solution. However, in the absence of a well-formulated theory of contracts in general equilibrium, one that takes account of the effects of aggre-

gate disturbances, it is as close as I am able to come to providing a consistent theoretical implementation of the ideas that I have described above. The details of the empirical implementation of my approach are described in the next section.

## 8.6 From Theory to Evidence

In the next two sections of the paper I explore the statistical evidence for an AIL-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  $t$  = 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 gross national product (GNP) deflator;  
 UNEM = the period  $t$  unemployment rate;



**Fig. 8.1** The interest rate and the inflation rate

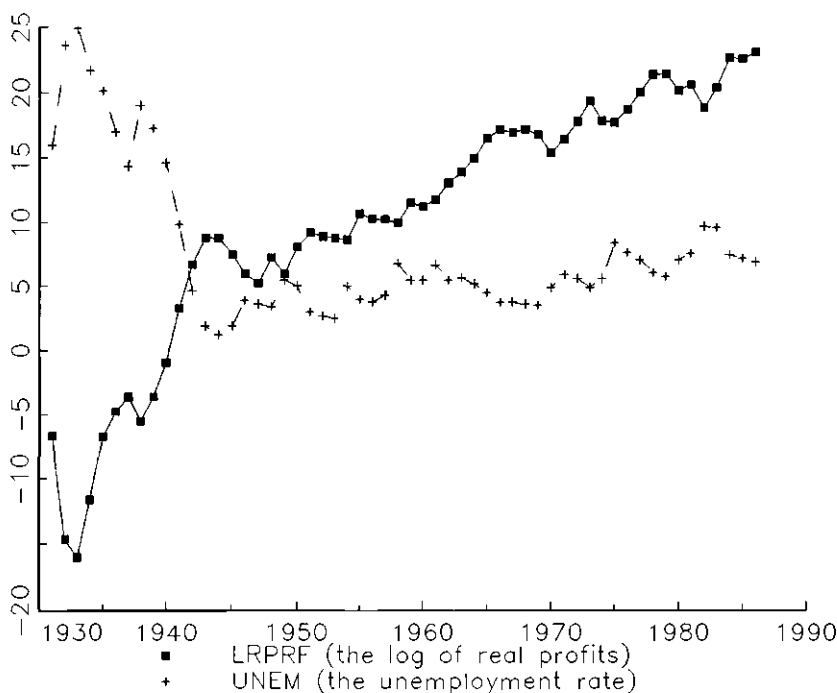
Source: Prewar data on interest rates is from *Banking and Monetary Statistics of the United States*; prewar data on the GNP deflator is from the *National Income and Product Accounts*; postwar data on both variables is taken from the *Economic Report of the President*.

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 8.1 and 8.2. 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:

$$\begin{array}{ll} \text{PRATE} = .13 & \text{DLPRICE} = .78 \\ \text{UNEM} = .18 & \text{LRPROF} = .04 \end{array}$$

J. D. Sargan and Alok Bhargava (1983) 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 nonstationary data, the regression results that I report below are based on first differences.<sup>9</sup> The data in first-difference form is presented in figures 8.3 and 8.4 and the corresponding Durbin-Watson statistics are given by:



**Fig. 8.2 The unemployment rate and the logarithm of real profits**

Source: Profits is taken from the *National Income and Product Accounts*; Real Profits is national income net of compensation to employees all deflated by the GNP deflator. Unemployment data are from the Bureau of Labor Statistics.

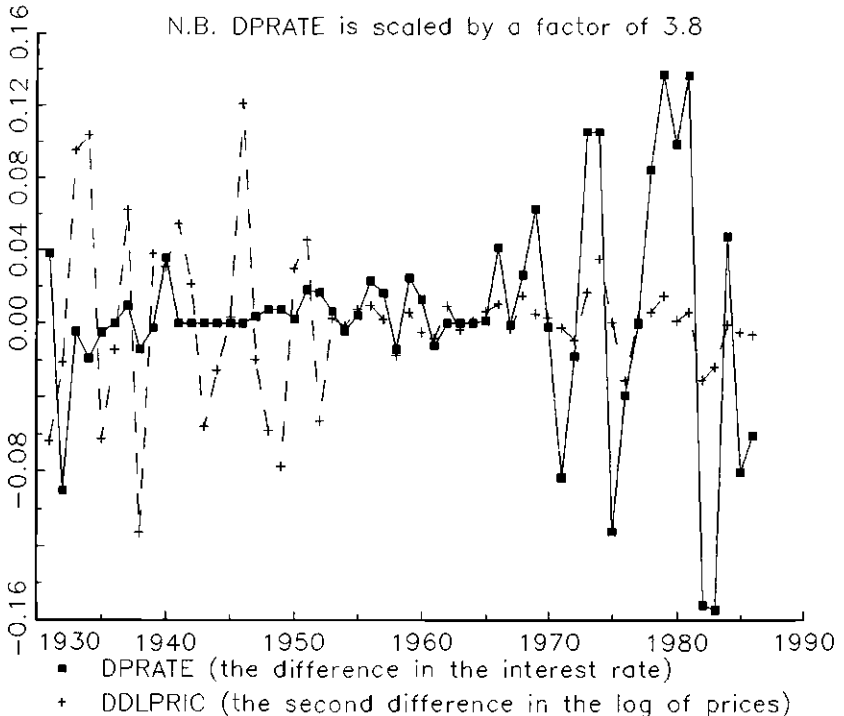
$$\begin{array}{ll} \text{DPRATE } 1 = & 1.57 \\ \text{DUNEM} = & .93 \end{array} \quad \begin{array}{ll} \text{DDLPRICE} = & 2.02 \\ \text{DLRPROF} = & 1.02 \end{array}$$

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, GNP, and the stock of high-powered money as instruments in instrumental-variables estimation of aggregate supply. The consumption and GNP data are 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 postwar period it is taken from the Economic Report of the President.

### 8.7 The Evidence for a Stable Supply Relationship

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



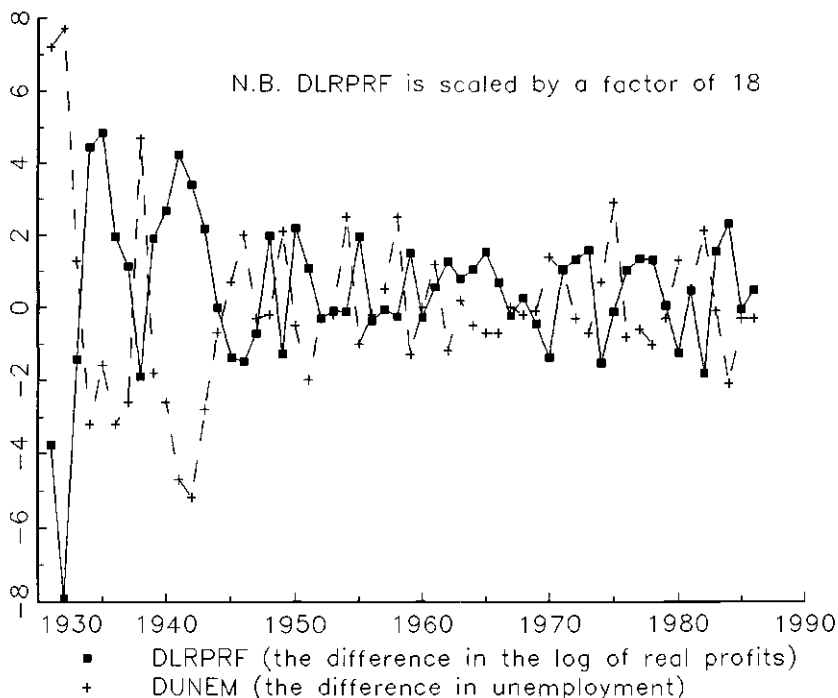
**Fig. 8.3** The interest rate and the inflation rate in first differences

$$(1) \quad \text{DUNEM} = -19.5 \times \text{DDLPRICE} + 42.7 \times \text{DPRATE} + 1 \\
\begin{matrix} (5.5) & (11.4) \\ -10.7 \times \text{DLPROF} + 1, \\ (1.6) \end{matrix}$$

where standard errors appear in parentheses. The equation was estimated for the entire sample period and for various subperiods to check stability across prewar and postwar samples. Equation (1) reports the results that I obtained for the full sample using a recursive instrumental-variables estimator.<sup>10</sup> 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;



**Fig. 8.4** The unemployment rate and real profits in first differences

- DDLRGNP 1 = the difference in the real logarithmic growth rate of GNP, lagged once;  
 DDLRGNP 2 = the difference in the real logarithmic growth rate of GNP, lagged twice;  
 DDLHMON 2 = the difference in the logarithmic money growth rate, lagged twice;  
 DLRCONS 1 = the lagged value in the logarithm of real consumption expenditure.

The reduced form equations for DUNEM and for DDLPRICE are presented in table 8.1, which also reports some additional statistics for the instrumental

**Table 8.1** Reduced Form and Two-Stage Least Squares (2SLS)

Variable	Coefficient	Standard Error	t-value
A. Reduced Form Estimate for DUNEM <sup>a</sup>			
DPRATE 1	30.86013	13.55965	2.2759
DLRPRF 1	-8.62344	3.33673	-2.5844
DDLPRIC1	-6.02328	5.11099	2.2154
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
B. Reduced Form Estimates for DDLPRICE <sup>b</sup>			
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
C. 2SLS Estimates for DUNEM <sup>c</sup>			
DDLPRICE	-19.50165	5.54802	-3.5151
DPRATE1	42.73199	11.41742	3.7427
DLRPRF1	-10.68548	1.64866	-6.4813

<sup>a</sup>Reduced form  $\sigma = 1.3797980$ ; residual sum of squares = 85.6729126;  $R^2 = .50888$ ;  $F(9,45) = 5.18089$ ; Durbin-Watson statistic = 2.52.

<sup>b</sup>Reduced form  $\sigma = .0246917$ ; residual sum of squares = .0274355;  $R^2 = .67899$ ;  $F(9,45) = 10.57576$ ; Durbin-Watson statistic = 2.01.

<sup>c</sup>Instruments used: DDLPRIC1, DLPRICE1, DLRCONS1, DLHMON1, DDLRGNP1, DDLHMON2, and DDLRGNP2. Residual sum of squares = 77.831906990;  $\sigma = 1.2353606$ ; Durbin-Watson statistic = 2.033; reduced form  $\sigma = 1.37979799$ ; specification  $\chi^2(6)/6 = 1.89$ ;  $\chi^2(3)/3$  testing  $\beta = 0.16.95$ .

**Table 8.2** Comparisons of Two-Stage Least Squares Estimates for Different Sample Periods: One Endogenous and Two Exogenous Variables with Six Instruments

Variable	Coefficient	Standard Error	t-value
A. Period 1944-45 <sup>a</sup>			
DDLPRIC	-32.00162	8.68435	-3.6850
DPRATE1	48.55340	116.41942	.4171
DLRPRF1	-14.88498	2.56745	-5.7976
B. Period 1946-86 <sup>b</sup>			
DDLPRIC	-7.14713	9.70822	-.7362
DPRATE1	39.03005	9.22832	4.2294
DLRPRF1	-6.29407	2.32061	-2.7122
Full Sample Period <sup>c</sup>			
DDLPRIC	-21.59181	7.33891	-2.9421
DPRATE1	42.19304	11.67587	3.6137
DLRPRF1	-11.30842	1.85985	-6.0803

<sup>a</sup>Instruments used: DDDLGRN2, DDLRCON1, DDLHMON2, and DDLPRIC1. Residual sum of squares = 16.157650115;  $\sigma = 1.3398860$ ; Durbin-Watson statistic = 1.763; reduced form  $\sigma = 2.85964940$ ; specification  $\chi^2(3)/3 = .89$ ;  $\chi^2(3)/3$  testing  $\beta = 0$ : 12.47.

<sup>b</sup>Instruments used: DDDLGRN2, DDLRCON1, DDLHMON2, and DDLPRIC1; residual sum of squares = 35.137310873;  $\sigma = .9615956$ ; Durbin-Watson statistic = 2.371; reduced form  $\sigma = .95093673$ ; specification  $\chi^2(3)/3 = 1.70$ ;  $\chi^2(3)/3$  testing  $\beta = 0$ : 7.95.

<sup>c</sup>Instruments used: DDDLGRN2, DDLHMON2, and DDLPRIC1. Residual sum of squares = 76.435856954;  $\sigma = 1.2364130$ ; Durbin-Watson statistic = 2.054; reduced form  $\sigma = 1.48459869$ ; specification  $\chi^2(3)/3 = .24$ ;  $\chi^2(3)/3$  testing  $\beta = 0$ : 15.98.

variable regression. The choice of instruments does not make a great deal of difference to the instrumental-variables 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.

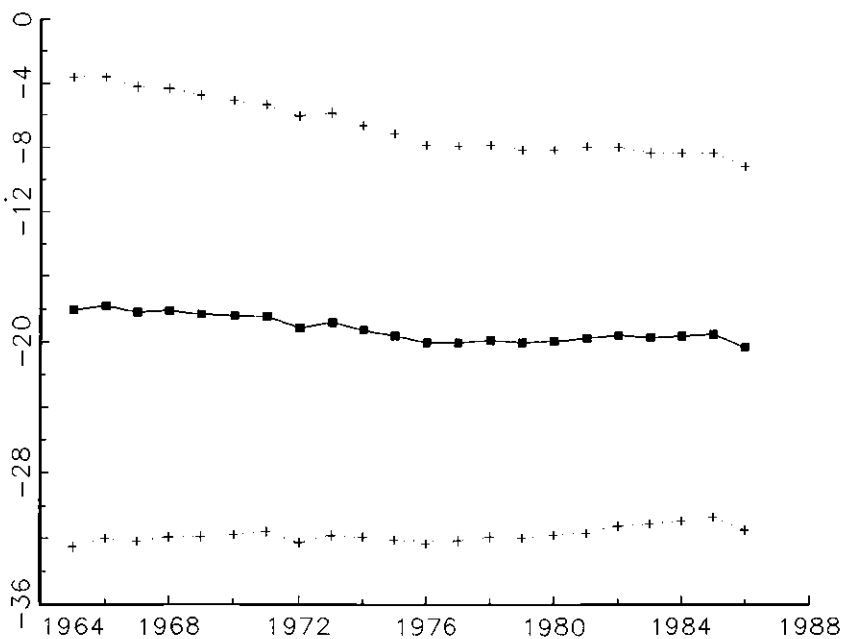
Equation (1) is typical of the results that I obtained using a number of different sample periods and a number of different instrument sets.<sup>11</sup> I have not restricted the coefficient on DDLPRICE to be equal and of opposite sign to the coefficient on DPRATE1, and it is clear from the precision with which these coefficients are 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.<sup>12</sup>

Figure 8.3 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

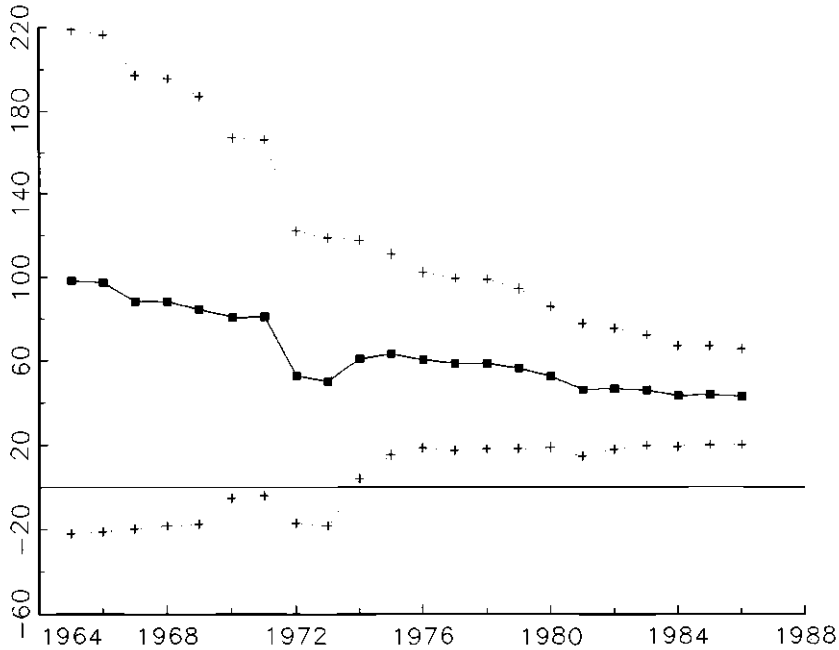


the initial part of the sample period there is a great deal of variability in the inflation rate but not much movement at all in the rate of interest. In the latter part of the sample period this situation is reversed. One might suspect that the data will be unable to identify the coefficient on the interest rate in prewar data and that it will similarly be unable to identify the separate effect of the inflation rate in postwar data. This suspicion is born out in table 8.2 in which I present separate estimates for pre-1945 and postwar samples. Since there are only 12 observations in the pre-1945 sample I was forced to use a restricted instrument set that drops DDLRGNP 1, DLHMON 1, and DLPRICE 1 as a way of increasing the number of degrees of freedom. Table 8.2 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 postwar sample period. Figures 8.5, 8.6, and 8.7 present recursive estimates of the coefficients on the realized inflation rate, on the lagged interest rate, and on profits, for sequential sample periods beginning with the period 1933 to 1964 and ending with the sample period 1933 to 1986. The dashed lines are approximate 5% standard error bounds. As an indication of the stability of this relationship in post-war data, figure 8.8 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



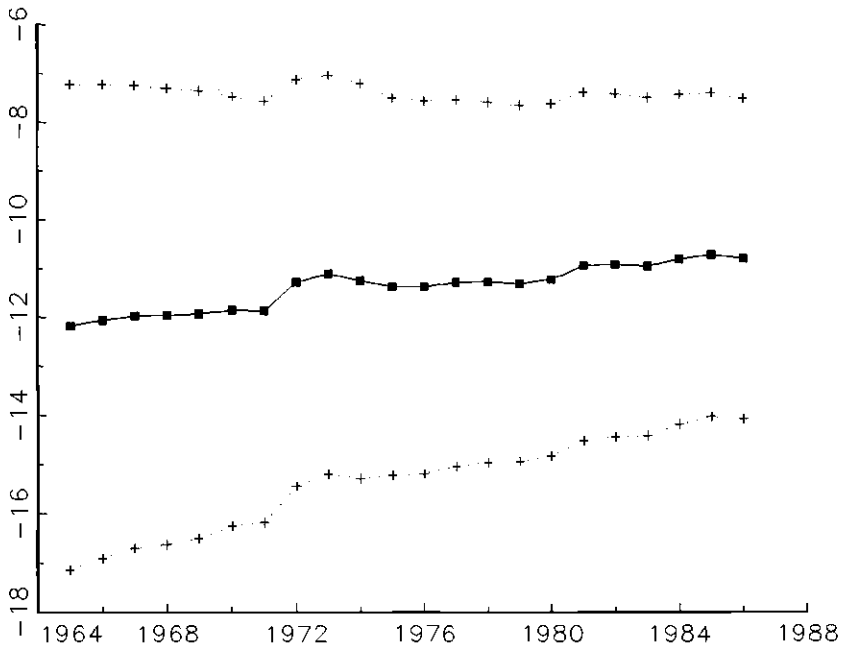
**Fig. 8.5** The coefficient on inflation with two standard-error bounds using a recursive two-stage least squares estimator



**Fig. 8.6** The coefficient on the interest rate with two standard-error bounds using a recursive two-stage least squares estimator

is graphed for the entire sample period. Although there is some evidence of a break between prewar and postwar 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 postwar period.<sup>13</sup>

In section 8.4 of this 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 8.3 reports the outcome of two of these tests. The top panel of the table tests an alternative model in which lagged profits are 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 8.3 presents similar results for a test of the model that replaces lagged



**Fig. 8.7** The coefficient on real profits with two standard-error bounds using a recursive two-stage least squares estimator



**Fig. 8.8** Out-of-sample forecasts

**Table 8.3** Alternative Specifications

A. Test of DUNEM1 vs. DLPRPF1				
Model 1 regresses DUNEM on DDLPRIC, DPRATE1, and DLPRPF1; model 2 regresses DUNEM on DDLPRIC, DPRATE1, and DUNEM1; both regressions use the instruments: DPRATE1, DLPRPF1, DDLPRIC1, DLPRICE1, DLRCONS1, DLHMON1, DDLRGNP1, DDLHMON2, DDLRGNP2, and DUNEM1.				
Model 1 vs. Model 2	Form	Test	Form	Model 2 vs. Model 1
-.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	$F[1,50]$	Critical values	$F[1,50]$	4.034
B. Test of DLRCMP1 vs. DLPRPF1				
Model 1 regresses DUNEM on DDLPRIC, DPRATE1, and DLPRPF1; model 2 regresses DUNEM on DDLPRIC, DPRATE1, and DLPRPF1; both regressions use the instruments: DPRATE1, DLPRPF1, DDLPRIC1, DLPRICE1, DLRCONS1, DLHMON1, DDLRGNP1, DDLHMON2, DDLRGNP2, and DLRCMP1.				
Model 1 vs. Model 2	Form	Test	Form	Model 2 vs. Model 1
.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	$F[1,50]$	Critical values	$F[1,50]$	4.034

Note: Part A tests whether lagged unemployment is a better explanatory variable than lagged profits. Part B tests if lagged real compensation to employees is better. Both tests overwhelmingly pick lagged profits over the alternative.

profits with the lagged value of compensation to employees. This model is again overwhelmingly rejected in favor of the AIL specification.

## 8.8 Conclusion

I hope to have persuaded the reader that the statistical evidence that I have presented lends qualified support to AIL theories of aggregate supply and that these theories offer a more promising research agenda for macroeconomics than the Phelps-Friedman alternative. In concluding I should add that if this view is correct it follows that expectational surprises play, at best, a secondary role in the business cycle. One is left with a view of the transmission mechanism, from policy to output, that occurs through the effects of intertemporal relative prices. According to this view, fiscal and monetary policy can affect the level of economic activity in the long run if and only if these policies can influence real and nominal rates of interest. There is little doubt that the money rate of interest is free to be chosen in a fiat money economy and, in this sense, the nonsupremacy of money that I have described above is

likely to prove uncontroversial. One may reasonably argue that these kinds of nonsuperneutralities are likely to be unimportant in practice, but this is a matter that is at least potentially capable of being decided by the evidence.

The ability of policy to influence the real rate of interest is a different matter. There are skeptics who will point to both theoretical and empirical reasons for doubting that this theory will provide a successful explanation of the transmission mechanism. On the empirical side, the real rate of interest in the postwar United States seems to be quite well described by a first-order autoregressive process and it does not seem to be Granger caused by any other economic time series.<sup>14</sup> On the theoretical side, if one works within the representative agent paradigm, then one would not expect that fiscal policy could influence the real rate of return in the long run. But this is not the only possible interpretation of the facts and the representative agent paradigm is not the only framework that one might use to organize the data. The overlapping generations model is an equally useful framework and, within this structure, one would predict that fiscal policy can have permanent long run effects on the rate at which agents can make intertemporal trades. From the overlapping generations perspective, the finding that fiscal policy does not Granger cause the real rate of interest represents evidence of a highly elastic aggregate supply curve.<sup>15</sup>

In any event, these issues will not be decided by the evidence that I have presented in this paper: they require a more fully specified theoretical model and a more complete simultaneous equations approach to the data: there is still much work to be done. In 1958, 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." Thirty years of intensive theoretical and applied work does not seem to have brought us much closer to a resolution.

## Notes

1. Some of the more recent approaches to contract theory combine asymmetric information with an insurance based approach. The *Quarterly Journal of Economics* supplement (98:1983) edited by Costas Azariadis and Joseph 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. But ALL theories require the *additional* assumption of limited collateral.

2. Roger E. A. Farmer (1984); also (1988a) which discusses the effect of nominal interest rates on aggregate supply in a general equilibrium model.

3. It should be pointed out that the implications of AIL-based theories of aggregate supply are distinct from New-Classical intertemporal-substitution (ITS) theories, which also stress the role of real interest rates. In ITS theories, agents supply more labor today if the currently anticipated real rate of interest is high. In contrast, AIL 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. Thus AIL 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 AIL theories are seen as second-order effects. Section 8.5 discusses the indexation issue in more depth.

4. Sims (1980) documents this assertion for small vector autoregressions. Evidence for the effect of nominal interest rates after correcting for anticipated inflation is found in Litterman and Weiss (1985).

5. See, e.g., the paper by Blanchard and Summers (1986). 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.

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 Myerson (1979).

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 AIL 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 Treasury-bill rate. It 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,b) discuss this issue in more depth and provide evidence of the relationship between loan rates and deposit rates for postwar U.S. time-series data.

8. I am grateful to Glenn Hubbard for drawing my attention to this issue. At the present time an approach that integrates theory and data with the same degree of precision as real business cycle theory is beyond our grasp. Economies with informational perfections of the kind that I describe in this paper cannot be described as solutions to a planner's problem and one cannot, therefore, exploit the second welfare theorem and reduce the equilibrium of such an economy to a representative agent problem.

9. See 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.

10. All regressions were run using David Hendry's program GIVE.

11. The residuals of the regression do not show evidence of autocorrelation, although I did find evidence of heteroscedasticity and they do not pass tests for normality. There is no evidence of ARCH effects. There is some evidence of misspecification 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.

12. Since there is some reason to believe that the methods of data collection differ between prewar and postwar samples (see 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.

13. There is no evidence of a structural break in the data at any point beyond 1947. The pre-1946 and postwar 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 wartime price controls. If 1946 is included in the postwar sample, it dramatically reduces (in absolute value) the magnitude of the postwar inflation coefficient. If 1946 is excluded from the postwar data, the effect of inflation in the postwar sample is much closer to the pre-1946 value, although it is still estimated very imprecisely.

14. See Litterman and Weiss (1985).

15. There are also open economy issues that I have not touched on. For example, it may well be that, in addition to real rates of return, policy may affect unemployment through effects on relative prices of domestic versus foreign goods. By changing fiscal policy, the government may induce a transition to a new equilibrium relative price. During the transition, the effective real rate of interest will fluctuate. This offers a possible channel by which fiscal policy may alter output in the short run even if the long-run rate of return is pegged by the world rate.

## References

- Azariadis, Costas and Joseph E. Stiglitz, eds. 1983. *Quarterly Journal of Economics*, suppl., vol. 98.
- Blanchard, Olivier, and Lawrence H. Summers. 1986. Hysteresis and the European unemployment problem. In *NBER macroeconomics annual 1986*, ed. S. Fischer. Cambridge, Mass.: MIT Press.
- Bernanke, Ben, and Mark Gertler. 1987. Banking and Macroeconomic equilibrium. In *New approaches to monetary economics*, ed. William A. Barnett and K. Singleton. New York: Cambridge University Press.
- Dickey, J. A., and W. A. Fuller. 1981. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* 49:1057-72.
- Farmer, Roger E. A. 1984. A new theory of aggregate supply. *American Economic Review* 74, no. 5 (December):920-30.
- . 1988a. Money and contracts. *Review of Economic Studies* 55:431-46.
- . 1988b. What is a liquidity crisis. *Journal of Economic Theory* 46(1): 1-15.
- Fazzari, Stephen, Glenn Hubbard, and Bruce Petersen. 1987. Financing constraints and corporate investment. Mimeograph. Northwestern University.
- Gertler, Mark. 1988. Financial structure and aggregate economic activity: An overview. *Journal of Money Credit and Banking*, vol. 20, pt. 2 (August): 559-88.
- Greenwald, Bruce, and Joseph E. Stiglitz. 1986. Information, finance constraints, and business fluctuations. Mimeograph. Princeton University.
- Greenwald, Bruce, Joseph E. Stiglitz, and Andrew Weiss. 1984. Informational imperfections in the capital market and macroeconomic fluctuations. *American Economic Review* 74:194-200.
- Litterman, Robert B., and Laurence Weiss. 1985. Money real interest rates, and output: A reinterpretation of postwar U.S. data. *Econometrica* 52, no. 1 (January):129-56.
- Myerson, Roger. 1979. Incentive compatibility and the bargaining problem. *Econometrica* 47:61-74.
- Phillips, A. W. 1958. The relationship between unemployment and the rate of change of money wage rates in the United Kingdom, 1861-1957. *Economica*, n.s., 25 (November):283-99.

- Romer, Christina. 1986. Spurious volatility in historical unemployment data. *Journal of Political Economy* 94, no. 1 (February):1-37.
- Sargan, J. D., and Alok Bhargava. 1983. Testing residuals from least squares regression for being generated by the Gaussian random walk. *Econometrica* 51, no. 1 (January):153-74.
- Sims, C. A. 1980. Comparison of interwar and postwar cycles: Montarism reconsidered. *American Economic Review* 70:250-57.
- Smith, Bruce. 1983. Limited information, credit rationing, and government lending policy. *American Economic Review* 73:305-18.
- Stiglitz, Joseph, and Andrew Weiss. 1981. Credit rationing in markets with imperfect information. *American Economic Review* 71:393-410.
- Williamson, Stephen. 1986. Costly monitoring, financial intermediation, and equilibrium credit rationing. *Journal of Monetary Economics* 18:159-79.



