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by

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ABSTRACT

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The purpose of this study is first to investigate the effects of inflation on the level of economic uncertainty, and second to determine whether inflation-induced uncertainty affects output growth and unemployment. Inflation's real effects are assumed to flow through the supply side of the model by increasing the level of uncertainty felt by producers regarding their future profits. Increased uncertainty about profits causes future output to fall below its trend level because of reduced investment or, at least, productivity-reducing alterations in the types of investments made.

I rest the hypothesis that higher inflation results in increased profit uncertainty in two ways. First, I test whether inflation increases the level of uncertainty in forecasting future inflation (thought to be one of the major sources of profit uncertainty). I use two proxies for inflation uncertainty: the variance of estimates of inflation forecast errors and the degree to which contracts are "indexed". The results vary according to the proxy used, but a fairly

weak positive relationship is found in some of the tests. Second, I test the hypothesis that inflation increases the dispersion of corporate profits across industries. I find a positive effect of lagged unexpected inflation on profit dispersion but no positive effect of expected inflation.

In estimating output growth and unemployment equations using two stage least squares regression, I find no effect of inflation-induced uncertainty, a finding that contrasts with much recent empirical research. This discrepancy can be attributed to my inclusion of the effects of energy-related supply shocks, a previously omitted factor, in the analysis.

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CHAPTER I

INTRODUCTION

Events of the last decade have caused many economists to reconsider the relationships between inflation and the level of economic activity and rate of unemployment. Neither of what were the two prevailing notions regarding the Phillips Curve, the long run "tradeoff" view or the "natural rate" hypothesis, can explain the periods of high and rising inflation and unemployment experienced by several industrialized countries in the 1970s. The "tradeoff view" is that policymakers can exploit an inverse relationship between inflation and unemployment both in the short and long run. The "natural rate" hypothesis states that a tradeoff exists only in the short run while the economy tends toward a natural rate of unemployment, irrespective of the rate of inflation, in the long run. A third view of the Phillips Curve has its origins in Milton Friedman's (1977) Nobel Lecture and arises from the observed "stagflation" of the 1970s: higher inflation leads to greater unemployment and a reduced level of economic activity because it results in a greater level of economic uncertainty that causes misallocation of resources. This relationship would hold until the economy adjusts fully to higher inflation (Friedman suggests this might take decades).

Friedman recognizes, however, that stagflation may have been caused not by inflation-induced uncertainty, but by supply shocks, especially those caused by rapid energy price increases:

> "Whatever effect the (oil) crisis had on the rate of inflation, it directly disrupted the productive process and tended to increase unemployment. Any such increase can hardly be attributed to the acceleration of inflation that accompanied them,...," (p. 463).

The purposes of this study are, first, to investigate the effects of inflation on the level of economic uncertainty and, second, to determine whether inflation-induced uncertainty affects economic activity when the effects of energy price shocks are taken into account. This issue is extremely important for the conduct of monetary and fiscal policy. If today's inflation implies a cost in terms of reduced output and higher unemployment in later periods, then anti-inflationary policies are of paramount importance.

My approach is to construct and test a simple macroeconomic model consistent with the notion that both inflation-induced uncertainty and energy-related supply shocks affect real output growth and unemployment. In the model, inflation affects the level of economic uncertainty for producers and consumers in two ways: (1) inflation coupled with differing degrees of price flexibility across industries creates greater uncertainty about relative prices, and (2) higher inflation increases uncertainty about the future direction of government policy and adds to the difficulty in forecasting future inflation. The magnitude of the effect depends upon the economy's institutional structure for dealing with inflation and the degree to which the inflation is anticipated. Real effects arise because the greater risk associated with long term commitments and the increased use of resources for search activities and transactions creates distortions in markets. The ability of the price system to allocate resources is inhibited, and the resulting misallocations may have detrimental effects on output growth and unemployment. However, in the short run, unanticipated inflation has an expansionary effect on output, and there is a tradeoff between unanticipated inflation and unemployment.

The effects of energy price shocks operate by altering the relative prices and the optimal mix of factors of production. An increase in the price of the energy input relative to other inputs results in a productivity loss as relatively energy-intensive production processes become obsolete and changes in production methods occur. It is also possible, however, that the real effects of energy price shocks arise because of increased uncertainty resulting from the turmoil created by drastic increases in the price of such an important commodity and confusion over the effects of the policy response.

In Chapter II, I present the model along with a discussion of relevant theoretical literature. Inflation's real effects flow through the supply side of the model by increasing the level of uncertainty felt by producers regarding their future profits. Increased uncertainty about profits causes future output to fall below its trend level because of reduced investment or, at least, productivity-reducing alterations in the types of investments made.

The model is tested and empirical evidence from other research is reviewed in Chapters III through V. Chapter III provides two tests of the hypothesis that higher inflation increases the uncertainty in forecasting future inflation. The first is based on the variance of estimates of inflation forecast errors and the second on the degree of "indexation" of contracts in the economy. The results vary according to the proxy used for inflation uncertainty and the price index used, but a fairly weak positive relationship is found in some of the tests.

In Chapter IV, I test the hypothesis that a positive relationship exists between inflation and the dispersion of corporate profits across industries under the assumption that profit dispersion is an indicator of profit uncertainty. I find a positive effect of lagged unexpected inflation on profit dispersion but no positive impact of expected inflation.

Chapter V presents estimates of output growth and unemployment equations using two-stage least squares regressions to account for the impact of inflation-induced uncertainty. Despite the use of several proxies for profit uncertainty, no uncertainty variable has a significant impact on either output or unemployment growth when the relative price of energy is included in the equations. Only when energy price variables are omitted from the analysis does uncertainty have the significant negative effect on output growth and positive effect on unemployment found by some other researchers.

I present conclusions and discuss policy implications in Chapter VI.

The major contributions of this dissertation lie both in its approach to the issue and in its conclusions. This study presents a framework for investigating the relationship between inflation-induced uncertainty and economic activity in which the key element is the role of uncertainty regarding a producer's future profits. The empirical analysis of the inflation-uncertainty relationship points out the difficulties in estimating the level of uncertainty in forecasting inflation and the sensitivity of one's results to the methods used. The most important contribution, however, is the finding that despite some indications that inflation is positively related (at least to some degree) to the level of economic uncertainty, there is no significant impact on output growth or unemployment. The evidence suggests that the link found by other researchers reflects an omitted factor, the energy-related supply shocks of the 1970s.

CHAPTER II

THE POTENTIAL REAL EFFECTS OF INFLATION

> "Prolonged and intense inflation upsets many habits of economic life, confronting consumers with price increases and price dispersions that send them shopping; making them doubt their ability to maintain their living standards, and downgrade the value of their career jobs and long-term savings; and forcing them to compile more information and to try to predict the future--costly and risky activities that they are poorly qualified to execute and bound to view with anxiety."
>
> - Arthur M. Okun, "Inflation: Its Mechanics and Welfare Costs", Brookings Papers on Economic Activity 1975(2), p. 383.

2.1 - Introduction

Economic theory has traditionally held that the welfare cost of anticipated inflation arises because people hold lower real money balances then they would desire if there were no inflation[1], and the costs of unanticipated inflation result from redistributions of income and wealth (i.e., there is no net welfare cost to society). It has also been recognized that institutional factors such as tax policies and accounting practices can cause inflation to have real effects on the economy. However, many economists now believe that costs arising from these sources are minor compared to those that would arise if inflation results in a substantial increase in the level of economic uncertainty. The most important cost of this inflation-induced uncertainty may be the loss of output resulting from resource misallocation and the increased risk associated with long-term projects.

In the next two sections of this chapter, I review some of the literature on the potential relationship between inflation and uncertainty and the implications for economic activity. Section 2.2 deals with the inflation-uncertainty nexus looking, first, at the effects of price level changes on uncertainty about relative prices and wages and individual business profits and, second, at uncertainty regarding future government policy in an inflationary economy. Section 2.3 looks at the potential effects of inflation-induced uncertainty on investment, output growth, and unemployment. In Section 2.4 I present a framework for testing some of the propositions put forth in the first two sections.

2.2 - Inflation and Uncertainty

A. Uncertainty Regarding Profits and Relative Prices and Wages

It has long been known that for competitive industries relative prices are affected by changes in the money supply if supply and demand elasticities differ across markets. Recent theoretical work has emphasized certain aspects of noncompetitive markets--costs of adjusting prices and long-term contracts--as factors influencing the responses of individual prices to price level changes (or money supply changes). Sheshinski and Weiss (1977) show that, for a firm that faces a fixed real cost for each price change, increases in the rate of inflation affect the magnitude and frequency of price changes and the firm's real profit. Higher expected inflation (1) increases the magnitude of price change, (2) has an ambiguous effect on the frequency of price change, and (3) reduces the real profit (assuming that costs of production increase at the same rate as the aggregate price level). If the cost of a price change rises, the magnitude of each change increases, but the frequency of change decreases. Though they do not incorporate unanticipated inflation in their model, they do point out that the costs of price adjustment should be higher if inflation is unanticipated than if it is anticipated (e.g., it becomes more difficult to follow simple price adjustment "rules").

Gray (1978) and Bordo (1980) look at differing degrees of price and wage flexibility across industries in the light of differences in contract lengths rather than costs of price adjustment. Gray also considers the role of indexation of wages. Both articles have essentially the same conclusion regarding long-term wage and price contracts: for a given degree of indexing, the length of contracts in an industry depends on the variability of the industry's relative prices and the costs involved in negotiating a contract (transactions costs); higher variance leads to shorter contracts which lead to increased price flexibility.

Furthermore, as Gray points out, greater uncertainty about inflation increases the degree of indexing in the economy.

In a world where the costs of adjusting prices, the average length of contracts, and the degree of indexing in contracts vary across industries, individual prices and wages will adjust at different rates to inflation (or deflation). The result would be greater dispersion of relative prices and wages than would have occurred with a constant aggregate price level, and this could affect business profits. To see this, assume that individual prices are determined by a process such as:

$$p_i = p^e + \gamma_i(p-p^e) + \lambda x_i$$

where p_i is the price of commodity i, p^e is the expected price level, x_i is the rate of change of excess demand for the i^{th} commodity, and γ and λ are parameters. Differential adjustment of individual prices to unexpected price level changes is reflected in the fact that γ is indexed by i. Then

$$\text{var }(p_i) = \text{var } \gamma_i \ (p-p^e)^2 + \lambda^2 \text{ var } x_i \ ,$$

i.e., unexpected price level changes cause increased variance of relative prices. If there are differences in the way individual prices adjust to expected price changes, the same argument can be made. An analogous argument can also be made for the variance of wages.

In general, unexpected changes in price level should have a greater effect on price and wage dispersion than expected changes, since firms can plan their price and wage policies according to their price level expectations. However, expected changes can affect dispersion if there are (1) nonzero costs of price adjustment even with perfect foresight, (2) contracts still in effect from before expectations of price level changes were formed, or (3) less than perfect indexation of incomes.[2] An unexpected reduction in the inflation rate could also result in greater dispersion if contracts and pricing mechanisms are based on a higher rate.

In any event, the precise effects of price level changes on relative prices and wages and on profits should be quite unpredictable, and a greater level of economic uncertainty could be the result.

B. Uncertainty Regarding Future Government Policy

Another potential source of inflation-induced uncertainty is the effect high inflation rates have on uncertainty about government policy actions. In the U.S. alone, one can isolate several fairly drastic measures taken in recent years at least partly in response to an inflationary economy: tax policy changes, deregulation of financial institutions, wage and price controls, and the Federal Reserve Board's announced change from interest rate to reserve aggregate targeting.

Several authors have discussed this aspect of inflation. Okun (1971) states that the application of fiscal and monetary policy is apt to be less consistent during inflationary times because of the difficulty in reducing inflation without causing unacceptably high rates of unemployment and interest. The result is greater difficulty in predicting the future course of all of these variables. Friedman (1977, p. 466) agrees:

> "A burst of inflation produces strong pressure to counter it. Policy goes from one direction to the other, encouraging wide variation in the actual and anticipated rate of inflation. And, of course, in such an environment, no one has single-valued anticipations. Everyone recognizes that there is great uncertainty about what actual inflation will turn out to be over any specific future interval."

In a similar vein, Flemming (1976, p. 104) states that:

> "...with inflation at 20 per cent p.a. talk of bringing it down to 'below 10 per cent in two years' is quite common. On the other hand, people are very sceptical of such claims; if they know that inflation tends to accelerate they may consider that it will rise to 30 per cent equally likely..."

It seems reasonable to expect that unexpected inflation would lead to greater anti-inflation sentiment than expected inflation, but exactly how this would affect uncertainty about government policy is unclear. It could actually make the public more certain that anti-inflationary measures will be followed. Similarly, the effect of an unexpected reduction in inflation is difficult to predict in advance.

The conclusion is that macroeconomic variables--especially inflation rates--should be harder to predict during inflationary times than in times of constant (or even possibly falling) prices because of uncertainty regarding the direction of government policy.

2.3 - Inflation-Induced Uncertainty and Economic Activity

A. Effects on Investment

In traditional theory, inflation leads to a shift in the demand for real goods (including capital) relative to money and a potentially positive effect on investment. However, when the effect of inflation uncertainty is considered, the result could well be the opposite. A recent article by Friend, Landskroner, and Losq (1978) shows how uncertain inflation affects the Capital Asset Pricing Model (CAPM). The traditional CAPM says that,

$$E(r_i) = r_f + \left(\frac{E(r_m - r_f)}{\sigma_m^2}\right) \sigma_{im}$$

where r_i = the rate of return on asset i,

r_f = the rate of return on risk-free assets,

r_m = the rate of return on the market portfolio,

σ_m^2 = the variance of the market rate of return,

σ_{im} = the covariance of the returns on asset i and the market portfolio,

E = the expectations operator.

The term in brackets is the "market price of risk" (MPR) and is common to all assets. They show that if there is uncertainty about inflation and positive covariance between the rate of inflation π and the market rate of return, this formulation understates the MPR. In other words, the rate of return on risky assets must rise relative to the rate of return on risk-free assets or else the demand for risky assets will fall relative to the demand for risk-free assets.[3] However, for a particular asset, the degree of risk and the required rate of return will depend on the covariance between the rate of inflation and the rate of return on the asset. If $\rho_{i\pi} < \rho_{\pi m}\, \rho_{im}$ (where $\rho_{i\pi}$ is the correlation between the return on asset i and the inflation rate π, and the other two are correlation coefficients defined similarly), the CAPM understates the required return on asset i. Therefore, inflation's effect on the demand for a risky asset depends on the responsiveness of its rate of return to inflation.

Many economists including Nelson (1976) and Able (1980) take the view that uncertain inflation leads to reduced overall capital investment because of the increased risk that results. One can certainly make a case that, even if aggregate investment does not fall, resource misallocation could result because the types of investments made will be affected. In particular, a reduction in long-term relative to short-term investment is likely.

B. Effect on Output Growth and Unemployment

The most well-known discussion of inflation's potential effect on uncertainty, growth, and unemployment is Friedman's (1977) Nobel lecture in which he suggests the possibility of a positively sloped Phillips Curve. After discussing inflation's effects on the volatility of inflation and government policy changes, he suggests that until an economy's institutions adjust fully to inflation, inefficiency of the price system and shortened average contract length may cause slower growth and more unemployment:

> "Just as the natural-rate hypothesis explains a negatively sloped Phillips curve over short periods as a temporary phenomenon that will disappear as economic agents adjust their expectations to reality, so a positively-sloped Phillips curve over somewhat longer periods may occur as a transitional phenomenon that will disappear as economic agents adjust not only their expectations but their institutional and political arrangements to a new reality." (p. 464).

He does, however, recognize that reduced efficiency in the economy does not necessarily result in increased unemployment:

> "High average inventories of all kinds are one way to meet increased rigidity and uncertainty. But that may mean labor hoarding by enterprises and low unemployment or a larger force of workers between jobs and so high unemployment. Shorter commitments may mean more rapid adjustment of employment to changed conditions and so low unemployment, or the delay in adjusting the length of commitments may lead to less satisfactory adjustment and so high unemployment." (p. 466).

Other authors including Okun (1975), Ackley (1978), and Fischer and Modigliani (1978) have discussed in detail the potentially far-reaching real effects of inflation. According to Ackley (p. 151):

> "All income redistributions, whether among classes or individuals, increase personal insecurity and lessen personal satisfactions (even on the part of the beneficiaries) and heighten interpersonal and

> institutional tensions. Thus they are destructive of the social and political fabric, and ultimately of economic efficiency...A significant real cost of inflation is thus what it does to morale, to social coherence, and to people's attitudes toward each other."

These authors also discuss other problems caused by inflation-induced uncertainty that, in principle, could result in reduced economic growth. For instance, resources are wasted if managerial talent is used to seek protection from inflation, if the usefulness of market information is reduced by inflation, (i.e., an increased amount of search activity is required), or if inflation results in more frequent negotiation of contracts. Furthermore, inflation's effects on capital investment may reduce the productivity of other factors of production.

In the next section, I develop a simple macroeconomic model consistent with the notion that inflation induces higher levels of economic uncertainty and, thereby, leads to lower rates of economic growth and, possibly, higher rates of unemployment.

2.4 - A Macroeconomic Model

From the discussion above, it is clear that there is fairly widespread feeling among economists that inflation leads to greater economic uncertainty for decision-makers, because higher inflation is associated with greater uncertainty about business profits, relative prices and wages, and about future inflation. This could well mean that inflation causes reduced output growth and greater unemployment over the fairly long term. The magnitude of inflation's real effects should depend on the degree to which inflation is anticipated and on the institutional arrangements for dealing with inflation (e.g., tax laws and accounting practices).

In this section I build a simple framework for testing whether output growth and unemployment are affected by inflation-induced uncertainty. I do not, however, deal with the impact of institutional changes on this relationship. The framework is consistent with that used in other research, except that it incorporates the influences of changes in the relative cost of energy inputs on output growth and unemployment.

I assume that consumer uncertainty affects the relative demands for products and causes uncertainty about individual business profits, which over the long term reduces aggregate supply. I expect aggregate demand effects (such as a higher marginal propensity to save in the face of greater uncertainty) to be relatively minor, so they are omitted from the analysis. In other words, the effects of uncertainty are treated as strictly a supply side phenomenon. This assumption is made so that the tests performed will be directly comparable to previous research which ignores aggregate demand effects.

A. Aggregate Supply

The starting point for the model is the aggregate supply function of Lucas (1973) which is based on the following assumptions: (1) business firms are located in a large number of scattered, competitive markets, (2) the demand for goods is distributed unevenly over these markets, leading to relative as well as aggregate price changes, and (3) rational agents cannot perfectly distinguish relative from general price movements. The implication is that a supplier views a greater than expected increase in the price of his product as an increase in its relative price, and this results in increased supply of the product. Aggregating over all producers implies a positively sloped aggregate supply curve given the expected price level (i.e., an unexpected increase in the price level results in an expansion of output). Lucas also assumes that the higher is the variance of the price level the less output responds to a given unexpected price level change. This assumption, however, is not incorporated in the model presented below.

The Lucas aggregate supply function can be written:

$$(2.1)\quad y_t = y_{nt} + \alpha_1(p_t - p_t^e|\omega_{t-1}) + \lambda(y_{t-1} - y_{n,t-1})$$

where

y_t = the log of output for period t,

p_t = the log of the price level for period t,

$p_t^e|\omega_{t-1}$ = the log of the price level expected for period t based on the information set ω_{t-1}, and y_{nt} is the secular component reflecting change in the capital stock and population. This component follows the trend line:

$$(2.2) \quad y_{nt} = \alpha_0 + \beta_0 t.$$

For simplicity, I assume that $\lambda = 1$ in equation (2.1), and I state the price level in terms of its log difference[4]. I also add an error term, v_t^s, so that (2.1) and (2.2) become:

$$(2.3) \quad \hat{y}_t = \hat{y}_{nt} + \alpha_1(\hat{p}_t - \hat{p}_t^e | \omega_{t-1}) + v_t^s,$$

$$(2.4) \quad \hat{y}_{nt} = \alpha_0$$

where "^" signifies the first difference. Combining the two equations yields:

$$(2.5) \quad \hat{y}_t = \alpha_0 + \alpha_1(\hat{p}_t - \hat{p}_t^e | \omega_{t-1}) + v_t^s \ .$$

I modify Lucas's supply function in three ways: (1) firms may belong to noncompetitive markets so that costs of price adjustment and long-term contracts are possible, (2) changes in the relative price of energy can affect aggregate supply, and (3) uncertainty about business profits can affect future growth. The first modification relaxes Lucas's assumption of competitive markets, but the essential form of the supply function should not change if some firms are not price takers but, instead, have costs of making price adjustments. With price stickiness, a greater than expected increase in aggregate demand will result in less inflation in the short term than there would be otherwise, but the aggregate supply curve would still be positively sloped. Since long-term contracts are just another form of price stickiness, their existence would also not affect the form of the equation.

The second change is to incorporate the effects of changes in the relative price of energy inputs. Rasche and Tatom (1977) show that increases in the relative price of energy can result in changes in the optimal mix of energy and other factors of production, and this can cause a reduction in the productivity of other factors and reduced growth of economic capacity. Since the capacity output for a firm is that which minimizes average cost given a quantity of fixed resources, increases in the relative price of a variable input such as energy affect the capacity output by increasing average cost. Short run supply is also affected because of a higher short run marginal cost. The degree to which these variables are affected depends upon the share of the variable input in total cost. Rasche and Tatom find that rising relative prices of energy inputs in the 1970s resulted in a permanent reduction in potential output, and Tatom (1981) also finds short term reductions in output growth and increases in unemployment.[5]

To account for this potential effect on aggregate supply, I follow Tatom and include lagged values of the change in the price of energy ($\hat{c}_t$) relative to the change in the aggregate price level ($\hat{p}_t$) in the equation:

$$(2.6)\quad \hat{y}_t = \alpha_0 + \alpha_1(\hat{p}_t - \hat{p}_t^e | \omega_{t-1}) + \sum_{j=1}^{n} \beta_j(\hat{c}_{t-j} - \hat{p}_{t-j}) + v_t^s .$$

The current value is not included since the effect on production techniques is expected to occur with a lag.

The third modification of the Lucas equation is to account for the effects of uncertainty on aggregate supply. I assume that firms are profit maximizers, so only uncertainty about profits matters. To be specific, the important variable is the aggregate of the uncertainty felt by each individual producer about his or her future profits, not the uncertainty regarding aggregate business profit.

The effect on output growth of an increase in profit uncertainty arises as a result of the increased risk associated with long term commitments. (I assume that producers are risk averse.) If greater uncertainty causes reduced investment, the amount of capital falls relative to the amount of other inputs and results in reduced productivity of other inputs. If uncertainty merely alters the types of investments made without reducing aggregate investment, it would alter the relative amounts of different types of capital in the production process and might still cause reduced overall productivity. As with the increasing relative price of energy, reductions in economic capacity and short-run supply (once the effects on production methods have been felt) would result.

Therefore, the aggregate supply equation now becomes:

$$(2.7)\quad \hat{y}_t = \alpha_0 + \alpha_1(\hat{p}_t - \hat{p}_t^{\,e}|\omega_{t-1}) + \sum_{j=1}^{n} \beta_j(\hat{c}_{t-j} - \hat{p}_{t-j})$$
$$+ \sum_{i=1}^{n} \phi_i \; R_t|\Psi_{t-i} + v_t^{\,s} \;,$$

where

$R_t|\Psi_{t-i}$ = the aggregate of the uncertainty felt by individual producers about their profits in period t based on an information set Ψ_{t-i}.

Since a single period's growth may depend on long-term commitments made in the past, period t growth depends on the uncertainty felt in previous periods. Three assumptions help to simplify the analysis: (1) only the arrival of new information changes R, and this occurs only once each time period, (2) a change in R_t implies a proportionate change in R for every other period in the future (i.e., greater short-term uncertainty implies greater long-term uncertainty and vice versa), and (3) R is greater the farther into the future one predicts. The second assumption enables me to ignore the possibility that uncertainty about profits in periods other than t affects output growth in period t in equation (2.5).

B. Uncertainty About Business Profits

To incorporate the hypothesis that uncertainty about period t profits given information from period t-i, $R_t|\Psi_{t-i}$, depends upon expected and unexpected inflation occurring during and prior to period t-i, I let i = 1 and include in the model the equation:

$$(2.8) \quad R_t|\Psi_{t-1} = f[\theta(B)\hat{p}_t^e|\omega_{t-1},\ \eta(B)(\hat{p}_{t-1}-p_{t-1}^e|\omega_{t-2}),\ \varepsilon_t]$$

where $\theta(B)$ and $\eta(B)$ are polynomials in the lag operator B and ε is a random component. A relationship of the same general form exists if $i > 1$. However, because of assumption (2) above, I need not include these additional equations in the model. As discussed above, inflation's effect on uncertainty about individual business profits arises as a result of its effects on uncertainty about relative prices and wages, government policy actions, future inflation, and the rates of return on investments.

I assume for simplicity that the error term ε in (2.8) is additive and that:

$$(2.9) \quad \varepsilon_t = \delta + v_t^R ,$$

where δ is a constant and v_t^R has a normal distribution with zero mean and constant variance. I can, therefore, rewrite (2.8) as:

$$(2.10) \quad R_t|\Psi_{t-1} = \delta + F[\theta(B)\hat{p}_t^e|\omega_{t-1},\ \eta(B)(\hat{p}_{t-1}-\hat{p}_{t-1}^e|\omega_{t-2})] + v_t^R .$$

C. Aggregate Demand

Turning to the demand side of the model, I include the equation:

$$(2.11) \quad \hat{y}_t = \alpha_2 + \alpha_3(\hat{M}_t-\hat{p}_t) + v_t^d$$

where M is the log of the money stock. Increases in money growth have the same effect on aggregate demand as reductions in the inflation rate, i.e., only real money growth affects aggregate demand.

D. Unemployment

I attempt to deal with unemployment in the simplest way possible; allowing reduced output growth, $\hat{y}$, to increase unemployment growth, $\hat{u}$:

$$(2.12)\quad \hat{u}_t = \alpha_4 + \alpha_5 \hat{y}_t + v_t^u .$$

E. Expected Inflation

The rate of inflation expected over the course of period t is determined rationally based upon the information set, ω_{t-1}:

$$(2.13)\quad \hat{p}_t^e | \omega_{t-1} = E(\hat{p}_t | \omega_{t-1}) .$$

F. Summary

The model has five structural equations:

(1) aggregate supply:

$$(2.7)\quad \hat{y}_t = \alpha_0 + \alpha_1(\hat{p}_t - \hat{p}_t^e | \omega_{t-1}) + \sum_{j=1}^{n} \beta_j (\hat{c}_{t-j} - \hat{p}_{t-j}) + \sum_{i=1}^{n} \phi_i R_t \Psi_{t-i} + v_t^s ,$$

(2) uncertainty about business profits:

$$(2.10)\quad R_t | \Psi_{t-1} = \delta + F[\theta(B)\hat{p}_t^e | \omega_{t-1}, \eta(B)(\hat{p}_{t-1} - \hat{p}_{t-1}^e | \omega_{t-2}] + v_t^R ,$$

(3) aggregate demand:

$$(2.11)\quad \hat{y}_t = \alpha_2 + \alpha_3(\hat{M}_t - \hat{p}_t) + v_t^d ,$$

(4) unemployment:

$$(2.12)\quad \hat{u}_t = \alpha_4 + \alpha_5 \hat{y}_t + v_t^u ,$$

(5) expected inflation:

$$(2.13)\quad \hat{p}_t^e|\omega_{t-1} = E(\hat{p}_t|\omega_{t-1}) ,$$

with five endogenous variables: $\hat{y}$, $\hat{p}$, $\hat{p}^e$, R, and $\hat{u}$.

Solving for $\hat{p}_t$, the rate of inflation, gives:

$$(2.14)\quad \hat{p}_t = \frac{1}{\alpha_1+\alpha_3}\ [(\alpha_2-\alpha_0) + \alpha_1\hat{p}_t^e|\omega_{t-1} + \alpha_3\hat{M}_t - \sum_{j=1}^{n}\beta_j(\hat{c}_{t-j}-\hat{p}_{t-j}) - \sum_{i=1}^{n}\phi_i R_t|\Psi_{t-i} + (v_t^d - v_t^s)].$$

The expected rate of inflation is the mathematical expectation of (2.14):

$$(2.15)\quad \hat{p}_t^e|\omega_{t-1} = \frac{1}{\alpha_1+\alpha_3}\ [(\alpha_2-\alpha_0) + \alpha_3\hat{M}_t^e|\omega_{t-1} - \sum_{j=1}^{n}\beta_j(\hat{c}_{t-j}-\hat{p}_{t-j}) - \sum_{i=1}^{n}\phi_i R_t|\Psi_{t-i}].$$

The inflation forecast errors are:

$$(2.16)\quad \hat{p}_t - \hat{p}_t^e|\omega_{t-1} = \frac{1}{\alpha_1+\alpha_3}\ [\alpha_3(\hat{M}_t - \hat{M}_t^e|\omega_{t-1}) + (v_t^d - v_t^s)].$$

Substituting (2.16) into (2.7) gives:

$$(2.17)\quad \hat{y}_t = \alpha_0+\gamma_1(\hat{M}_t-\hat{M}_t^e|\omega_{t-1}) + \sum_{j=1}^{n}\beta_j(\hat{c}_{t-j}-\hat{p}_{t-j})$$

$$+ \sum_{i=1}^{n}\phi_i R_t|\Psi_{t-i} + e_{1t} \quad .$$

where $\gamma_1 = \dfrac{\alpha_1\alpha_3}{\alpha_1+\alpha_3}$ and $e_{1t} = \dfrac{\alpha_1}{\alpha_1+\alpha_3}\; v_t^d + \dfrac{\alpha_3}{\alpha_1+\alpha_3}\; v_t^s$.

Substituting (2.17) into (2.12) gives:

$$(2.18)\quad \hat{u}_t = \tau_1 + \tau_2(\hat{M}_t-\hat{M}_t^e|\omega_{t-1}) + \alpha_5 \sum_{j=1}^{n}\beta_j(\hat{c}_{t-j}-\hat{p}_{t-j})$$

$$+ \alpha_5 \sum_{i=1}^{n} \phi_i R_t|\Psi_{t-i} + e_{2t}$$

where $\tau_1 = \alpha_4+\alpha_5\alpha_0$, $\tau_2 = \dfrac{\alpha_5\alpha_1\alpha_3}{\alpha_1+\alpha_3}$, and $e_{2t} = \alpha_5 e_{1t} + v_t^u$.

In the empirical analysis to follow, only equations (2.10), (2.17), and (2.18) will be estimated. Of course, the dependent variable in (2.10), $R_t|\Psi_{t-1}$, is not observable, so before estimation I must relate it to variables that are observable.

2.5 - Conclusions

In recent years many economists have come to view inflation as having the potential to affect real economic activity through its effect on economic uncertainty. In this chapter, I have presented a simple macroeconomic model consistent with this view. The model is easily adapted to econometric testing of the hypotheses that (1) uncertainty about business profits is positively related to inflation, and (2) output growth is, over the fairly long term, reduced (and unemployment increased) by higher inflation. The model allows for the possibility that the effects of anticipated and unanticipated inflation are different.

In Chapters 3 and 4, I perform several different tests of hypothesis (1), and in Chapter 5, I test hypothesis (2).

CHAPTER II

NOTES

CHAPTER TWO

NOTES

[1]See Tobin (1965) for the theoretical analysis of money demand during inflation.

[2]An increase in aggregate price flexibility (resulting from, say, increased indexation) does not necessarily reduce price dispersion, since the variance of price flexibility across industries does not necessarily fall.

[3]CAPM revised for expectations of uncertain inflation is:

$$E(r_i) = r_f + \sigma_{i\pi} + \left[\frac{E(r_m) - r_f - \sigma_{m\pi}}{\sigma_m^2 - (\frac{\sigma_{m\pi}}{\alpha})}\right] (\sigma_{im} - \frac{\sigma_{i\pi}}{\alpha})$$

where $\alpha = \sum_k \sum_j \gamma_k \alpha_{jk}$, γ_k - the relative wealth of individual k, α_{jk} = the proportion of individual k's assets held in the risky asset j. Therefore, α represents the proportion of risky assets to all assets.

[4]Korteweg (1979) uses a Lucas type model altered in this way.

[5]These findings are discussed in more detail in Chapter V.

CHAPTER III

INFLATION AND UNCERTAINTY IN FORECASTING INFLATION

3.1 - Introduction

The model presented in Chapter 2 implies that higher inflation increases uncertainty among producers about both present and future profits. One source of this inflation-induced uncertainty is uncertainty in forecasting inflation; higher inflation may make predicting future inflation more difficult and may lead to reduced confidence in the predictions. This makes it harder for firms to estimate the real rates of return on investments, and it increases the uncertainty associated with other long-term commitments.

In this chapter, I test whether increased inflation, expected or unexpected, increases uncertainty about future inflation rates. Economists do not know exactly what uncertainty is or how it can be measured, and I make no pretense of providing an answer. I merely state my own ideas about possible indicators of uncertainty. In Section 3.2, I review the variety of proposals in the literature for estimating inflation uncertainty and the results of several tests of the inflation-uncertainty hypothesis. In general, those who have examined inflation uncertainty have had little to say about how inflation expectations are actually formed, so in Section 3.3, I attempt to determine how a "rational" forecaster might predict future inflation rates. Section 3.4 contains tests of the hypothesis using the variance of residuals from the expectations model to indicate forecast uncertainty. If the variance is not constant through time (i.e., the residuals exhibit heteroskedasticity), this could mean that forecast uncertainty changes through time.[1] If so, I can test whether the variance for a given time period is a function of information known when a forecast for that time period is made. Section 3.5 provides a different test of the hypothesis based upon the notion that the prevalence of indexing in wage contracts and the degree to which the rate of return on securities investment is indexed are proxies for inflation uncertainty.

3.2 - Previous Research

Studies of inflation uncertainty are generally based on one of three proxies for forecast uncertainty: (1) variability of inflation, (2) dispersion of expectations across respondents to inflation expectations surveys and (3) proxies based on forecast errors from an inflation expectations model. In this section I look at each of these in turn.

A. Variability of Inflation

Early research used the variance (or standard deviation) of actual inflation rates as the indicator of uncertainty in forecasting inflation. Okun (1970) found a correlation coefficient of .78 between the average annual percentage increase in the GNP deflator and the standard deviation of annual inflation rates for seventeen industrialized OECD countries from 1951-1968. He felt this might indicate a causal link between inflation and uncertainty regarding future inflation. In a companion piece, Gordon (1971) found the correlation coefficient to be only .40 between 1960 and 1968. Furthermore, he found that excluding five relatively small countries from the sample caused the correlation to disappear for this time period. His conclusion was that Okun's result was merely a temporary phenomenon caused by ususual price behavior following the Korean War.[2]

Logue and Willett (1976) had similar findings based on a sample of forty-one industrialized and nonindustrialized countries from 1949-1970. They used the regression model:

$$SD(I)_{ji} = a_i + b_i\bar{I}_{ji} + \varepsilon_{ji}$$

where $\bar{I}_{ji}$ is the average annual rate of inflation for the jth country in the ith class, and $SD(I)_{ji}$ is the standard deviation of inflation for the jth country in the ith class, classifying countries as either Highly Industrialized, Latin American or All Other (and Industrialized Other or Relatively Non-industrialized Other). For the Highly Industrialized class, the estimated coefficient b is not significant for either the 1949-1959 period or the 1960-1970 period. For the other groups, however, b is positive and highly significant, although its value is lower for the latter period. They then test the hypothesis that the lack of a relationship between inflation and its variance for the Highly Industrialized class is a result of lower average inflation rates for this group of countries. Using the above regression model, they reclassify the countries into quartiles according to their average annual inflation rates. They find the coefficient b to be insignificant for either period for the lower two quartiles.[3] Their conclusion is that inflation rates of no more than 2-4 percent cause no problem of increased variability of inflation.

Some recent research on inflation variance has updated the sample period, changed the countries studied, and used different price indices to measure inflation. The conclusions of Jaffee and Kleiman (1978) and Taylor (1980) are consistent with those presented above; the correlation across countries between inflation and its variance is weak in the 1960's but strong during the 1970's as inflation rates rise throughout the world. For the U.S. alone, using data from 1806-1979, Fischer (1980) finds a positive relationship between inflation and its variability over the entire period. He calculates the mean and standard deviation of annual inflation rates over non-overlapping five-year periods and uses a regression analysis similar to that of Logue and Willett (each five-year period is one observation). The relationship is especially strong when he uses quarterly data for the post-World War II period (each twelve-quarter period is one observation).[4]

Research on the variance of inflation rates is at best an initial step in the process of understanding uncertainty about inflation; at worst, it could provide an inaccurate picture of this uncertainty. Foster (1978) shows by constructing an artificial example that "the faster a country's rate of inflation is growing, the higher its standard deviation -- even if the year-to-year change includes no random component but is strictly systematic." (p. 347). He solves this problem by using the average absolute change in inflation rates instead of deviations about the mean. Like Okun, he gets large correlations between his measure of uncertainty and inflation (for both industrialized and nonindustrialized countries and for the period 1961-1975 as well as 1954-1975).

B. Dispersion of Inflation Expectations Across Survey Respondents

Several recent studies have used observed inflation expectations from surveys to construct measures of inflation uncertainty. The results have been consistently favorable to the inflation-uncertainty hypothesis. Jaffee and Kleiman (1978) find a positive relationship between the mean and standard deviation of the inflation rates expected by individual respondents to the University of Michigan SRC (Survey Research Center) survey. Taylor (1980) shows that the variance of expectations (from both the Livingston and SRC surveys) is positively associated with lagged average unanticipated inflation as well as current average expected inflation for nearly all time periods and data sets. Cukierman and Wachtel (1980) find that the variance of expected inflation is positively related to the variance of actual inflation. They regress the variance of expectations across respondents to both surveys on a moving variance of the rate of inflation.[5]

C. Measures Based on Forecast Errors

Another approach to dealing with uncertainty in forecasting future inflation is to construct a proxy based on the forecast errors of an inflation expectations model. Klein (1978) suggested the use of a moving standard deviation of past forecast errors. His model of annual inflation expectations is a simple first order autoregressive process re-estimated every year with the standard deviation calculated for residuals from the previous twelve years. He terms this measure the "short-term price uncertainty" and he uses this estimate, as well as the estimated autoregressive parameter, to construct a "long-term price uncertainty" measure.[6]

For inflation uncertainty to change from period to period as in Klein's model, there must be heteroskedasticity in the residuals of an inflation expectations model covering multiple periods. This is the key point made by Engle (1982), whose approach is to construct a model in which the variance of a regression is allowed to change through time. The variance at time t can be a function of information known at time t including the disturbances from previous periods. In this and other papers [Engle (1980) and Engle and Kraft (1981)], Engle has found the current squared residual of an inflation expectations model to depend on the squared residuals from previous periods. He, therefore, refers to his model as the Autoregressive Conditional Heteroscedasticity (ARCH) model.[7] His inflation variance estimates are the fitted values of this regression.

In looking at U.S. quarterly inflation data from 1947:4 through 1979:3, Engle (1980) models inflation expectations as a function of several factors: two quarters lagged inflation; the rates of change of the import price deflator, wages, and the money supply (all lagged one quarter); and a time trend. He finds that "the 1970's represent only a slight increase in variance (over the 1960's) which is completely dwarfed by the high variances in the late 1940's and early 1950's" (p. 9). He does test whether the squared residual at time t for this model depends on the inflation rate for period t-1, but he finds no statistically significant effect for either the GNP deflator or the CPI.[8]

The Engle approach, comes closer than any of the others discussed here to capturing uncertainty in forecasting inflation, because it attempts to measure only the unpredictable variance in the inflation process.[9] Of course, the major problem with this approach is the difficulty in estimating inflation expectations. His finding that only lagged values of squared unexpected inflation and not inflation itself, affect this variance contrasts sharply with the other findings discussed in this section. However, Engle uses a single inflation expectations model for the entire period 1947 to 1979, despite drastic differences in price behavior in the post-World War II and Korean War eras from later periods.[10] It is, therefore, not surprising that he found inflation variance highest for these periods.

In the next two sections of this chapter, I will use Engle's basic methodology for dealing with inflation uncertainty, but I will modify the analysis to correspond to the model of Chapter 2 and to eliminate the problem associated with his choice of sample period.

3.3 - Modelling Inflation Expectations in the United States

In considering the formation of inflation expectations, I assume that expectations are formed "rationally". This assumption has been used to justify a wide variety of expectations models whose essential feature is that forecasts are based on an information set known at the time the forecasts are made. In empirical work this information set generally consists of lagged values of all or part of the variables that actually generate the variable to be predicted. Models that exclude some variables from the information set are sometimes called "partly rational".[11] However, Feige and Pearce (1976) show that excluding some variables from the set is "economically rational" if the marginal cost of obtaining information on these variables exceeds the marginal benefit of improved predictive accuracy. Therefore, expectations models based on everything from distributed lags of the predicted variable[12] to a vast array of lagged variables[13] have been termed "rational".

My approach is essentially no different from the norm; inflation expectations are based on lagged values of a subset of the variables in the model. From Chapter II, recall that expected inflation in period t, $\hat{p}_t^e$, depends on an information set available at the end of period t-1, ω_{t-1}. For my purposes, ω_{t-1} consists of known values of past inflation rates, $\hat{p}$, money stock growth rates, $\hat{M}$, and unemployment rates, u.[14]

I generate quarterly expectations series for the rates of change of the Consumer Price Index and the GNP deflator for 1954:4 to 1981:2 below. The data are not seasonally adjusted. I assume that the forecast of $\hat{p}_t$ is made when information on p_{t-1}, M_{t-1}, and u_{t-1} becomes available, which is usually about three weeks after the end of quarter t-1. The money growth variables $\hat{M}_{t-j}$ (j=1, ..., n) are based on the M1 figures (after 1979:3, M1B) available when the forecast for period t-j+1 is made.[15] Therefore, the value of M_{t-j} used in calculating $\hat{M}_{t-j}$ differs from the value used in calculating $\hat{M}_{t-j+1}$ if M_{t-j} has been revised during period t-j+1.

I report ordinary least squares (OLS) results for the following equations in Table 3-1:

TABLE 3-1

ESTIMATES OF INFLATION EXPECTATIONS

Variable	(1) CPI: 1955:3-1981:2	(2) GNP deflator: 1955:4-1981:2
Intercept	.465 (2.38)	.032 (.450)
$\hat{P}_{t-1}$	.359 (4.02)	.361 (3.44)
$\hat{P}_{t-2}$	.282 (2.98)	.258 (2.44)
$\hat{P}_{t-3}$	.342 (3.60)	.184 (1.83)
sum	.983 (16.7)	.803 (11.9)
$\hat{M}_{t-1}$	-.012 (-.621)	.066 (3.25)
$\hat{M}_{t-2}$	.055 (2.64)	.058 (2.79)
$\hat{M}_{t-3}$	.060 (3.37)	.043 (2.05)
$\hat{M}_{t-4}$	------	.048 (2.36)
sum	.103 (2.30)	.215 (3.12)
u_{t-1}	-.494 (-4.21)	------
u_{t-2}	.406 (3.58)	------
sum	-.088 (-2.38)	
SSE	18.4	11.4
S.E.	.440	.347
R^2	.800	.764

t-statistics are in parentheses.

For CPI (1) $$\hat{p}_t = a_1 + \sum_{i=1}^{3} b_{1i}\hat{p}_{t-i} + \sum_{j=1}^{3} c_{1j}\hat{M}_{t-j} + \sum_{k=1}^{2} d_{1k}u_{t-k} + \mu_{1t}$$

For GNP Deflator (2) $$\hat{p}_t = a_2 + \sum_{i=1}^{3} b_{2i}\hat{p}_{t-i} + \sum_{j=1}^{4} c_{2j}\hat{M}_{t-j} + \mu_{2t}$$

where $\hat{p}_t = 100(\log p_t - \log p_{t-1})$

$\hat{M}_t = 100(\log M_t - \log M_{t-1})$

u = unemployment rate: all workers, 16 years and older.[16]

The number of lags for each variable was based on the usual t-tests and F-tests.[17] Using Durbin's test, no evidence of autocorrelation was found in either equation.[18] The equations were also not significantly affected by the inclusion of seasonal dummies or dummies for changes in the way M1 is calculated (including the change from use of M1 to M1B).

The inclusion of lagged values of unemployment, an endogenous variable in the model, makes it difficult to interpret the coefficients in Equation (1). One cannot determine the effect of money growth on future CPI inflation by simply looking at the coefficients for the inflation and money growth terms, because money growth affects unemployment as well. This creates no problem for prediction, however, so I continue to include unemployment in the model.[19] In any case, the sum of the coefficients of lagged inflation and lagged money growth is not significantly different from one (1.086). Lagged unemployment has no significant effect on the rate of change of the GNP deflator, so it is excluded from equation (2). The coefficients in Equation (2) sum to 1.018 and imply that the long term effect of a one percent increase in money growth is very close to a one percent inflation of the GNP deflator.[20]

Estimates of expected inflation rates and inflation forecast errors along with actual inflation rates are presented in Tables 3-2 and 3-3. In the next section, I test the forecast errors for heteroskedasticity.

3.4 - Tests Based on Inflation Forecast Errors

A cursory examination of the data in Tables 3-2 and 3-3 suggests there may be some relationship between the magnitude of forecast errors and inflation rates. For example, for the CPI, there are seven quarters in which the forecast errors differ from zero by more than twice the standard error of the regression (.880), and six of them occur during the relatively high-inflation period, 1974-1981. For the GNP deflator, there are three of these quarters (two times S.E. equals .694), and they all occur between 1975 and 1978. These numbers appear with an asterisk in the tables. Splitting the sample into a low-inflation subperiod, 1955:4-1967:4, and a high-inflation subperiod, 1968:1-1981:2,[21] I can reject the hypothesis that the error variance is the same in both periods using the Goldfeld-Quandt test. For the CPI, the F-test statistic is 2.62, and for the GNP deflator the value is 2.08. The variance is higher in

TABLE 3-2

ESTIMATED QUARTERLY INFLATION EXPECTATIONS AND FORECAST ERRORS, U.S. CONSUMER PRICE INDEX, 1955:3 - 1981:2

Period	Inflation Rate	Expected Inflation Rate	Forecast Error
1955:3	.4981	.3009	.197
:4	-.1243	.1200	-.244
1956:1	0.	.2284	-.228
:2	1.236	.5789	.657
:3	.7344	.4113	.323
:4	.8500	.6414	.209
1957:1	.7229	.8945	-.172
:2	1.193	1.398	-.205
:3	.7092	.7443	-.351E-01
:4	.3527	.5883	-.236
1958:1	1.399	.4041	.994*
:2	.3466	.3382	.846E-02
:3	0.	.1271	-.127
:4	0.	.2436	-.244
1959:1	0.	.4891	-.489
:2	.6897	.6275	.622E-01
:3	.4571	.5970	-.140
:4	.3415	-.8203E-01	.424
1960:1	0.	.5847	-.585
:2	.7923	.4921	.300
:3	.1127	.2945	-.182
:4	.5615	-.1746	.736
1961:1	0.	-.7188E-01	.719E-01
:2	.1119	.2369	-.125
:3	.5577	.1431	.415
:4	0.	-.8746E-02	.875E-02
1962:1	.4440	.4636	-.197E-01
:2	.2212	.6354	-.414
:3	.7705	.2311	.539
:4	-.2195	.3663	-.586
1963:1	.3291	.2477	.814E-01
:2	.4372	.5183	-.811E-01
:3	.4353	.2904	.145
:4	.4334	.2524	.181
1964:1	.1080	.4719	-.364
:2	.3235	.7006	-.377
:3	.3224	.4914	-.169
:4	.4283	.1385	.290
1965:1	.1068	.5135	-.407
:2	1.062	.8352	.226
:3	.1055	.7282	-.623
:4	.6309	.3831	.248
1966:1	.9390	.9360	.294E-02
:2	.8273	1.213	-.386
:3	1.025	1.079	-.544E-01
:4	.5084	.9788	-.470
1967:1	.3038	.8622	-.558
:2	.8056	.9642	-.159
:3	.9980	.6889	.309
:4	.8898	.7787	.111
1968:1	1.174	1.164	.100E-01
:2	1.161	1.160	-.469
:3	1.052	1.305	-.253
:4	1.229	1.310	-.803E-01
1969:1	1.493	1.431	.611E-01
:2	1.562	1.843	-.281
:3	1.358	1.661	-.303
:4	1.517	1.313	.204
1970:1	1.407	1.697	-.289
:2	1.560	1.398	.162
:3	1.027	1.371	-.344
:4	1.353	.9260	.427
1971:1	.5860	1.044	-.458
:2	1.409	1.326	.829E-01
:3	.5745	1.215	-.640
:4	.7338	.7334	.377E-03
1972:1	.7285	1.016	-.288
:2	.8032	.9850	-.182
:3	.9554	.9199	.355E-01
:4	.8679	.7428	.125
1973:1	1.945	1.218	.727
:2	1.983	1.874	.109
:3	2.314	1.768	.547
:4	2.190	2.045	.145
1974:1	3.267	2.232	1.03*
:2	2.621	2.904	-.284
:3	3.215	2.667	.548
:4	2.410	2.679	-.269
1975:1	1.533	2.115	-.582
:2	1.759	1.789	-.300E-01
:3	1.851	1.526	.324
:4	1.637	1.557	.796E-01
1976:1	.7190	1.701	-.982*
:2	1.540	1.670	-.129
:3	1.459	1.173	.286
:4	.9801	.9601	.201E-01
1977:1	2.213	1.097	1.12*
:2	2.000	1.900	.100
:3	1.203	1.719	-.516
:4	1.135	1.746	-.611
1978:1	1.969	1.769	.200
:2	2.857	1.832	1.02*
:3	2.027	2.158	-.131
:4	1.790	2.101	-.311
1979:1	3.010	2.385	.625
:2	3.524	2.679	.845
:3	3.091	2.666	.425
:4	2.868	2.906	-.376E-01
1980:1	4.216	3.267	.949*
:2	3.201	3.527	-.326
:3	1.642	2.675	-1.03*
:4	2.627	2.629	-.152E-02
1981:1	2.560	2.578	-.178E-01
:2	2.312	2.540	-.228

TABLE 3-3

ESTIMATED QUARTERLY INFLATION EXPECTATIONS AND FORECAST ERRORS, U.S. GNP DEFLATOR, 1955:4 - 1981:2

Period	Inflation Rate	Expected Inflation Rate	Forecast Error
1955:4	.6040	.7629	-.159
1956:1	.8270	.7108	.116
:2	.8360	.6162	.220
:3	1.115	.6558	.459
:4	.8830	.8288	.542E-01
1957:1	1.109	.8859	.223
:2	.3870	.8196	-.433
:3	.9700	.5465	.424
:4	.1380	.7086	-.571
1958:1	.3970	.3853	.117E-01
:2	.2430	.2791	-.361E-01
:3	.5760	.1763	.400
:4	.4520	.4862	-.342E-01
1959:1	.8540	.6226	.231
:2	.7580	.7166	.414E-01
:3	.3840	.7054	-.321
:4	.2800	.6678	-.388
1960:1	.6450	.4696	.175
:2	.1750	.2910	-.116
:3	.4370	.1393	.298
:4	.1450	.3301	-.185
1961:1	-.1160	.2518	-.368
:2	.4920	.1512	.341
:3	.4610	.2494	.212
:4	.1580	.4333	-.275
1962:1	.8290	.3085	.521
:2	.3550	.5076	-.153
:3	.1980	.4783	-.280
:4	.6490	.4349	.214
1963:1	.4630	.6794	-.216
:2	.7000E-01	.5283	-.458
:3	.2790	.3937	-.115
:4	.7090	.4623	.247
1964:1	.2630	.6361	-.373
:2	.2900	.5310	-.241
:3	.5500	.4733	.767E-01
:4	.2600	.6163	-.356
1965:1	.8300	.6115	.219
:2	.4870	.6459	-.159
:3	.5780	.5930	-.150E-01
:4	.5350	.7533	-.218
1966:1	.9960	.8018	.194
:2	1.143	.8898	.253
:3	.5340	1.028	-.494
:4	.9820	.9117	.703E-01
1967:1	.6410	.8833	-.242
:2	.3570	.7084	-.351
:3	.9510	.6376	.313
:4	1.066	.8871	.179
1968:1	1.265	1.135	.130
:2	1.213	1.204	.889E-02
:3	.8490	1.273	-.424
:4	1.379	1.207	.172
1969:1	1.160	1.371	-.211
:2	1.321	1.218	.103
:3	1.602	1.209	.393
:4	1.283	1.339	-.562E-01
1970:1	1.423	1.308	.115
:2	1.304	1.246	.582E-01
:3	.7870	1.194	-.407
:4	1.342	1.143	.199
1971:1	1.462	1.238	.224
:2	1.368	1.308	.596E-01
:3	.8530	1.498	-.645
:4	.8970	1.326	-.429
1972:1	1.356	1.170	.186
:2	.7070	1.201	-.494
:3	.8310	1.014	-.183
:4	1.279	1.114	.165
1973:1	1.350	1.331	.188E-01
:2	1.705	1.283	.422
:3	1.658	1.578	.797E-01
:4	2.064	1.637	.427
1974:1	1.770	1.851	-.808E-01
:2	2.438	1.826	.612
:3	2.553	1.997	.556
:4	2.824	2.226	.598
1975:1	2.543	2.467	.760E-01
:2	1.256	2.338	-1.08*
:3	1.771	1.919	-.148
:4	1.803	1.771	.317E-01
1976:1	.8970	1.658	-.761*
:2	.9040	1.375	-.471
:3	1.198	1.122	.756E-01
:4	1.563	1.117	.446
1977:1	1.393	1.428	-.351E-01
:2	1.648	1.423	.225
:3	1.316	1.559	-.243
:4	1.523	1.627	-.104
1978:1	1.404	1.663	-.259
:2	2.521	1.474	1.05*
:3	1.860	1.963	-.103
:4	2.330	2.065	.265
1979:1	2.025	2.168	-.143
:2	1.886	1.853	.331E-01
:3	1.881	1.890	-.882E-02
:4	1.954	1.890	.643E-01
1980:1	2.228	1.868	.352
:2	2.338	1.979	.359
:3	2.201	1.980	.221
:4	2.551	2.238	.313
1981:1	2.328	2.332	-.441E-02
:2	1.598	2.275	-.677

the latter period as expected. A Chow test, however, does not reject the hypothesis that the parameters of the two regressions are equal for either price index.[22]

The greater variance of inflation forecast errors in recent times may not be caused by higher inflation rates, but may instead be the product of random shocks to the inflation process that are not necessarily associated with a high-inflation economy. The most important of these shocks would probably result from the drastic increases in the price of imported oil that occurred in 1973-1974 and again in 1979-1980. From 1973:1-1974:3, the price index for fuels and related products and power rose from 121.9 to 225.0, and from 1979:2-1980:1, it rose from 393.7 to 553.5.

In attempting to determine the cause of the heteroskedasticity in the inflation expectations models, I apply Engle's (1982) procedure -- an errors in variables model of the form:

$$UNC_t | \Psi_{t-1} = \sigma_t^2 + m_t$$

where $UNC_t | \Psi_{t-1}$ is period t forecast uncertainty given an information set Ψ_{t-1} known when the forecast is made, σ_t^2 is the residual variance for period t from the inflation expectations model (what Engle calls the conditional forecast variance), and m_t is an independently distributed measurement error. The procedure is to regress the squared residual from the expectations model for period t on a set of regressors and compare the test statistic TR^2 (T = number of observations) to the critical χ^2 value for k degrees of freedom (k = number of regressors).

I first replicate Engle's (1980) test that the variance σ_t^2 depends on the rate of inflation lagged one period, $\hat{p}_{t-1}$. the results using my model and sample period are presented in Equation (1) of Table 3-4 for the CPI and in Equation (4) for the GNP deflator. The relationship is positive and significant at the .05 level for both price indices, a finding different from Engle's but consistent with most other research on inflation variance. In Equations (2) and (5), I enter the inflation rate expected in the current period and the unexpected inflation experienced in the previous period. The unexpected inflation variable has no significant effect on the variance in either regression and, in fact, has a negative coefficient in both regressions. In other regressions, I include lagged values of inflation and expected and unexpected inflation beyond one quarter, but in no case do these variables have significant effects. I also find no evidence that past squared residuals (lagged up to twelve quarters) have a positive effect on σ_t^2, the finding reported by Engle for a different inflation expectations model and time period.

Equations (3) and (6) of the table include a dummy variable to indicate periods in which inflation uncertainty is likely to be affected by rapidly rising energy prices. The variable D takes the value 1 for observations during the periods 1973:1-1975:1 and 1979:2-1980:3, and 0 otherwise. The variable is constructed to allow the effect

TABLE 3-4

OLS REGRESSIONS OF SQUARED INFLATION FORECAST ERRORS ON PAST INFLATION RATES AND A DUMMY VARIABLE FOR PERIODS OF RAPID ENERGY PRICE INCREASE, 1955:4 - 1981:2

Variable	CPI			GNP Deflator		
	(1)	(2)	(3)	(4)	(5)[a]	(6)
Intercept	.107 (7.53)	.0908 (1.96)	.134 (2.97)	.0416 (1.26)	.0268 (.761)	.0448 (1.27)
$\hat{P}_{t-1}$	.0616 (2.18)	------	.0169 (.431)	.0632 (2.47)	------	.0580 (1.83)
$\hat{P}_t^e$	------	.0741 (2.31)	------	------	.0768 (2.52)	------
$\hat{P}_{t-1}-\hat{P}_{t-1}^e$	------	-.023 (-.356)	------	------	-.0422 (-.754)	------
D_t	------	------	.171 (1.64)	------	------	.0174 (.282)
SSE	7.32	7.27	7.13	3.20	3.18	3.20
TR^2	4.62*	5.21	7.20*	5.88*	6.21*	5.95
$\bar{R}^2$	.0354	.0316	.0513	.0477	.0413	.0390

* indicates statistical significance of TR^2 at the .05 level.

[a]Equation (5) is based on data from the period 1956:1-1981:2.

to last two quarters past the time of the most rapid energy price increases, since an energy price shock may continue to affect prices of other goods even after energy prices have become relatively stable. For the CPI, this variable is the dominant factor in determining the error variance. In fact, if the dummy variable is entered in the regression alone, the sum of squared errors is only 7.14 (compared to 7.13 when the inflation variable is included). However, the variable has no effect in the GNP deflator regression.[23]

The discrepancy between results using the CPI and the GNP deflator could be caused by differences in the way the two indices are calculated. A reduction in the use of energy-related products would show up in the deflator because goods are weighted according to current production. The CPI, however, uses fixed weights for goods over long periods of time and, therefore, does not reflect substitution away from energy-intensive commodities. It is not surprising, then, that the variance of CPI forecast errors is affected more by changes in the relative price of energy than the variance of GNP deflator forecast errors.

In conclusion, I have found evidence of greater variance of inflation forecast errors in the recent high-inflation periods. However, only for errors in forecasting the GNP deflator is the variance clearly related to the rate of inflation. The higher variance in the CPI errors may be the result of the oil price shocks of recent years.

Although the inflation expectations models exhibit heteroskedasticity, I can still use the expectations figures obtained from these models in this and the next two chapters, because the parameters are consistent.[24] The regressions of the conditional forecast variances in Table 3-4 also have heteroskedastic errors,[25] but these parameter estimates are also consistent, and the use of the value TR^2 in a χ^2 test is still valid. I can, therefore, generate estimates of σ_t^2, the conditional forecast variance, using the fitted values from the equations in Table 3-4.

3.5 - Another Test of the Hypothesis: the Effect of Inflation on Indexation

In this section, I consider another possible indicator of uncertainty in forecasting inflation, the prevalence of indexation in wage and other contracts in the economy. As Gray (1978) points out, "the incentive to index is related to the (imperfectly anticipated) variability of the price level, not to its mean rate of change." However, "...the greater the uncertainty associated with any mean rate of inflation, the stronger the case for indexing." (p. 3). Therefore, a test of the effect of inflation on indexation might be interpreted as a test of the effect of inflation on uncertainty in forecasting inflation.

I attempt to quantify the degree of indexation in two ways. First, the variable INDEX is used to approximate the percentage of disposable personal income subject to cost-of-living clauses in collective bargaining agreements.

For annual data from 1957-1980,

$$\text{INDEX} = 100 \times \frac{(\text{COVER}/\text{EMPLOY})(\text{WAGES}(\frac{\text{DPI}}{\text{PI}})}{\text{DPI}}$$

where

COVER = the number of workers covered by collective bargaining contracts with COLA clauses (this variable only includes workers whose contracts cover 1,000 workers or more),

EMPLOY = total employment of the Civilian Labor Force,

WAGES = total wage and salary disbursements,

DPI = disposable personal income,

PI = total personal income.[26]

In using WAGES$(\frac{\text{DPI}}{\text{PI}})$ as the measure of after-tax wage and salary disbursements, I am assuming that the proportion of wages and salaries paid in taxes equals the proportion for personal income as a whole. The variable INDEX has a mean of 3.10 with a minimum of 1.35 in 1963 and a maximum of 4.41 in 1976.

The second proxy is designed to measure "indexation" of income streams from investment in securities. Investors are concerned with the real rate of return on their investments, not the nominal rate. If market interest rates (for both long and short term bonds) contain an "inflation premium", then the return on short term bonds is effectively "indexed", i.e., the interest earned lags behind the inflation rate by a fairly short period of time. The return on long term bonds is not effectively indexed. The investor would have to sell his long term bonds at a discount to take advantage of higher interest rates resulting from unexpected inflation. Therefore, the average length of time to maturity of outstanding securities is a possible indicator of the degree to which debt contracts are "indexed".

The variable used, MATUR, equals the average maturity in months of outstanding government debt measured on a quarterly basis from 1958:1 to 1980:4.[27] Ideally, I would look at all debt contracts, but data are not available. As MATUR declines, the stream of payments from investment in government securities becomes more closely linked to the inflation rate, i.e., one approaches a situation of making "floating rate" loans to the government as MATUR approaches one period.

Test results using the variable INDEX are reported in Table 3-5. Equations (1) and (2) show that inflation of the CPI or the GNP deflator has a positive effect on the degree of indexation over a two year period. (The F-statistic reported in the table tests the hypothesis that all of the coefficients except the lagged value of the dependent variable are zero.) However, the sum of the squared residuals declines substantially if expected and unexpected inflation are entered separately, as in Equation (3). Since I have not estimated an annual inflation expectations model, the value of $\hat{p}_t^e$ used in this regression is the twelve-month average expectation from the Livingston survey of economists. Two years' lagged unexpected inflation has a positive and significant effect on INDEX, but, as Gray predicts, expected inflation has no effect. Increasing the

TABLE 3-5

OLS REGRESSION OF "INDEX" ON INFLATION
1957-1980

Variable	CPI (1)	GNP Deflator (2)	CPI w/Livingston Expectations (3)
Intercept	.500 (1.47)	.342 (1.02)	.465 (1.66)
$INDEX_{t-1}$	.721* (7.02)	.731* (6.53)	.700* (7.31)
$\hat{p}_{t-1}$	-.028 (-.658)	.019 (.284)	------
$\hat{p}_{t-2}$	.130* (2.54)	.099 (1.32)	------
sum	.102* (3.05)	.118* (2.71)	------
$\hat{p}_t^e$	------	------	.022 (.613)
$\hat{p}_{t-1}-\hat{p}_{t-1}^e$	------	------	.124 (1.95)
$\hat{p}_{t-2}-\hat{p}_{t-2}^e$	------	------	.188* (2.93)
sum (unexpected inflation)	------	------	.312* (3.49)
SSE	3.15	3.49	2.49
R^2	.830	.811	.865
F	5.07*	3.65*	5.64*

number of lagged quarters to four for both variables does not alter the result. A one percent increase in unexpected inflation leads to an increase in the proportion of incomes covered by COLA of about .31% over a two year period.[28]

The use of a dummy variable for periods directly following energy price shocks does not affect the outcome. However, the largest single increase by far in the variable INDEX occurs between 1973 and 1974 (from 3.08 to 4.02). A similar increase does not occur, though, between 1979 and 1980, the year after the other large oil price shock.

I report regression results using MATUR, the average maturity of outstanding government debt, as the dependent variable in Table 3-6. I include in the regressions the variable r_L/r_S, where r_L is the interest rate on long term government bonds (an average for bonds maturing in ten years or more) and r_S is the rate of short term securities (I use the ninety-day Treasury bill rate). Only results using the GNP deflator appear in the table, but the CPI results are similar. A Chow test indicates a split in the sample, one subperiod being 1958;1-1967;4 and the other 1968;1-1980:4. In no case do any of the inflation variables have a significant impact on MATUR. Furthermore, only in the earlier subperiod does the interest rate variable have a positive effect.

This result may indicate that the variable MATUR reflects not the choice of economic agents, but Treasury policy. The average maturity of outstanding government

TABLE 3-6

OLS REGRESSIONS OF "MATUR" ON INFLATION, GNP DEFLATOR

	1958:1-1967:4 (1)	1968:1-1980:4 (2)	1958:1-1967:4 (3)	1968:1-1980:4 (4)
Intercept	-1.48 (-.264)	2.42 (1.03)	-7.20 (-.204)	4.19 (1.33)
$MATUR_{t-1}$	.969* (11.2)	.941* (24.9)	.977* (11.0)	.926* (22.4)
r_L/r_S	2.56* (2.88)	-.492 (-.482)	2.28* (1.99)	-.758 (-.711)
$\hat{P}_{t-1}$	-.570 (-.464)	.018 (.045)	------	------
$\hat{P}_t^e$	------	------	-.124 (-.592)	-.380 (-.612)
$\hat{P}_{t-1}-\hat{P}_{t-1}^e$	------	------	-.072 (-.055)	.324 (.508)
SSE	143.4	77.7	142.5	76.9
R^2	.782	.951	.784	.951

debt may be supply-determined rather than demand-determined, and the suppliers evidently do not consider the inflation rate in making decisions on the maturity of debt issue.

I, therefore, gain little support for the inflation-uncertainty hypothesis from the results of this section. Although inflation results in increased COLA coverage, there is no independent effect of expected inflation. It is all due to unexpected inflation. I find no relationship at all between inflation and the average maturity of outstanding government debt.

3.6 - Conclusion

This study finds mixed evidence regarding the relationship between inflation and uncertainty in forecasting inflation. The result one finds is sensitive to the proxy used to indicate uncertainty. There is a positive relationship between the most recently experienced quarterly inflation rate and the variance of errors in forecasting the GNP deflator, but if one uses the CPI, the error variance is a function of energy price shocks rather than inflation.

I conclude that in recent times inflation has been to a large degree unexpected, and this has resulted in increased uncertainty regarding future inflation. In all likelihood, this results from both random shocks to the inflation process and from higher average inflation rates. Energy price shocks, for instance, have unpredictable effects on the prices of many different commodities, and high rates of inflation may create uncertainty about the direction of future government policy. The greater uncertainty in forecasting inflation has resulted in more indexing of wage contracts but does not appear to have affected the degree to which government securities are "indexed". Whether the level of uncertainty has increased enough to affect economic growth in the U.S. remains to be seen in Chapter 5. First, however, I look at the effects of inflation on the dispersion of business profits in Chapter IV.

CHAPTER III

NOTES

CHAPTER THREE

[1]This approach was pioneered by Engle (1982).

[2]The correlation coefficient for 1951-60 was .90.

[3]The median inflation rate is 4.08% for 1949-70, 4.56% for 1949-49, and 3.50% for 1960-70.

[4]Another method of quantifying variability of inflation, the moving variance of past inflation rates, was proposed by Klein (1975). The problem with this approach as Ibrahim and Williams (1978) show, is that a moving variance of inflation is inappropriate as a measure of inflation variability unless the rate of inflation has a constant mean plus a random disturbance. This is clearly not the case in recent years for the United States.

[5]The variance covers a two-year span centered on the current period.

[6]By construction, a positive autoregressive parameter leads to greater long-term price uncertainty than one that is negative or zero. Klein proposed this approach as a response to the criticism of his earlier moving variance of inflation measure.

[7]His results are for inflation data for the United States and the United Kingdom.

[8]He did find a positive effect when the Producer Price Index was used. Engle and Kraft (1981) use a simpler expectations model (fourth-order autoregressive) for the GNP deflator over essentially the same period of time and get similar results, though they do not test for an effect of inflation on the variance.

[9]It should be emphasized that the proper measure is the "unexplained" variance in an inflation <u>expectations</u> model and not an inflation model. These may not be very different in a rational expectations world except that only values known at the time expectations are formed can be included in the expectations model. Of course, it is assumed that one uses all of the independent variables used by agents in forecasting inflation.

[10]This was the point made by Gordon (1971). Furthermore, as Klein (1975) points out, the movement to a new world monetary standard caused very different expectations of price behavior from the mid-1950's on from what had gone before.

[11]A term coined by Sargent (1973).

[12]e.g., Pesando (1976).

[13]e.g., McCallum (1976).

[14]These are the variables from my model that appear most often in recent empirical work on inflation expectations (e.g., Mullineaux (1980a)).

[15]Mullineaux (1980a) discusses the importance of using as initially published money supply data. However, he finds that the results of inflation expectations models using multiple lags of money growth are not sensitive to whether one revises the money growth figures for forecasts made after the revision becomes known.

[16]Sources: CPI, GNP deflator, and unemployment--Citibase Data Tape, money growth--Federal Reserve Bulletin.

[17]Additional lags up to eight quarters for $\hat{p}$ and $\hat{M}$ and four quarters for u were tried.

[18]Durbin's h cannot be calculated, so the procedure is to regress the residuals on their one-quarter lagged value plus the regressors of the model. The test is a t-test for significance of the lagged dependent variable.

[19]A similar pattern of signs for lagged unemployment is also found by Mullineaux (1980a). He says that, "one way to rationalize such a result would be to posit that forecasters envision a lagged response by the Federal Reserve to an observed increase in unemployment in the form of an increase in the money growth rate; i.e., that the lagged unemployment rate is a proxy for anticipated rather than observed money growth." (his emphasis).

[20]If the sum of the coefficients of lagged inflation and money growth are restricted to equal one, both equations change very little.

[21]For the CPI, the average quarterly rate of inflation between 1955:3 and 1967:4 is .476% (1.90% annual rate) with a maximum of 1.40% and a minimum of -.220% and between 1968:1 and 1981:2 is 1.82% (7.28% annual rate) with a maximum of 4.22% and a minimum of .586%. For the GNP deflator, the average between 1955:4 and 1967:4 is .562% (2.25% annual

rate) with a maximum of 1.14% and a minimum of -.116% and for 1968:1-1981:2 the average is 1.16% (6.44% annual rate) with a maximum of 2.82% and a minimum of .707%.

[22]The Chow F-value for the CPI is 1.13 and for the GNP deflator is 1.07.

[23]The results are virtually identical if $\hat{p}_t^e$ is used instead of $\hat{p}_{t-1}$. Adding the variable $D_t\hat{p}_{t-1}$ also does not affect the result.

[24]However, the usual t-tests for the individual coefficients in the inflation expectations models are no longer valid.

[25]Judge, et. al (1980, pp. 136-138) show that if the error variance of a regression is a linear function of a set of variables, then the residuals of a regression estimating that variance also exhibit heteroskedasticity.

[26]Sources: COVER -- Monthly Labor Review; EMPLOY -- Handbook of Labor Statistics; WAGES, DPI, PI -- Survey of Current Business.

[27]Source: Economic Report of the President.

[28]If I include social security payments in the variable INDEX, no relationship is present between the variable and inflation.

CHAPTER IV

INFLATION AND THE DISPERSION OF BUSINESS PROFITS

4.1 - Introduction

In Chapter III, I looked at one possible cause of uncertainty regarding the future profits of a business firm, uncertainty in forecasting inflation. In this chapter I use a different indicator of profit uncertainty, the dispersion of business profit rates, to test the hypothesis that higher inflation increases profit uncertainty. I choose this variable over a moving variance of total profit growth rates, for instance, because I feel it is more closely linked to the type of uncertainty I am trying to estimate, i.e, profit uncertainty arising from changes in relative prices, wages, and demands for products and from differences in the way inflation affects rates of return on investments.

Previous research has looked at inflation's effect on relative price dispersion as an indirect way to investigate its effect on profit dispersion. As Friedman (1977) noted, increased dispersion of relative prices causes greater inefficiency in the price system and greater use of resources in search activities. Since the effects of the resulting changes in consumer spending habits are certain to be distributed unevenly across markets, it is likely that profit dispersion is affected. This view is stated by Malkiel (1979, p. 297):

> "High levels of inflation are associated with considerable variability in the inflation rate and with large relative price changes, which make long-run future planning especially hazardous. Thus, even if total profits increase pari passu with inflation, the dispersion of profits among businesses increases with the rate of inflation."

There are, however, at least two reasons why higher relative price dispersion need not always lead to higher profit dispersion: (1) with differing demand and supply elasticities across markets a firm may actually reduce fluctuations in its profit by allowing the relative price of its output to vary, and (2) firms with prices slow (quick) to adjust to increased demand may also have factors of production whose prices are slow (quick) to adjust, which could mean very little effect of inflation on the dispersion of profits.

In Section 4.2 I review recent empirical studies of inflation's effects on price and wage dispersion since both of these may affect profit dispersion. Section 4.3 contains the results of empirical tests of the hypothesis that higher inflation increases the dispersion of corporate profits using quarterly data from 1954-1978 for fourteen broadly defined industries.[1]

4.2 - Inflation's Effects on Relative Prices and Wages

From Chapter II recall that in a world with long-term price contracts and costs of adjusting prices, there is reason to expect a positive relationship between the rate of price change (expected or unexpected) and the dispersion of prices across different products.[2] Some recent empirical research provides support for this hypothesis. Vining and Elwertowski (1976) find a positive association between the unweighted standard deviation of individual price changes at time t and the average price change at time t using components of the U.S. Wholesale Price Index and Consumer Price Index (annual data at the eight-digit level from 1948-1974). They also find the distribution of price changes to be more positively skewed during periods of inflation, with the majority of price changes below the mean.

Using regression analysis, Parks (1978) investigates the difference between the effects of anticipated and unanticipated inflation on relative price changes and finds that "...there is some evidence supporting a separate effect for the rate of inflation (on variance of relative price changes). Its magnitude is much smaller, however, than that of unanticipated inflation,..." (p. 93). The dependent variable in his model is a weighted variance of relative price changes (VP_t) based on expenditures and implicit price deflators for several product types. The series used are from annual data on "Personal Consumption Expenditure by Major Type" for prewar and postwar periods, 1930-1975.

For the most part, he uses variants of the following model:

$$\begin{aligned} VP_t &= A_0 + A_1 (Dm_t - DP_t)^2 + A_2(DP_t - DP_t{*}) \\ &+ A_3(Dm_t - DP_t)(DP_t - DP_t{*}) + A_4(Dm_t - DP_t) \\ &+ A_5(DP_t - DP_t{*}) + A_6(DP_t{}^2) \end{aligned}$$

where

DP_t = rate of change of prices for period t,

Dm_t = rate of change of money stock for period t,

$DP_t{*}$ = anticipated rate of change of prices for period t (DP_{t-1} used as proxy).

The variable $(Dm_t - DP_t)$ indicates real income growth in his model. $DP_t{}^2$ and $(Dm_t - DP_t)^2$ have significant positive coefficients only when the two time periods are combined. The effect of $(DP_t - DP_t{*})^2$ is strongly positive for the prewar period and for the combined sample but not for the postwar period alone. Therefore, his results leave some doubt as to the strength of the relationship between inflation and relative price dispersion in the period I am studying.[3]

Because both of the studies mentioned above use annual data, there is a problem in associating their findings with the price stickiness argument. It seems unlikely that costs of price adjustment are high enough to preclude any price change over the course of an entire year, unless fixed-price contracts have more than one year's duration. However, since firms change prices at different times of the year (and a single firm may not change prices at the same time every year), one might argue that the timing of the collection of price data enables this research to capture some of the effects of price stickiness.

A recent study by Fischer (1981) uses quarterly data to investigate the differences between the effects of expected and unexpected inflation and between unexpected increases and decreases in inflation on the dispersion of relative price changes. He uses a regression model of the following form for data from 1948:1-1980:4:

$$\text{VARDEF} = a_0 + a_1\text{PIMICH} + a_2\text{PIUNPOS} + a_3\text{PIUNNEG}$$

where

VARDEF = weighted variance of inflation rates for eleven components of the U.S. PCE deflator,

PIMICH = expected inflation rate, Michigan SRC survey data,

PIUNPOS = actual minus expected inflation, when positive, otherwise zero,

PIUNNEG = actual minus expected inflation, when negative, otherwise zero.

For the entire period and four of five subperiods, he finds the positive effect of unexpected inflation increases to be greater than that of expected inflation and the effect of unexpected inflation decreases to be insignificant.[4] He also adds other variables to the above regressions such as the growth rate of real income, the Treasury Bill rate, and the growth rate of M2 with little effect on the results.[5] Fischer also does Granger causality tests of the effects of inflation on VARDEF and rejects the hypothesis that inflation does not Granger cause VARDEF only for the 1960-1980 period, not for 1950-1980 or any ten-year subperiod within those years.

The evidence from the studies cited above provides fairly strong but not overwhelming support for the hypothesis that higher inflation leads to greater dispersion of prices at least in the U.S. A recent study of the dispersion of relative wage changes by Hamermesh (1982) finds that unexpected inflation (using Livingston and SRC survey data actually reduces wage dispersion across seven one-digit industries from 1955-1981 and across twenty manufacturing industries. This result supports the theory that the supply of labor increases in response to unanticipated inflation and labor flows into higher growth industries in greater numbers than other industries. This shift in labor supply reduces the dispersion of relative wage change across industries.

Since there is no guarantee that changes in the dispersion of price and wage changes have any effect on profit dispersion, I look directly at data on the dispersion of corporate profits since the mid-1950s in the next section.

4.3 - Empirical Results

The model presented in Chapter II states that uncertainty about period t profits given information from period t-1, $R_t|\Psi_{t-i}$, depends upon information about expected and unexpected inflation known by the end of period t-1:

$$(4.1)\quad R_t|\Psi_{t-1} = \delta + F(\theta(B)\hat{p}_t^{\,e}|\omega_{t-1},\ \eta(B)(\hat{p}_{t-1}-\hat{p}_{t-1}^{\,e}|\omega_{t-2}) + v_t^R .$$

Substituting the dispersion of profit rates, $DISP_t$, for $R_t|\Psi_{t-1}$ and linearizing gives:

$$(4.2)\quad DISP_t = \delta + \sum_{j=0}^{\wedge} \theta_j(\hat{p}_{t-j}^{\,e}|\omega_{t-j-1}) + \sum_{j=1}^{n} \eta_j(\hat{p}_{t-j}-\hat{p}_{t-j}^{\,e}|\omega_{t-j-1}) + e_t \quad .$$

The profit figures used in constructing the dispersion index are quarterly (at seasonally adjusted annual rates) from 1954:3-1981:1 for the following broadly defined industries:

- Mining
- Construction
- Manufacturing Industries
  - Food and kindred products
  - Chemicals and allied products
  - Petroleum (including integrated) and coal products
  - Primary metal industries
  - Fabricated metal industries
  - Machinery, except electrical
  - Electrical and electronic equipment
  - Motor vehicles and equipment
  - All other manufacturing
- Transportation and public utilities
- Wholesale and retail trade
- Services[6]

Profits include the Inventory Valuation Adjustment (IVA) but do not include the Capital Consumption Adjustment (CCA).[7]

Although reported profits may not always provide an accurate measure of true profits, I hope that the dispersion of reported profits behaves in a manner similar to the dispersion of true profits.

The index is calculated using the following formula:

$$DISP_t = \sum_{i=1}^{14} \left(\frac{A_{it}}{\sum_{j=1}^{14} A_{it}} \right) \left| \left(\frac{\pi_{it}}{A_{it}} - \frac{\sum_{j=1}^{14} \pi_{jt}}{\sum_{j=1}^{14} A_{jt}} \right) \right| \times 100$$

where

A_{it} = total assets of industry i at time t,[8]

π_{it} = total profits of industry i at time t.

DISP is a weighted average -- each industry is weighted by its percentage of the total assets of the industries -- of the deviations from average of the rates of return on assets. The variable $\frac{\sum_{j=1}^{14} \pi_{jt}}{\sum_{j=1}^{14} A_{jt}}$ is used instead of, for example, $\sum_{j=1}^{14} \frac{\pi_{jt}}{A_{jt}}$ because the former provides a weighted average rate of return while the latter is unweighted.[9] The data for assets are available only on an annual basis up through 1978. (Each income year covers July 1-June 30, so the 1978 income year covers 1977:3-1978:2). Therefore, in the variable DISP, assets remain constant through the income year while profits may change from quarter to quarter.

There is at least one major problem with using $DISP_t$ to indicate $R_t | \Psi_{t-1}$: some changes in relative business profits may be predictable. For instance, some firms may know that their profits are more susceptible to changes in business conditions than the average firm, and this could result in cyclical behavior in the variable DISP. To account for this possibility I revise (4.2) as follows:

$$(4.3)\quad DISP_t = \delta + \sum_{j=0}^{n} \theta_j (\hat{p}^e_{t-j} | \omega_{t-j-1})$$

$$+ \sum_{j=1}^{n} \eta_j (\hat{p}_{t-j} - \hat{p}^e_{t-j} | \omega_{t-j-1}) + a_1 CAP_t + a_2 CAP_t^2$$

$$+ e_t ,$$

where CAP is the rate of capacity utilization for manufacturing.[10]

In Table 4-1, I present estimates of (4.3) using least-squares regression corrected for first-order autocorrelation.[11] The effect of inflation expected in the current period is to increase the dispersion of profits, possibly because many firms are unable to adjust prices over a period as short as one quarter, even if they expect a certain amount of inflation to occur over the period. In later periods as firms are able to fully adjust prices, profit dispersion falls. The sum of the coefficients does not differ significantly from zero.

The strong positive effect of unexpected inflation (lagged up to eight quarters for the CPI and six quarters for the GNP deflator) on DISP is as expected. However, the timing of the effect is difficult to explain. The mean length of lag is 4.68 quarters in the CPI regression and

TABLE 4-1

OLS REGRESSIONS OF PROFIT DISPERSION ON EXPECTED AND UNEXPECTED INFLATION AND CAPACITY UTILIZATION

Variable	CPI, 1957:1-1978:2 (1)	GNP Deflator, 1956:3-1978:2 (2)
Intercept	27.0* (2.74)	27.7* (2.46)
$\hat{P}_t^e$	.189 (1.60)	.220 (1.17)
$\hat{P}_{t-1}^e$	-.429* (-3.78)	.151 (.425)
$\hat{P}_{t-2}^e$	-.117 (-1.06)	-.249 (-.668)
$\hat{P}_{t-3}^e$	-2.44* (-2.06)	-.576 (1.77)
sum	-.601 (-1.57)	-.454 (-1.50)
$\hat{P}_{t-1}-\hat{P}_{t-1}^e$	-.085 (-.949)	.028 (.530)
$\hat{P}_{t-2}-\hat{P}_{t-2}^e$	.122 (1.21)	-.028 (-.182)
$\hat{P}_{t-3}-\hat{P}_{t-3}^e$	.168 (1.43)	.122 (.725)
$\hat{P}_{t-4}-\hat{P}_{t-4}^e$	.425* (3.68)	.355* (2.62)
$\hat{P}_{t-5}-\hat{P}_{t-5}^e$	.401 (4.02)	.341* (2.85)
$\hat{P}_{t-6}-\hat{P}_{t-6}^e$	.343* (3.11)	.228* (2.47)
$\hat{P}_{t-7}-\hat{P}_{t-7}^e$	.198 (1.89)	------
$\hat{P}_{t-8}-\hat{P}_{t-8}^e$	.253* (3.02)	------
sum	1.89* (3.27)	1.05* (2.09)
CAP_t	-.656 (-2.68)	-.702 (-2.40)
CAP_t^2	.0044 (2.87)	.0048* (2.69*)
$\hat{\rho}$	.729 (8.44)	.849* (14.6)
SSE	.423	5.07
R^2	.589	.439
$\bar{R}^2$	.508	.349

* Indicates statistical significance at the .05 level.

4.15 quarters for the deflator, but the effect is strongest in the fourth quarter and after. It is possible that ambiguities in profit accounting practices lead to this strange lag pattern. Since corporations may manipulate profit figures for tax purposes, it may be necessary to look at profit behavior over several periods to get an accurate result. It is also possible that the rate of return on individual capital investment projects respond differently to unanticipated inflation, and this results in the delayed response of profit dispersion to inflation surprises.

As for the cyclical behavior of the series, the pattern of signs of the coefficients of CAP_t and CAP_t^2 indicates that $DISP_t$ is greater at very high and very low rates of capacity utilization. The minimum value of DISP occurs at a capacity utilization rate of 73.13.

To test whether the results presented above are sensitive to the inflation expectations variable used, I performed the same set of regressions using expectations of the CPI from the Livingston survey. Since the shortest time period over which respondents are asked to predict inflation is six months, the dispersion index uses six-month instead of quarterly profit figures.[12] The results, presented in Table 4-2, are not very different from those using my expectations data, although for unexpected inflation the sum of the coefficients for three six-month periods is not statistically significant.

TABLE 4-2

OLS REGRESSIONS OF PROFIT DISPERSION USING
LIVINGSTON INFLATION EXPECTATIONS DATA, SIX MONTHS DATA,
1957:2 - 1978:1

Variable	
Intercept	7.71 (.601)
$\hat{p}_t^e$	-.222* (-3.07)
$\hat{p}_{t-1}^e$	.116 (1.62)
sum	-.106 (-1.73)
$\hat{p}_{t-1}-\hat{p}_{t-1}^e$	-.021 (-.434)
$\hat{p}_{t-2}-\hat{p}_{t-2}$	.048 (1.03)
$\hat{p}_{t-3}-\hat{p}_{t-3}^e$	.096* (1.99)
sum	.123 (1.33)
CAP_t	-.217 (-.677)
CAP_t^2	.0018 (.900)
SSE	2.79
$\hat{\rho}$	.700* (6.07)
R^2	.568
$\bar{R}^2$	.479

4.4 - Conclusion

The tests performed in this chapter indicate that an unexpected burst of inflation in the current period increases the dispersion of industry profits up to eight quarters later. For an individual firm, it may be harder to predict future profits (and the effects of various strategy alternatives on future profits) if the firm has experienced recent episodes of unanticipated inflation.

In no case does anticipated inflation have a positive overall effect on profit dispersion. In fact, what effect there is is uniformly negative, although the sums of the coefficients are not statistically significant.

These findings should be regarded as only an initial step in the process of investigating inflation's effect on profit dispersion, since the data used here only allow for comparison of profits between very broad industry groupings. The results of tests using profit data for more narrowly defined industries may be quite different.

CHAPTER IV

NOTES

CHAPTER IV

NOTES

[1]The period of time studied for the U.S. does not include any significant episodes of deflation, so my primary concern is the effect of inflation. However, price level changes in any direction could have an effect on the dispersion of profits.

[2]There is some argument as to the direction of causality in this relationship. Some feel that with downward price rigidity the necessity for relative price changes causes higher inflation rates. Cukierman (1979) states his belief that the variance of general price changes and individual price changes are both affected by common exogenous variables, such as the variance of aggregate and relative excess demand shocks.

[3]Parks also looks at data from the Netherlands and finds the effect of price changes on the relative price change variance to be primarily the result of deflation, not inflation.

[4]The coefficient for expected inflation is negative but not significant for the period 1948:1-1955:4.

[5]Fischer gets similar results using expectations generated from time series models for both the U.S. and Germany, except that for the U.S. the growth rate of real GNP and changes in money stock have independent effects on VARDEF.

[6]Source: Citibase Data Tape.

[7]IVA corrects the understatement of inventory costs arising from firms using FIFO accounting. CCA corrects the distortion in reported depreciation by taking account of the accelerated depreciation allowed by tax laws and the difference between replacement cost and historic cost. These adjustments are discussed by Shoven and Bulow (1975).

[8]Source: Internal Revenue Service, Statistics of Income, Corporation Income Tax Returns, U.S. Government Printing Office.

[9]This makes the index similar to the indices of price dispersion commonly used because the average rate of price change is, of course, based on a weighted price index.

[10]Source: Citibase Data Tape.

[11]The method for dealing with autocorrelated errors is that used in TSP, Version 3.5 and is due to Beach and MacKinnon (1978).

[12]Since the figures are seasonally adjusted annual rates, the six month profits are taken to be the average of the two quarterly figures.

CHAPTER V

INFLATION-INDUCED UNCERTAINTY AND ECONOMIC ACTIVITY

5.1 - Introduction

The aggregate supply function presented in Chapter II (equation 2.7) implies that increased uncertainty about business profits leads to reduced output growth and increased unemployment in future periods. If this uncertainty is caused by increased inflation, the result could well be the positively-sloped "long term" Phillips Curve described by Friedman (1977). In Chapters III and IV, I found some evidence that inflation induces increases in the level of profit uncertainty, so in this chapter I attempt to determine if inflation-induced uncertainty has a significant effect on output growth and unemployment.

I review previous research on the effects of inflation-induced uncertainty on investment, growth, and unemployment in Section 5.2. I also look at some research on the role of energy price increases in the observed "stagflation" of the last decade. In Section 5.3, I estimate output growth and unemployment equations based on the model of Chapter II. To proxy uncertainty I use some of the measures used by other researchers as well as some of those I have already used in Chapters III and IV.

5.2 - Previous Research

Recent empirical research on the effects of inflation on economic activity uses as a starting point Friedman's Nobel Lecture in which he suggests the possibility of a positively-sloped Phillips Curve. Friedman (1977) presents no evidence other than the fact that for seven large industrialized countries the rates of inflation and unemployment rose simultaneously over much of the 1970s. In the research that followed, most of the authors look at the effects of either uncertainty in forecasting inflation or the dispersion of relative prices on economic activity, maintaining (or sometimes testing) the assumption that inflation is positively associated with the variable used.

A. Inflation-Induced Uncertainty and Investment

Able (1980) modifies a neoclassical investment model to include the effect of uncertainty regarding future profits on gross investment. In its simplest form his model is:

$$I_t = \sum_{i=1}^{n} w_i \,\Delta\left(\frac{pQ}{c}\right)_{t-i} - \sum_{i=1}^{n} \gamma_i \Delta U_{t-i} + \delta K_{t-1}$$

where

I = gross investment
p = price of output
Q = quantity of output
c = cost of capital
U is the uncertainty variable
K = capital stock
w's, γ's, and δ are coefficients (δ is the rate of depreciation).

The variable he uses to indicate uncertainty about business profits is based on the variance of the price level,

$$U = \frac{var(p)Q^2}{c}$$

$Var(p)Q^2$ is assumed to be proportional to the variance of profits. The problems associated with using this type of variable to indicate uncertainty were discussed in Chapter III.

When Able estimates the above equation with $c = q(r+\delta)$ where q = the purchase price of capital and r = the rate of interest, he finds that errors in forecasting investment for the period 1975:1-1978:4 are substantially smaller with this model than they are with a model where the uncertainty variable is excluded. Uncertainty has a significant negative effect on investment in both equipment and structures.[1]

B. Inflation-Induced Uncertainty, Output Growth, and Unemployment

Four recent articles investigate the effects of uncertainty caused by inflation on other real economic variables. Levi and Makin (1980) and Mullineaux (1980) look at the effects of uncertainty in forecasting inflation, while Blejer and Leiderman (1980) and Korteweg (1979) consider the effects of relative price dispersion. Levi and Makin attempt to estimate the effect of inflation uncertainty on employment using a modified Lucas-type model of the form:

$$\hat{N}_t = b_0 + b_1(\hat{p}_t - \hat{p}_t^{\,e}) + b_2\sigma_t + \mu_t$$

where $\hat{N}$ is the percentage change in employment, $\hat{p}$ and $\hat{p}^e$ are the percentage change in price level and expected price level (from the Livingston survey), respectively, and σ_t is the standard deviation of expectations from the Livingston survey. The coefficient b_2 is negative and significant for the periods 1948-1975 and 1965-1975 using both six- and twelve-month inflation expectations.[2] They attempt to determine whether the positive impact of unexpected inflation on employment outweighs its indirect negative impact on employment (through increased inflation uncertainty) by calculating β-statistics. They find that the latter effect is stronger and conclude that the Phillips Curve is positively sloped, at least for unexpected inflation.

Unlike Levi and Makin, Mullineaux considers lags in the effect of inflation uncertainty on economic activity, an approach more in line with the theory of how inflation affects real variables. Otherwise, his approach is similar to theirs expect for the choice of dependent variable (the expectations data is the same). His model is:

$$U_t = \alpha + \sum_{i=1}^{k} \gamma_i U_{t-1} + \beta(\hat{p}_t - \hat{p}_t^{\,e}) + \sum_{j=0}^{r} \lambda_j \sigma_{t-j} + \mu_t$$

where U is the unemployment rate in some regressions and industrial production in others. The inclusion of lagged values of the dependent variable places his test in a Granger causality framework. He finds that σ has a positive and significant effect on unemployment and a negative and significant effect on industrial production for lags of an incredible number of years: up to eleven for unemployment and seven for industrial production. Since he finds σ_t to be a function of lagged inflation surprises, he concludes that, "...even if (contrary to rational expectations theory) it were possible to generate a sustained unanticipated increase in the rate of inflation, within a fairly short period the effect of added uncertainty in increasing unemployment would more than offset the employment gains from unanticipated inflation." (p. 166). However, his result is somewhat sensitive to the measure of inflation uncertainty used. When he replaces the standard deviation of expectations from surveys with a six-term moving standard deviation of inflation, he gets an insignificant effect for the periods 1950-1975 and 1953-1975 but significant (although weaker than before) effects for most subperiods.[3]

Blejer and Leiderman use a similar approach to estimate the effects of relative price dispersion on real output and unemployment. Their model is (for annual data 1949-1975):

$$X_t = b_1 + b_2 t + b_3 X_{t-1} + b_4(\hat{p}_t - \hat{p}_t^{\,e}) + b_5 V_t + \mu_t$$

where X_t is the log of either real GNP or unemployment, and t is a time trend. Inflation expectations, $\hat{p}_t^{\,e}$, are generated by a second-order autoregressive process. In some regressions $V_t = VP_t = \sum_{i=1}^{h} w_{it}(\hat{p}_{it} - \hat{p}_t)^2$, an index of relative price dispersion using the same data used by Parks (1978) and discussed in Chapter IV. In other regressions they account for lagged effects by letting $V_t - VP_t + VP_{t-1}$ or $VP_t + VP_{t-1} + VP_{t-2}$. The coefficient for V_t is significant with the expected sign except in the unemployment regression for the purely contemporaneous effect case.[4]

Korteweg's much more complex model of output and unemployment in the Netherlands includes changes in the "natural rate of unemployment", exchange rates, fiscal policy, agricultural production, and world trade as well as relative price variance. He finds a significant negative effect of relative price dispersion lagged half a year on the annual growth rate of Dutch output for the period 1954-1976, and a significant positive effect on unemployment.

C. Other Potential Causes of "Stagflation"

The existence of "stagflation", high or rising rates of inflation accompanied by high or rising rates of unemployment, in the United States and many other countries in recent years does not necessarily imply a causal relationship between inflation-induced uncertainty and unemployment. This phenomenon could well be the result of a series of events that tend to push up both inflation rates and unemployment rates, the most important of which are probably the recent periods of rapidly rising energy prices. I have already discussed in Chapter II Rasche and Tatom's (1977) model of the effects of changes in the relative price of energy inputs on productivity and economic capacity. Tatom's subsequent (1981) study of the effects of rising energy prices on real output growth and unemployment finds a strong short-term reduction in growth and increase in unemployment. He finds the effect to dissipate after six quarters with no long-term effect on growth rates or unemployment, but a permanently reduced level of real GNP (a decline in potential GNP).

Of the studies dealing with the effects of inflation-induced uncertainty described above, only Korteweg considers the effects of other factors on economic activity, but even his model does not explicitly account for energy price changes. It is possible, therefore, that these researchers have overestimated the effects of inflation-induced uncertainty on real variables due to bias caused by omitted variables. It is also possible that Tatom overestimates the effect of relative energy price changes by not considering inflation-induced uncertainty. Therefore, I include both of these effects in the models of growth and unemployment estimated in the next section.

5.3 - Empirical Results

I estimate below the following two equations corresponding to equations (2.17) and (2.18) from Chapter II.

$$(5.1) \quad \hat{y}_t = \alpha_0 + \gamma_1(\hat{M}_t - \hat{M}_t^e | \omega_{t-1}) + \sum_{j=1}^{n} \beta_j(\hat{c}_{t-j} - \hat{p}_{t-j}) + \sum_{i=1}^{n} \phi_i \, R_t | \Psi_{t-i} + e_{1t} \, .$$

$$(5.2)\quad \hat{u}_t = \alpha_5 + \tau_1(\hat{M}_t - \hat{M}_t^{\,e}|\omega_{t-1}) + \alpha_6 \sum_{j=1}^{n} \beta_j (\hat{c}_{t-j} - \hat{p}_{t-j})$$

$$+ \alpha_6 \sum_{i=1}^{n} \phi_i \; R_t|\Psi_{t-i} + e_{2t} .$$

The changes in both output and unemployment are functions of unexpected money supply growth, lagged values of the growth of energy prices relative to actual inflation, and past and present profit uncertainty. The endogenous uncertainty variable, R_t, is a function of anticipated and unanticipated inflation:

$$(5.3)\quad R_t|\Psi_{t-1} = \delta + F[\theta(B)\hat{p}_t^{\,e}|\omega_{t-1},\; \eta(B)(\hat{p}_t - \hat{p}_t^{\,e}|\omega_{t-1})]$$

$$+ v_t^{R} .$$

I estimate (5.1) and (5.2) for quarterly data using two-stage least squares with the first stage a regression of R_t on the exogenous variables in the model. Unlike ordinary least squares, this provides consistent estimates even if the error term v_t^R is correlated with e_{1t} or e_{2t}.

I use the GNP deflator as the price index, since the variable $(\hat{c}_t - \hat{p}_t)$ is actually a proxy for the price of energy relative to the prices of all other factors of production, and this is more closely approximated by comparing c to a comprehensive price index like the GNP deflator than to the CPI. The inflation expectations variable is that estimated in Chapter III, and the money stock measure is M1B.[5] A χ^2 test indicates that deseasonalized money growth is a random walk, so $\hat{M}_t^{\,e}$ is just $\hat{M}_{t-4}$. To measure the price of energy inputs, c, I use, as Rasche and Tatom (1977) do, the price index for "fuels and related products and power", a component of the Producer Price Index. The dependent variables are real GNP and the unemployment rate of the Civilian Labor Force aged 16 and older. The log differences are multiplied by 100 to get the quarterly growth rates (not at annual rates) in percentage terms.

I use four different proxies for R_t, the first of which is $DISP_t$, the index of profit dispersion from Chapter IV. The results using this variable are presented in Table 5-1. The instruments for $DISP_t$ other than the exogenous variables in the equation are $\hat{p}_t, \ldots, \hat{p}_{t-3}$ and $\hat{p}_{t-1}-\hat{p}^e_{t-1}, \ldots, \hat{p}_{t-6}-\hat{p}^e_{t-6}$, expected inflation in the current and three lagged periods and unexpected inflation for six lagged periods.[6] Profit dispersion has no effect on either $\hat{y}_t$, the growth of real GNP, or $\hat{u}_t$, the growth of unemployment. The unexpected money growth variable, $\hat{M}_t - \hat{M}_t^e$, has the expected positive and significant effect on $\hat{y}_t$, but the effect on $\hat{u}_t$ is not significant. An increase in the relative price of energy results in reduced growth of output and increased unemployment over the subsequent four quarters, but the effect is partially offset in the fifth quarter. The use of lagged values of DISP does not affect the result nor does removal of the energy price variables from the equation.[7]

The Durbin-Watson statistics indicate the possibility of autocorrelated errors especially in the $\hat{u}$ equation.

TABLE 5-1

2SLS ESTIMATION OF REAL GNP AND UNEMPLOYMENT GROWTH EQUATIONS USING PROFIT DISPERSION AS THE PROXY FOR UNCERTAINTY, 1956:2-1978:2

Dependent Variable	(1) $\hat{y}_t$	(2) $\hat{u}_t$
Intercept	.757 (1.26)	1.16 (.244)
$\hat{M}_t-\hat{M}_t^e$	.219 (2.03)	-.648 (-.763)
$\hat{c}_{t-1}-\hat{p}_{t-1}$	.009 (.238)	-.011 (-.038)
$\hat{c}_{t-2}-\hat{p}_{t-2}$	-.060 (-1.46)	.308 (.948)
$\hat{c}_{t-3}-\hat{p}_{t-3}$	-.017 (-.409)	.168 (.513)
$\hat{c}_{t-4}-\hat{p}_{t-4}$	-.129 (-3.12)	.774 (2.39)
$\hat{c}_{t-5}-\hat{p}_{t-5}$	.054 (1.41)	-.159 (-.532)
sum	-.143 (-2.72)	1.08 (2.62)
$DISP_t$	.081 (.272)	-.532 (-.229)
SSE	64.2	3970
S.E.	.913	7.18
D-W	1.47	1.07

t-statistics are in parentheses.

Estimating the equations by two-stage least squares with a correction for autocorrelated errors does not substantially alter any of the results presented in this chapter.

The second proxy for R_t is the variable RP_t, an index of the dispersion of relative prices. As mentioned in Chapter IV, greater relative price dispersion may imply increased uncertainty about profits. In fact, because of the problems associated with using profit data, relative price dispersion may be a better indicator of profit uncertainty than the dispersion of profits. The variable I use is of the same type used by Parks (1978), except that energy-related commodities are not included:[8]

$$(5.4) \quad RP_t = \sum_{i=1}^{10} w_{it}(\hat{p}_{it} - \hat{p}_t)^2 ,$$

where the w's are weights (summing to one) based on Personal Consumption Expenditures for commodity i (i=1,2, ..., 10), $\hat{p}_{it}$ is the rate of change of the implicit deflator of PCE for commodity i, and $\hat{p}_t$ is the weighted average rate of price change for the ten commodities. The commodities included in the index are: motor vehicles and parts, furniture and household equipment, and other durable goods; clothing and shoes, food, and other nondurable goods; housing, household operations, transportation, and other services.[9]

Results using RP_t are presented in Table 5-2. The first stage is a regression of RP_t on the exogenous variables in the equation and $\hat{p}_{t-1}$. The choice of $\hat{p}_{t-1}$ as an instrument is based on OLS regressions of RP_t on lagged

TABLE 5-2

2SLS ESTIMATION OF REAL GNP AND UNEMPLOYMENT GROWTH EQUATIONS USING THE STANDARD DEVIATION OF LIVINGSTON INFLATION EXPECTATIONS AS THE PROXY FOR UNCERTAINTY, SIX-MONTH DATA, 1955:2-1979:2

Dependent Variable	(1) $\hat{y}_t$	(2) $\hat{y}_t$	(3) $\hat{u}_t$	(4) $\hat{u}_t$
Intercept	1.26 (3.46)	1.50 (5.53)	-1.24 (-.509)	-3.62 (-1.98)
$\hat{M}_t-\hat{M}_t^e$	.199 (1.89)	.250 (2.13)	-.560 (-.795)	-.790 (-1.00)
$\hat{c}_{t-1}-\hat{p}_{t-1}$	-.020 (-.562)	------	.168 (.700)	------
$\hat{c}_{t-2}-\hat{p}_{t-2}$	.0005 (-.010)	------	.114 (.353)	------
$\hat{c}_{t-3}-\hat{p}_{t-3}$	-.026 (.620)	------	.270 (.962)	------
$\hat{c}_{t-4}-\hat{p}_{t-4}$	-.117 (-2.78)	------	.606 (2.15)	------
$\hat{c}_{t-5}-\hat{p}_{t-5}$	.079 (2.01)	------	-.305 (-1.15)	------
sum	-.084 (-1.01)	------	.853 (1.53)	------
RP_t	-.839 (-.816)	-1.68 (-2.70)	2.01 (.292)	10.00 (2.40)
SSE	64.8	95.6	2990	4311
S.E.	.911	1.07	6.10	7.21
D-W	1.69	1.53	1.35	1.23

t-statistics are indicated in parentheses.

actual, expected, and unexpected inflation. The results differ depending on whether the relative price of energy is included in the equations. In equations (2) and (4), the results are similar to the findings of Blejer and Leiderman (1980): increased relative price dispersion causes a significant reduction in the growth of output and increased unemployment. There is no evidence of lagged effects using the index stripped of energy-related products, but when these products are included in RP, lags of up to four quarters are significant. In the full model estimated in equations (1) and (3), the effects of relative price dispersion are greatly reduced and are not statistically significant. As in Table 5-1, the effects of changes in the relative price of energy on output growth and unemployment are significant over five quarters. However, the sums of the coefficients are smaller and fall short of statistical significance.

The third proxy for R_t is SD_t, the standard deviation of inflation expectations for period t from the Livingston survey of period t-1. This is the same variable used by Levi and Makin (1980) and Mullineaux (1980) to indicate uncertainty in forecasting inflation, a possible indicator of profit uncertainty. Since the survey is taken only every six months, all of the data is converted to six-month growth rates rather than quarterly ones.

Table 5-3 presents results using SD_t as the uncertainty variable. The excluded instrument is $\hat{p}_{t-1}$. As with relative

TABLE 5-3

2SLS ESTIMATION OF REAL GNP AND UNEMPLOYMENT GROWTH EQUATIONS USING THE STANDARD DEVIATION OF LIVINGSTON INFLATION EXPECTATIONS AS THE PROXY FOR UNCERTAINTY, SIX-MONTH DATA, 1955:2-1979:2

Dependent Variable	(1) $\hat{y}_t$	(2) $\hat{y}_t$	(3) $\hat{u}_t$	(4) $\hat{u}_t$
Intercept	2.00 (3.76)	2.60 (5.87)	-1.10 (-.253	-5.93 (-1.63)
$\hat{M}_t-\hat{M}_t^e$	.219 (1.57)	.202 (1.43)	-1.38 (-.121)	.012 (.011)
$\hat{c}_{t-1}-\hat{p}_{t-1}$	-.061 (-1.21)	------	.449 (1.10)	------
$\hat{c}_{t-2}-\hat{p}_{t-2}$	-.079 (-1.61)	------	.668 (1.66)	------
sum	-.140 (-1.99)	------	1.12 (1.96)	------
SD_t	-.202 (-.408)	-.870 (-2.39)	.868 (.215)	6.20 (2.08)
SSE	89.4	98.3	5949	6595
S.E.	1.43	1.46	11.6	12.0
D-W	1.55	1.53	1.34	1.36

t-statistics are in parentheses.

price dispersion, SD_t has a significant negative effect on $\hat{y}_t$ and positive effect on $\hat{u}_t$ (similar to the finding of Levi and Makin) if energy price variables are omitted from the equations. However, the effect is reduced to almost nothing when the impact of relative energy price changes over two periods is accounted for. No evidence of lagged effects is found.

I use a fourth proxy for uncertainty, $\hat{\sigma}_t^2$, the conditional forecast variance of the GNP deflator (i.e., the fitted values of a regression of the squared residuals from the inflation expectations model of Chapter III on the lagged value of the GNP deflator) in OLS estimates of the real GNP and unemployment equations. The results, presented in Table 5-4, are the same as those for RP_t and SD_t, i.e., a significant effect appears only when the relative price of energy is excluded.

To test whether the effects of changes in the relative price of energy on output growth and unemployment are due totally to the two periods of energy price shocks, I added a dummy variable for these periods in all of the regressions reported above. The variable is the same as that used in Chapter III, where D = 1 for 1973:1-1975:1 and 1979:2-1980:3 and 0 otherwise. For six month data the periods covered are 1973:1-1975:1 and 1979:1-1980:2. In no case is D significant when lagged values of the relative price of energy are included in the equation, and the coefficients for these variables change little.

TABLE 5-4

OLS ESTIMATION OF REAL GNP AND UNEMPLOYMENT GROWTH EQUATIONS WITH THE CONDITIONAL FORECAST VARIANCE OF THE GNP DEFLATOR AS THE PROXY FOR UNCERTAINTY, 1956:2-1981:2

Dependent Variable	(1) $\hat{y}_t$	(2) $\hat{y}_t$	(3) $\hat{u}_t$	(4) $\hat{u}_t$
Intercept	.868 (2.75)	1.41 (5.37)	1.21 (.496)	-2.86 (-1.43)
$\hat{M}_t-\hat{M}_t^e$	.284 (2.91)	.309 (3.20)	-.892 (-1.18)	-1.02 (-1.39)
$\hat{c}_{t-1}-\hat{p}_{t-1}$	-.031 (-.993)	------	.143 (.584)	------
$\hat{c}_{t-2}-\hat{p}_{t-2}$	-.025 (-.683)	------	.165 (.578)	------
$\hat{c}_{t-3}-\hat{p}_{t-3}$	-.030 (-.791)	------	.335 (1.15)	------
$\hat{c}_{t-4}-\hat{p}_{t-4}$	-.102 (-2.78)	------	.605 (2.14)	------
$\hat{c}_{t-5}-\hat{p}_{t-5}$	.036 (1.06)	------	-.137 (-.514)	------
sum	-.152 (-2.79)	------	1.11 (2.64)	------
$\hat{\sigma}_t^2$	.358 (.121)	.584 (-2.57)	-13.2 (-.579)	31.2 (1.88)
SSE	77.0	89.6	4594	5175
S.E.	.910	.956	7.03	7.27
R^2	.277	.158	.163	.057
D-W	1.66	1.54	1.43	1.33

t-statistics are in parentheses.

In summary, there is no evidence that inflation-induced uncertainty results in reduced output growth or increased unemployment if the effects of energy price shocks are accounted for. The result is not sensitive to the choice of a proxy for uncertainty. The effects of changes in the relative price of energy on real GNP and unemployment are of roughly the same magnitude as those found by Tatom (1981), although in some of the regressions the sum of the coefficients of the lagged values of the relative energy price variable falls short of statistical significance.

5.4 - Conclusion

In this chapter I have found that, although higher inflation may increase the level of economic uncertainty in the economy, the effect is not great enough to cause a significant impact on output growth or unemployment. There is, therefore, no evidence that the Phillips Curve has a positive slope as suggested by Friedman. This result is contrary to recent empirical research that investigates the effects of inflation-induced uncertainty on economic activity, but does not account for the possibility that rapid energy price increases have had qualitatively similar effects.

CHAPTER V

NOTES

CHAPTER V

NOTES

[1]In a more complex model incorporating the effects of taxation policies on the cost of capital, Able shows that "...the impact of stimulative tax policy measures on investment spending is impaired when inflation uncertainty is high." (p. 10).

[2]They also find that the inclusion of σ_t causes b_1 to increase, which they argue supports Lucas's contention that increased inflation uncertainty causes less of an expansionary effect of unexpected inflation.

[3]Recall the discussion in Chapter III, however, about the problems with using a moving standard deviation of inflation as a measure of uncertainty in forecasting inflation.

[4]They get similar results with equations excluding the unexpected inflation term.

[5]For the pre-1959 period the series is M1 adjusted to make it comparable to the M1B series that starts in 1959. The adjustment procedure is due to Koch (1980).

[6]Results with CAP_t, the capacity utilization rate for manufacturing, and CAP_t^2 added to the list of instruments are almost identical to those reported in the text.

[7]I ran some regressions including variables designed to account for changes in labor productivity resulting from the changing composition of the labor force, but they did not have a significant effect. The variables used were the average experience level of the labor force (average age minus years of schooling minus five), the average education level, and the average labor force participation rate of women (all in logs).

[8]Energy-related commodities are excluded, so that the effects of changing relative energy prices and changes in the relatives prices of other commodities can be clearly separated.

[9]The excluded categories for which data is available are fuel oil and coal, gasoline and oil, and electricity and gas.

CHAPTER VI

CONCLUSIONS

This dissertation investigates the relationship between inflation and the level of economic uncertainty and considers the implications for output growth and unemployment. The principal findings are:

1. There is some evidence of a positive relationship between the rate of inflation and uncertainty in forecasting inflation, but the results are sensitive to the method used in measuring uncertainty, the time period studied, and the price index used.

2. Unexpected inflation results in greater dispersion of corporate profits across broadly defined industries, a possible indication that the level of producer uncertainty about profits is increased.

3. There is no evidence that inflation-induced uncertainty affects output growth of unemployment once one accounts for the effects of energy-related supply shocks.

Several aspects of this study distinguish it from previous research. First, the study is unique in its use of the following proxies for uncertainty: (1) the variance of estimated inflation forecast errors based on a rational inflation expectations model for the U.S. for the period

1954-1981, (2) the percentage of workers covered by contracts with built-in cost-of-living adjustments, and (3) the average maturity of outstanding government debt. Second, it deals empirically with inflation's effect on the dispersion of profits, whereas other research has focused on the dispersion of price or wage changes. Third, it provides a framework that accounts for the effects of both inflation-induced uncertainty and energy-related supply shocks on output growth and unemployment.

The major policy implication of this study is that anti-inflation policies should not be pursued under the assumption that output growth will be higher and unemployment lower in the long term as a result of the action. This implies that an existing positive inflation rate may be preferable to a reduction in the rate that results in a short term loss of output. However, there are still substantial costs associated with an inflationary economy, the most important being those arising from the redistributions of wealth that result. The damage to the quality of life and the social fabric that Okun and Ackley have spoken of may still be considerable. Whether the extent of inflation-induced redistributions can be most effectively reduced by lowering the average rate of inflation or by modifying the institutional structure that causes them remains an important question for future research.

There remain several other areas for future research as well. First, more research on the effects of inflation (or inflation-induced uncertainty) on investment is needed, since much of the data on investment have been revised recently. Furthermore, it is important to study the effects of inflation on long-term versus short-term investment as well as on aggregate investment. Second, research should attempt to determine whether the effect on economic activity of changes in the relative price of energy is a reflection of changes in the productivity of the existing labor and capital stock or of its effect on the level of uncertainty. Third, the nature of the institutional responses to inflation (e.g., increased indexation of contracts, changes in the regulation of financial institutions, and changes in the treatment for tax purposes of inflation-induced increases in nominal income) and the implications for the inflation-uncertainty relationship should be explored. Fourth, research should examine data from other countries that have experienced "stagflation" to determine whether the results regarding the effects of inflation-induced uncertainty and oil price shocks differ from those for the U.S. Fifth, an empirical investigation of the aggregate demand effects of inflation-induced uncertainty arising from, for example, changes in savings behavior would be worthwhile. Sixth (and most important), more consideration should be given to the meaning of "uncertainty" in this context.

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