

Inflation and productivity growth in the Federal Republic of Germany

I am after all this, left with the outstanding problem in inflation theory: Why do people seem to hate it? Why does it drive politicians to destructive frenzy? (Frank Hahn, Money and Inflation)

1. Introduction

The relationship between inflation and real economic activity has become a topic of increasing concern to economists as stagflation has come to dominate policy discussions in the 1970s and 1980s. The earlier "monetarist counter-revolution" and accelerationist attacks on the Phillips curve had set the stage, and writers such as Hayek (1945), Leijonhufvud (1981), and Friedman (1977) had emphasized how the informational content of the price system would be blurred by the "noise" resulting from unexpected or fluctuating rates of inflation. Though some evidence has accumulated that higher average inflation is associated with more variable rates of inflation, no compelling theoretical foundations for any such association seem to have emerged as yet.

Moreover, the traditional monetarist emphasis on the conceptual and empirical independence of absolute and relative prices may also help to explain why it is only since Vining and Elwertowski (1976) that the connection between the variance of relative prices and the rate of inflation has been examined. The authors are Associate Professor of Economics at Temple University and Research Fellow of the International Institute of Management, West Berlin, respectively.

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inflation has been systematically explored.¹ Ancillary research has been undertaken to determine, empirically, the direction of causation in this relation. But this work has been unable to distinguish between competing theoretical explanations (see Fischer, 1981). The real economic cost of this relationship is well documented for the United States (Blejer and Leiderman, 1980).

An additional open question remains. Namely, does inflation cause productivity declines, or does declining productivity cause inflation? The empirical finding for the United States is that causation runs from prices to productivity (Clark, 1982a; 1982b). However, there are numerous plausible explanations for this finding, between which our data cannot discriminate. Rather than the implication that the empirical findings presented here are suggestive of any particular model, there remains the inevitable conclusion that a more general model of price adjustment and productivity is needed. In the empirical section of the paper the prices-productivity hypothesis is tested with industry level postwar West German data and cannot be rejected. Since West Germany has had the lowest rate of inflation among the major industrial countries for most of the postwar period and suffered little of the declining productivity (-growth) plaguing the United States and the United Kingdom, this represents a fairly stringent test of the hypothesis. The paper closes with implications of the reported research for further investigations.

2. A taxonomy of inflation and productivity

In his Nobel address, Friedman (1977) popularized the idea of shocks perturbing prices in an uneven manner, thus introducing noise into the system of relative prices with the consequence that economic agents are unable to extract relative price information from the overall rate of inflation. The result of this is that firms do not, probably cannot, choose optimal combinations of inputs. With increasing noise in the system the representative firm deviates more frequently from the optimal choice of inputs. Keynes (1935) was not unaware of these problems

¹More recent work in this area includes Sellekaerts and Sellekaerts (1984; 1986) and Glezakos and Nugent (1986). The Sellekaerts and Sellekaerts papers, in particular, allude to the problem of inflation, sluggish relative price adjustment, and the possibility of consequent productivity growth declines, which is the subject of the present paper.

and the implications for the conduct of business and the effectiveness of government policy.²

Friedman's hypothesis has been formalized by Cukierman (1983) in a recent review article. As a result of an inability to distinguish between permanent and transitory shocks to either the supply or the demand side which would lead to price revision in a world of price flexibility and full information, firms produce less than the optimal level of output. Both Cukierman and Friedman leave open the behavioral question of why firms adjust nominal prices periodically in an inflationary environment, thus perturbing real relative prices and disrupting choices of optimal combinations of inputs.

A possible explanation is given by the fixed or "menu-costs" models of price adjustment postulated by Mussa (1978), Sheshinski and Weiss (1977), Rotemberg (1982), and others. These explanations seem plausible but ad hoc because they do not provide a convincing account of these costs.

Stiglitz (1984) offers an interesting menu of explanations for gradual and periodic price adjustment to fill the void. All his scenarios lead to price rigidity and reduced productivity even in a profit-maximizing and inflationary environment. Stiglitz ends with the disturbing conclusion that we need a different theory of price adjustment for every situation as the stylized facts are changed.

The essence of most of the propositions surveyed by Stiglitz had appeared in Okun (1975; 1981). Careful thought suggests that infrequent price change amounts to a service to buyers by reducing their search costs. This idea, in conjunction with the additional issues raised by Stiglitz, can be the basis for explaining the productivity costs of anticipated inflation and discrete price adjustment.

While changes in technology and taste always require periodic adjustment of *some relative* prices, a positive overall rate of inflation necessitates periodic change of *all nominal* prices. However, and this is the first crucial point, each nominal adjustment of an individual price implies a change in the *relative* price of that product with respect to all others. Secondly and less obviously, even if the macro-inflation rate is correctly anticipated, it does not follow that *individual price changes* are predictable. Hence, input choices will seldom be correct in the sense of neoclassical microeconomic theory.

²See, in particular, the appendix to Chapter 6, the end of Chapter 19, and Chapter 21. His solution to the problem was to assume homogeneous, though gradual, price adjustment.

The determination of the size and frequency of price changes requires consideration of the costs of such changes to both consumers and firms. In any case, the growing unreliability of price signals under higher inflation does lead to reduced efficiency.

Consider the effect of the *rate* of (anticipated) inflation on the frequency and magnitude of price increases. Casual empiricism suggests that frequency increases quite rapidly with the rate of inflation, reaching daily or even hourly changes at the peak of historical hyperinflations. The usual (percentage) price-change, however, seems to grow much more slowly, if at all, with the current rate of inflation (Pazos, 1977). Whatever the reasons for this pattern, the theories referenced above predict costs to buyers which grow with the frequency of price-rise-induced search. Thus even anticipated inflation imposes transactions-costs which increase with the rate of this inflation.

Briefly, there are two conflicting influences: more frequent but shorter search episodes, with an ambiguous effect on total search outlays (per unit time) in response to higher inflation. However, we can predict an unambiguous decline in efficiency or total output per unit input in the following sense. The growing unreliability of (nominal) price-signals under higher inflation raises the cost of calculating and finding the best time sequence of input vectors for firms. "Optimally" chosen inputs by agents of bounded "rationality" or calculating ability will thus deviate ever further from the "first-best," benchmark inputs (which an omniscient computer might have chosen) as the effectivity of search declines. Aggregate measures of actually chosen physical inputs or real expenditures will thus yield smaller real net output per "unit input" as these inputs depart further from benchmark optimality at higher levels of inflation.³

³We offer two demonstrations of our assertion. Given an average flow of expenditure, s , on search activity per period by a firm, optimal input vector purchases and output decisions conditional on the information provided by s are made. Let average (expected) profit per period, net of all costs except s , be given by a continuous differentiable function of s and the rate of inflation (π), say $f(s, \pi)$. Since more search yields on average cheaper (or better) inputs, we have

$$f_s > 0$$

and since more inflation renders information on point observations of nominal price relationships obsolete sooner, we have

$$f_\pi < 0.$$

The firm is assumed to maximize value

We would be remiss if we proceeded directly to the empirical evidence confirming the prices-productivity hypothesis if the reverse possibility were not considered at least briefly. It seems quite plausible to suggest that declining productivity is inflationary. As the (rate of change of) output per worker declines it becomes more expensive to produce the same output. But, any general price increases must be validated by the monetary authority. Also, continuously declining productivity does not provide an explanation for periodic adjustment. Finally, the decline in productivity is not endogenous to this explanation.

3. Inflation and production functions

We have argued that even a steady anticipated inflation of the general price level will reduce measured (and unmeasured) productivity. In practice, of course, we observe fluctuating inflation rates in a far-from-stationary world with output growth generated mainly by improved

$$V = f(s, \pi) - s.$$

If $f_{ss} < 0$ then the optimal search outlay $s^*(\pi)$ satisfies

$$f_s(s^*, \pi) = 1$$

and

$$f_{ss}(s^*, \pi) < 0.$$

Substituting s^* into V and differentiating with respect to π gives

$$\frac{dV^*}{d\pi} = f_s \frac{ds^*}{d\pi} + f_\pi - \frac{ds^*}{d\pi}$$

which, using the first order condition above, is clearly less than zero.

The notion of value used here is similar to value-added used in the empirical section of the paper.

As an alternative explanation consider the firm which takes the price, r , of K and the price, w , of L as given in period t . On this basis the firm contracts for K_{t+1}^* units of "fixed" input and plans to hire L_{t+1}^* units of its variable input. As the sun rises on the morning of $t + 1$ the price of L is $w + \pi$. The result is that the firm hires less labor than it planned and uses the capital stock for which it contracted, K_{t+1}^* , less intensively. The problem is that the firm cannot adjust its capital stock continuously, even in the face of fully anticipated inflation. Even though it anticipates inflation exactly, its fixed inputs have a long life and the prices of all inputs do not change in a synchronized fashion.

Thus, by definition of the production function the firm is producing less output than is possible with the contracted amount of "fixed" input for at least some of the periods in the lifetime of the fixed asset.

technology and techniques. While each new product or technology suggests recalculation of optimal input combinations by its potential users, these calculations are also hampered by inflation-induced jumps in the prices of existing commodities. Thus theories of price adjustment suggest that even the anticipated or "trend" component of inflation should impede the factor-productivity increases which are usually ascribed to "technological progress" in growth-accounting exercises.

Productivity indices depend on the underlying production function specification for their validity, and strong assumptions based on purely competitive theory are often built into these calculations. Here we shall use the simplest log-linear specification but with no additional assumptions on the parameters of the production function. Following Lucas (1970) and Nadiri and Rosen (1973) we incorporate measures of the utilization of capital (K) and labor (N) stocks by including electricity consumption (E) and hours per production worker (H) in the estimated relation.⁴ (Also see Feldstein, 1967, on the specification used here.) Real output (Q) is defined as cash-flow plus labor costs, or value-added plus depreciation. This has the advantage that no theory-dependent or arbitrary measure of unobservable depreciation is subtracted from observed quantities.

Using lowercase letters to denote log rates of change, we find that the simplest way to incorporate the influence of inflation on productivity growth (consistent with the previous section) would be to estimate the parameters of (1)

$$(1) \quad q_t = \alpha + \beta_1 e_t + \beta_2 k_t + \beta_3 h_t + \beta_4 n_t + \partial_0 \pi_t + \partial_1 \pi_{t-1} + \epsilon_t$$

where α measures the rate of disembodied technical progress, π_t and π_{t-1} are current and lagged rates of inflation, and ϵ_t is the error term.⁵ The theory of the previous sections suggests various reasons for using the data in rates-of-change form. There are practical considerations as well. First, the data, reported in levels, have undergone substantial revisions over the years while the rates of change show only small differences. Second, there have been minor changes in industry definitions. Finally, for the period 1950-59, the data do not include the Saarland and West Berlin. In merging the two time series, even in

⁴The data set used here reports a capacity utilization series. This series is calculated from a Cobb-Douglas production function compared to a peak-to-peak trend. Thus capacity utilization is algebraically equivalent to the rate of growth of the capital stock, clearly unacceptable in our formulation.

⁵The specification in equation (1) has a long history in productivity studies. The most notable application is in the works of Denison (1974).

growth rates, one is assuming that the industrial compositions of West Berlin and the Saarland are the same as those of the rest of West Germany.

In any case, the use of levels would have entailed modeling a structural change in 1960. Given the short time span of the time series, this was thought to be undesirable as it would effectively eliminate other more interesting tests (see footnote 7 in particular).

The parameters of equation (1), and several variants, were estimated from data of 40 West German industries observed annually for the period 1950–77 (Krengel et al., various editions).⁶ The 40 industries were pooled to form 5 broad industry groups. Thus mining and foodstuffs each contain 5 industries, production goods is made up of 10, investment goods is comprised of 8, and consumer goods is made up of 12 industries.

Table 1 presents parameter estimates for (1). These results are reported as a check on the plausibility of the Cobb-Douglas specification and as a check on the stability of the coefficient estimates when inflation terms are added in later stages.⁷

In general, the parameter estimates are encouraging. The negative technical progress terms in mining and foodstuffs are best interpreted in light of a bit of economic history. Immediately following World War II there were tremendous infusions of investment in coal mining in the Ruhr. The industry was then left alone to struggle with increasingly militant unions and a declining price of oil. Problems with the industry reached a head in the late 1960s with a major reorganization. The result was the closing of mines in the Ruhr in favor of smaller, newer, more technologically advanced mines in the Saar.

The foodstuffs industry in our data set is dominated by the tobacco, brewing, and sugar industries. None of the three has experienced significant technology change (Scherer, 1980). In addition, they have

⁶The DIW [Deutsches Institute für Wirtschaftsforschung] has changed its reporting methods so substantially that it is impossible to update the data used in the study and the new series is not yet long enough for a similar analysis.

⁷Additionally we used the Chow (1960) test to check for a structural break at the end of 1960. The null hypothesis, no structural change, was rejected only for the consumer goods and foodstuffs industries. We did not pursue the latter case because of the generally poor results. In the case of consumer goods, rejection is the result of the hours-per-man coefficient changing for the two periods. Since the other coefficients were statistically the same for the two periods, the coefficients remain quite stable with the addition of other variables and for purposes of ease of exposition we have chosen not to model the structural break for the hours-per-man variable.

Table 1

The Cobb-Douglas production/growth function for 5 industry groups

Industry	Intercept	Hours/man	Electricity	Capital	Labor	R ²
Mining n = 120	-0.0092 (-.85)	.4845 (2.31)	.6964 (6.88)	.5068 (3.23)	.0798 (.70)	.58
Production goods n = 240	.0531 (9.36)	1.5353 (10.58)	.2231 (3.16)	-0.111 (-.83)	.7409 (8.82)	.71
Investment goods n = 192	0.217 (1.86)	1.3293 (5.07)	.4216 (4.21)	.2021 (4.51)	.4210 (9.15)	.50
Consumer goods n = 288	.0206 (2.62)	.1547 (2.63)	.0059 (.19)	.3444 (3.53)	.6378 (7.32)	.45
Foodstuffs n = 120	-.0250 (-2.62)	-.2098 (-.72)	1.3020 (13.27)	-.1595 (-1.00)	-.1672 (-1.15)	.66

Notes: *t*-Statistics are in parentheses.

All variables are (annual) rates of change. Hours per man is total hours spent in production work per production worker. It should be noted that this is the number of hours contracted for and thus includes such items as paid holidays and sick leave as well as overtime. If a person is employed only part-time he is included in the employment figure.

Electricity is kilowatt hours consumed.

Capital includes structures, machinery, and equipment and is gross of depreciation allowances.

Labor is total employment, that is, the sum of salaried workers and wage earners.

experienced negative rates of growth of their net capital stock over much of the 1950-77 period.

The next noteworthy point of Table 1 is the relationship between the hours-per-man variable and the labor variable. The parameter estimates exhibit greater returns to changing hours than to changing workers, in spite of controlling for capital or capacity utilization with our proxy variable electricity consumption.

The last observation to be made about Table 1 is that the returns to an increase in electricity consumption exceed the returns to a change in the capital stock.⁸ This is probably due to overtime and shift work. Note also that with two exceptions the capital variable is positive and significant.

⁸The simple correlation between hours per man and electricity is, however, quite low!

Table 2

The effect of current inflation on output growth

Industry	Intercept	Hours/man	Electricity	Capital	Labor	π_1	π_2	\bar{R}^2
Mining	.0142 (.81)	.4629 (2.22)	.6611 (6.45)	.3439 (1.88)	.1361 (1.15)	-.0065 (-1.68)		.58
$n = 120$	-.0017 (-.13)	.4873 (2.32)	.6862 (6.73)	.4542 (2.69)	.1082 (.91)		-.1635 (-.83)	.57
Production goods	.0648 (8.33)	1.5420 (10.17)	.2004 (2.83)	-.0126 (-.95)	.6864 (7.89)	-.0043 (-2.18)		.72
$n = 240$	.0569 (9.05)	1.4984 (10.17)	.2145 (3.03)	-.0115 (-.86)	.7298 (8.67)		-.1433 (-1.39)	.71
Investment goods	.0380 (2.06)	1.2925 (4.90)	.3899 (3.76)	.1984 (4.42)	.4138 (8.92)	-.0058 (-1.14)		.50
$n = 192$	.0228 (1.57)	1.3212 (4.86)	.4189 (4.08)	.2018 (4.48)	.4203 (9.04)		-.0357 (-.12)	.49
Consumer goods	.0417 (3.87)	.1493 (2.57)	.0050 (.10)	.2554 (2.52)	.6043 (6.95)	-.0063 (-2.81)		.46
$n = 288$	.0365 (4.22)	.1365 (2.37)	-.0153 (-.31)	.2980 (3.11)	.6272 (7.37)		-.4465 (-3.94)	.48
Foodstuffs	-.0289 (-2.47)	-.2047 (-7.0)	1.2968 (13.04)	-.1588 (-.98)	-.1415 (-8.7)	.0009 (.36)		.66
$n = 120$	-.0276 (-2.75)	-.1817 (-6.2)	1.2934 (13.10)	-.1487 (-.93)	-.1482 (-1.00)		.1156 (.84)	.66

Notes: For variable definitions see notes to Table 1. t -Statistics are in parentheses.

Here π_1 is the rate of increase of the consumer price index; π_2 is the rate of increase of a price index constructed from the 40-industry sample as

$$\pi_2_t = \sum_i W_{it} (\ln P_{it} - \ln P_{it-1})$$

where the W_{it} are 2-period moving averages of expenditure shares.

Table 3

The effect of current and lagged inflation on output growth

Industry	Intercept	Hours/man	Electricity	Capital	Labor	π_t	π_{t-1}	π_{t-2}	π_{t-3}	R^2
Mining	.0149 (.85)	.4468 (2.14)	.6432 (6.24)	.3322 (1.82)	.1346 (1.14)	.0018 (.24)	-.0092 (-1.30)			.58
$n = 120$	.0179 (1.19)	.3319 (1.58)	.5764 (5.49)	.3465 (2.07)	.2195 (1.82)			.0350 (.17)	-.6508 (-3.03)	.60
Production goods	.0625 (7.81)	1.5046 (10.21)	.2121 (2.97)	-.0122 (-.91)	.7182 (7.89)	-.0083 (-2.09)	.0049 (1.17)			.72
$n = 240$	.0653 (9.71)	1.4117 (9.59)	.1762 (2.50)	-.0127 (-.97)	.6495 (7.51)			-.507 (-1.48)	-.39.05 (-3.14)	.72
Investment goods	.0358 (1.93)	1.3214 (4.99)	.4136 (3.92)	.1996 (4.45)	.4184 (9.00)	-.0177 (-1.62)	.0132 (1.23)			.50
$n = 192$	.0319 (2.02)	1.2450 (4.53)	.3780 (3.57)	.2033 (4.53)	.4121 (8.83)			.1111 (.36)	-.4469 (-1.47)	.50
Consumer goods	.0397 (3.87)	.1444 (2.49)	-.0034 (-.06)	.2771 (2.72)	.6349 (7.16)	-.0127 (-2.82)	.0074 (1.63)			.47
$n = 288$	.0416 (4.72)	.1363 (2.39)	-.0119 (-.24)	.2892 (3.04)	.5669 (6.48)			-.3339 (-2.76)	-3.171 (-2.54)	.49
Foodstuffs	-.0263 (-2.39)	-.1809 (-6.1)	1.2839 (12.54)	-.1602 (-1.00)	-.1056 (-.60)	-.0017 (-.31)	.0032 (.56)			.66
$n = 120$	-.0268 (-2.68)	-.1809 (-6.7)	1.2839 (13.15)	-.1421 (-.89)	-.2116 (-1.35)			.1874 (1.25)	-.1815 (-1.18)	.66

Notes: For variable definitions see notes to Tables 1 and 2. t -Statistics are in parentheses.

Table 4

Anticipated and unanticipated inflation and output growth

Industry	j	Intercept	Hours/man	Electricity	Capital	Labor	$E_{\pi j}$	$U_{\pi j}$	R^2
Mining $n = 120$	1	.0392 (2.06)	.3318 (1.58)	.5764 (5.48)	.3465 (2.07)	.2195 (1.82)	-1.4862 (-3.12)	.0350 (.17)	.60
	2	.0222 (1.27)	.3833 (1.81)	.6301 (6.08)	.4265 (2.55)	.1763 (1.45)	-.9355 (-2.35)	.0253 (.12)	.59
	3	.0202 (1.11)	.4468 (2.14)	.6432 (6.24)	.3322 (1.82)	.1346 (1.14)	-.0088 (-2.07)	.0018 (.24)	.58
	4	.0206 (1.14)	.4391 (2.10)	.6422 (6.24)	.3317 (1.81)	.1381 (1.18)	-.0089 (-2.12)	.0027 (.36)	.59
Production goods $n = 240$	1	.0781 (6.54)	1.4117 (9.59)	.1762 (2.50)	-.0127 (-.97)	.6495 (7.51)	-.9635 (-3.83)	-.0507 (-1.18)	.72
	2	.0770 (9.22)	1.2550 (7.88)	.1831 (2.63)	-.0117 (-.90)	.6893 (8.31)	-.9623 (-3.83)	-.0507 (-1.18)	.73
	3	.0597 (6.73)	1.5046 (10.21)	.2121 (2.97)	-.0122 (-.91)	.7818 (7.89)	-.0026 (-1.10)	-.0084 (-2.10)	.72
	4	.0606 (6.95)	1.5219 (10.48)	.2088 (2.93)	-.0123 (-.92)	.7151 (7.85)	-.0029 (-1.20)	-.0080 (-1.98)	.72

Investment goods <i>n</i> = 192	1	.0465 (2.14)	1.2450 (4.53)	.3780 (3.57)	.2033 (4.53)	.4121 (8.83)	-.9337 (-1.40)	.1111 (.37)	.50
	2	.0434 (2.17)	1.2074 (4.31)	.3911 (3.76)	.2064 (4.59)	.4108 (8.78)	-.8198 (-1.37)	.1408 (.45)	.50
	3	.0283 (1.41)	1.3214 (4.99)	.4136 (3.92)	.1996 (4.45)	.4184 (9.00)	-.0024 (-.41)	-.0177 (-1.62)	.50
	4	.0250 (1.24)	1.3608 (5.11)	.4263 (4.03)	.1994 (4.44)	.4225 (9.08)	-.0012 (-.21)	-.0218 (-1.94)	.50
Consumer goods <i>n</i> = 288	1	.0518 (4.94)	.1363 (2.39)	-.0119 (-.24)	.2892 (3.04)	.5669 (6.48)	-1.0751 (-3.96)	-.3339 (-2.76)	.49
	2	.0559 (6.00)	.1270 (2.28)	-.0317 (-.66)	.3699 (3.95)	.5427 (6.46)	-1.3603 (-6.09)	-.1976 (-1.63)	.52
	3	.0356 (3.12)	.1444 (2.48)	-.0034 (-.07)	.2771 (2.72)	.6349 (7.16)	-.0041 (-.159)	-.0127 (-2.82)	.47
	4	.0391 (3.48)	.1486 (2.55)	.0013 (.03)	.2610 (2.57)	.6204 (6.96)	-.0053 (-2.06)	-.0097 (-2.09)	.46
Foodstuffs <i>n</i> = 120	1	-.209 (-1.82)	-.1966 (-.67)	1.3107 (13.16)	-.1421 (-.89)	-.2116 (-1.35)	-.2368 (-.72)	.1874 (1.25)	.66
	2	-.0181 (-1.62)	-.2035 (-.70)	1.3058 (13.33)	-.1448 (-.92)	-.1745 (-1.18)	-.3028 (-1.13)	.2429 (1.59)	.66
	3	-.0281 (-2.52)	-.1809 (-.61)	1.2839 (12.54)	-.1602 (-1.00)	-.1056 (-.80)	.0019 (.60)	-.0017 (-.31)	.66
	4	-.0276 (-2.50)	-.1812 (-.61)	1.2859 (12.49)	-.1594 (-.99)	-.1176 (-.68)	.0016 (.53)	-.0012 (-.21)	.65

Note: For variable definitions see notes to Tables 1 and 2. *t*-Statistics in parentheses.

The tests of the costs of inflation are reported in Tables 2, 3, and 4. The inflation series are based on the rate of increase of the Consumer Price Index (CPI) of the Federal Republic of Germany (FRG), π_1 , and weighted averages of the rates of increase of prices in the 40 industries in the sample, (π_2). The weights are two-year moving averages of sales shares.

The pattern of input coefficients in Table 2 is similar to that in Table 1. More significant is the persistent negative sign on the current-rate-of-inflation variable. The only exception is the foodstuffs industry, whose coefficients while positive are not significant. Most importantly, the addition of the inflation variable did not reduce the adjusted R^2 . We conclude that the coefficient on inflation is not a statistical artifact.

To further test the theory of the cost of inflation we included both current and lagged inflation, the results of which are reported in Table 3. Again, the input coefficients are quite similar to those reported in Table 1. The coefficient on current inflation is not as uniformly negative; however, when positive it is insignificant. The lagged inflation term is insignificant when positive. Again, the adjusted R^2 did not decline with the inclusion of another variable. The amelioration of the model is not then a "kitchen sink" phenomenon.

At this point the skeptic might argue that we are only demonstrating the impact of unanticipated inflation on output. To counter this argument both anticipated ($E\pi$) and unanticipated ($U\pi$) inflation rates for both price series were included in the production model, the results of which are reported in Table 4.⁹ In all but 2 equations the expected inflation coefficient is negative, and in 10 equations it is highly significant. Unanticipated inflation, on the other hand, is negative in 12 equations; however, it is significant in only 8. Unanticipated inflation is never positive and significant, contrary to what one might have expected from the natural rate hypothesis.

⁹Expected inflation, denoted $E\pi_j$, is constructed as the set of predicted inflation rates from an AR(1) or AR(2) process using two different definitions of inflation. Unanticipated inflation, $U\pi_j$, is the set of residuals. The two inflation series are constructed from the CPI (π_1 , π_2) and from a price series for the 40-industry sample (π_3 , π_4).

$$E\pi_{1t} = .0078 + .79493\pi_{1,t-1} \quad R^2 = .54$$

(1.64) (5.44)

$$E\pi_{2t} = .0116 + 1.0028\pi_{2,t-1} - .3634\pi_{2,t-2} \quad R^2 = .64$$

(2.56) (6.38) (-2.59)

Table 5

Using unexplained output growth to explain the growth of industrial prices

Industry	Intercept	Res _t	Res _{t-1}	R ²
	.0262 (2.40)	-.4473 (-2.48)		.05
Mining n = 120	.0251 (2.25)		-.2546 (-1.35)	.01
	.0262 (2.40)	-.4107 (-2.12)	-1.059 (-.53)	.04
	.0210 (4.74)	-.3431 (-3.46)		.05
Production goods n = 240	.0217 (4.76)		.1555 (1.53)	.01
	.0212 (4.80)	-.3698 (-3.73)	.2043 (2.05)	.07
	.0356 (8.50)	-.0503 (-1.40)		.01
Investment goods n = 192	.0357 (8.47)		-.0036 (-.09)	.00
	.0356 (8.47)	-.0504 (-1.40)	-.0049 (-.14)	.00
	.0295 (10.41)	-.6331 (-13.03)		.41
Consumer goods n = 288	.0309 (8.42)		.1555 (2.48)	.02
	.0298 (10.57)	-.6244 (-12.89)	.1031 (2.13)	.42
	.0203 (2.92)	-.8586 (-5.33)		.22
Foodstuffs n = 120	.0225 (2.88)		.2904 (1.57)	.01
	.0209 (3.00)	-.8360 (-5.15)	.1831 (1.10)	.22

Note: *t*-Statistics in parentheses. Here Res_t and Res_{t-1} are the residuals from the corresponding equations of Table 1.

The results from Tables 2 through 4 thus are consistent with the hypothesis that expected inflation adversely affects productivity. The

$$E\pi_3 = .0139 + .4278\pi_3 - 1 \quad R^2 = .12$$

(1.89) (2.27)

$$E\pi_4 = .0189 + .5355\pi_4 - 1 - .2627\pi_4 - 2 \quad R^2 = .22$$

(2.47) (2.80) (-1.47)

counter-hypothesis which closed section 2 has been tested by Clark (1982a; 1982b) and Nordhaus (1982). An approach similar to theirs was used to test the robustness of the results in Tables 2 through 4.

The residuals from the equations reported in Table 1 were used as independent variables in an effort to explain the rate of increase of prices in the 40 industries of the sample by exogenous productivity shifts. The results are reported in Table 5. The current residual term is always negative in accordance with the prices-to-productivity theory of causation, although failing a reasonable test of significance for the investment goods industry. The lagged terms when significant are positive, which fails to support the story that productivity declines lead to cost and price increases. Since the data are annual for only 25 years, these results only give an indication of causality (in the sense of temporal precedence).

4. Conclusion

Events of the last decade have focused attention on inflationary surprises and their ramifications for the economy. Oil price shocks obviously disturb relative prices and resource allocation, but we have argued a less obvious and neglected point; even steady anticipated inflation of the macromodel kind (which is seldom observed in practice) will add noise to the price system and depreciate search investment. Nor is it necessary to rely exclusively on direct fixed costs of price adjustment to motivate the irregular movement of individual nominal prices which generates confusion between transitory and permanent relative price changes. German industry data are consistent with a productivity-slowness effect of less efficient search activity and input employment during inflation.

In Denison-type (1974) models of production we have included current and lagged inflation based on two different measures of general price level increase: one based on the CPI of the Federal Republic of Germany and the other based more narrowly on the 40 industries in our sample. In any event, the impact of inflation on productivity growth is negative. The stability of coefficients, their economic reasonableness, and the essentially constant adjusted R^2 in various model specifications lead us to conclude that the negative association between inflation and productivity growth is more than statistical happenstance. To drive the point home, we used a technique suggested by Clark (1982a; 1982b) to test for the reverse causality. A cause-and-effect relation from productivity declines to inflation was resoundingly rejected.

The inflation-to-productivity effect is apparent both before and after the oil shocks, in spite of the low inflation and good productivity performance of the Federal Republic during the sample period for our data. We expect further research on other industrial countries to yield substantial negative productivity effects of expected inflation.

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