Price Change and Output Change: A Short-Run Three-Equation Analysis*

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> "One theory asserts that the change in nominal income will all be absorbed by price change; the other, that it will all be absorbed by quantity change. In my opinion, this is the central common defect of the two approaches as theories of short-run change."
>
> (Milton Friedman)

I. Variations on a Theme by Friedman

Milton Friedman's "Monetary Theory of Nominal Income," also known as the "modern" quantity of theory of money,[1] expands and develops a central empirical proposition that both levels and changes in nominal income and consumption are better explained, respectively, by contemporaneous and lagged levels and growth rates of a nominal money-supply measure than by levels and changes of nominal "autonomous expenditures" defined as nominal $[I + (G - T) + (X - M)]$ — a simple but unsophisticated reading of the *Keynes*ian Gospel.[2] This is

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1 Seven key *Friedman* papers are, in chronological order: "The Quantity Theory of Money — A Restatement" in *Friedman* (ed.), Studies in the Quantity Theory of Money (1956); "The Demand for Money: Some Theoretical and Empirical Results," *J. P. E.* (August 1959); "The Relative Stability of the Investment Multiplier and Monetary Velocity in the U.S., 1897 - 1958," (with *David Meiselman*) in Commission on Money and Credit (ed.), *Stabilization Policies* (1963); "Interest Rates and the Demand for Money," *J. L. E.* (October 1966); "A Theoretical Framework for Monetary Analysis," *J. P. E.* (March - April 1970); "The Counter-Revolution in Monetary Theory," *I. E. A. Occasional Paper 33* (1970); "A Monetary Theory of Nominal Income," *J. P. E.* (March - April 1971). Many of the earlier papers are reprinted in *Friedman,* The Optimum Quantity of Money and Other Essays (1969).

2 The "*Friedman-Meiselman*" issue of the *A. E. R.* (September 1965) deals in part with the sensitivity of the *Friedman-Meiselman* results to the defi-

not to deny that the explanation of nominal income by monetary considerations falls significantly short of statistical perfection in the standard senses of unitary R^2 and zero S^2.

Over and beyond statistical imperfections, the theory does not preclude the possibility of non-monetary factors (wage rates, oil prices, or anchovies) operating in both money and income, with the monetary aspect coming first in time for essentially institutional reasons. (Such explanations are stressed in "cost-push" and "sellers' inflation" arguments in favor of incomes policies and similar direct controls.) Nor, as *Friedman* explicitly admits, does the new theory have "anything to say about the factors that determine the proportions in which a change in nominal income will, in the short run, be divided between price change and output change."[3] It is this limitation which we investigate here for the post-Korea U.S. economy.

Fleshing out his model's algebraic skeleton, of course, *Friedman* has had much to say about the division (of the effects of money-induced changes in nominal income) between prices and output. In the "Theoretical Framework" article he surmises that "the division of a change in nominal income between prices and output depends on: anticipations about the behavior of prices — the inertia factor stressed by *Keynes* — and the current level of output or employment compared with the full-employment level — the supply-demand response stressed by quantity theorists."[4] In the following year, *Friedman's* "Monetary Theory of Nominal Income" adds another inertial factor — the interest rate as adjusted for anticipated price changes, so that "the difference between the permanent real interest rate and the secular growth of output"[5] may be assumed constant for the short run.

But the fullest literary statement of *Friedman's* view — not, however, the most firmly anchored to a theoretical model — is to be found in his Wincott Memorial lecture (London, September 1970). A running quotation follows:[6]

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nition of "autonomous expenditures." The variables in the bracketed expression refer, in order, to: private investment, public expenditures less public receipts, export less imports.

[3] *Friedman,* "Theoretical Framework," P. 222. A fuller statement is: "Neither [(Fisherine) quantity nor (Keynesian) income] theretical model has [statement in text, followed by statement in head-note].

[4] *Ibid.*, p. 223 (running quotation).

[5] *Friedman, op. cit.*, p. 333.

[6] *Friedman,* "Counter-Revolution," *op. cit.*, pp. 22 - 24 (running quotation).

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A change in the rate of monetary growth produces a change in the rate of growth of nominal income about six to nine months later. This is an average that does not hold in every individual case. But I have been astounded at how regularly an average delay of six to nine months is found under widely different conditions.

The changed rate of growth of nominal income typically shows up first in output and hardly at all in prices. On the average, the effect on prices comes about six to nine months after the effect on income and output, so the total delay between a change in monetary growth and a change in the rate of inflation averages something like 12 - 18 months. That is why it is a long road to hoe to stop an inflation that has been allowed to start.

Even after allowance for the delay in the effect of monetary growth, the relation is far from perfect. In the short run, which may be as much as five or ten years, changes affect primarily output. Over decades, on the other hand, the rate of monetary growth affects primarily prices.

These long and at least moderately variable lags, and this uncertain division of nominal income effects between prices and output, also affect the accuracy of econometric forecasts. After examining a dozen hopefully-independent macroeconomic forecasts over the period 1953 - 76, Victor *Zarnowitz* found that they did well on nominal income, but overestimated real growth and underestimated the inflation rate in a period of accelerating inflation.

Furthermore:[7]

The errors in predicting real growth are negatively correlated with the errors in predicting inflation which helps to explain the greater accuracy of the nominal G.N.P. forecast. In recent times, confronted with the unprecendented concurrence of accelerating price rises and slowing or declining output, forecasters (optimistically, and probably also from a lingering faith in a simple Phillips trade-off) kept underestimating inflation and overestimating growth. But earlier, in times of relatively stable-prices, offsetting errors often resulted from the opposite combination of too much inflation and too little growth.

II. Our Model: Dependent Variables

In the present study we hope to carry the short-run analysis of the price-output division somewhat further than *Friedman* left it. More specifically, we propose to devise empirical explanations for the post-Korean War U.S. (1952.1 - 1976.4) fluctuations of:

[7] *Zarnowitz*, in *Economic Outlook USA*, vol. v, no 2 (University of Michigan, Spring 1978). (I owe this citation to Professor *Alexej Wynnyczuk*.)

The growth rate of the G.N.P. deflator (p_t/p_{t-1})

The growth rate of real G.N.P (Y_t/Y_{t-1})

Their logarithmic difference, which we shall call g.

It is the artificial variable g which relates to the *Friedman* problem. A positive value of g implies that prices are rising more rapidly than output (or falling more slowly), and vice versa for a negative value. This measure involves some ambiguity, however, in interpreting a particular g-value. One percent rises in both price and output yield the same value, namely zero, as ten percent rises. Both theoretical concerns and public reactions will often be different in these two cases.

Our methodology is simple, perhaps simple-minded. We have selected a number of variables which are believed to influence real income positively. These include not only the money stock but also fiscal, employment and foreign-trade variables. To this extent, we complicate the *Friedman* prototype.

Instead of regressing nominal income upon these variables explicitly, however, we regress real income and the price level upon them separately (with appropriate lags) and compare regression coefficients. In this way, variables which exercise their primary influences on the real side may, we hope, be distinguished from those whose influence is on the price side. We use quarterly data for the U.S. from Korean War (1952.1) through 1976.4 as our sample period, and extend regressions fitted to this period for two additional years (through 1978.4) as a post-sample-period check on our results.

More explicitly: We believe that growth rate of nominal G.N.P., denoted by Y*, may be written in logarithmic-differential form:

$$\frac{d \ln Y_t^*}{dt} = f\left(\frac{d \ln M_t}{dt}\ ;\ \alpha, \beta, \gamma, \ \ldots\right) \tag{1}$$

where $\frac{d}{dt}$ ($\ln M_t$) actually represents a distributed-lag growth rate of a nominal money supply and (α, β, γ, ...) may be any non-monetary variables we choose.

But this growth rate is the logarithmic sum of:

$$\frac{d \ln p_t}{dt} = f_p\left(\frac{d \ln M_t}{dt}\ ;\ \alpha, \beta, \gamma, \ \ldots\right) \tag{2}$$

and

$$\frac{d \ln Y_t}{dt} = f_y\left(\frac{d \ln M_t}{dt} ; \alpha, \beta, \gamma, \ldots\right) \tag{3}$$

where p_t is the G.N.P. deflator and Y_t is real income. Furthermore, defining the quantity [(2) − (3)] as g:

$$g = f_g\left(\frac{d \ln M_t}{dt} ; \alpha, \beta, \gamma, \ldots\right) \tag{4}$$

We fit neither (1) nor (4) directly; instead, we fit [(2, 3)] and estimate g as their difference. It is, however, the artificial variable g which relates most clearly to the decomposition problem of separating the income and price consequences of impulses acting upon nominal income.

And what of (α, β, $\gamma, \ldots$)? These are, we recall, the several non-monetary variables which are believed to affect the growth rates of (p, Y, g). We select these variables on the basis of casual empiricism plus suggestions in the literature, and drop those candidates which "test" badly. Candidates include: Fiscal variables; (labor) unemployment variables; "excess capacity" variables; labor-productivity variables; deflated import-price and export-price variables. Other possibilities may of course occur to readers.

III. Price Rise: Output Growth: The g-Variable: Their Regressors

Regressions were fitted to quarterly data on price rise and output growth (equations 2 - 3) in logarithmic form. All the regressors (independent variables) were used as 7-quarter, second-degree distributed lags of the Almon type. These included contemporaneous observations over 6 quarters (18 months). The fits covered the entire 24-year sample period (96 observations) as a whole, and also its two sub-periods of equal length. The break point between these sub-periods came on New Year's day of 1965.

Both price and output growth were regressed on (lagged) monetary growth and (lagged) deficit growth. Four monetary alternatives (M) were used ($M1$, $M2$, $M3$, and the monetary base as estimated by the Federal Reserve Bank of St. Louis).[8] The fiscal variable (G/T) was the ratio of public expenditures to public receipts, transfers excluded in each case; the use of the quotient rather than the conventional difference avoided problems arising from the non-existence of logarithms of ne-

[8] The statistical computations of this paper were completed prior to the publication of the 1980 Federal Reserve revisions of the statistical series defining and measuring the principal U.S. monetary aggregates.

gative numbers. (Similar adjustments were made where necessary to substitute fractional for negative values.)

In the price rise equation, the growth rates of deflated import price level (p_m/p) and of the real wage level (w) were also used as regressors. In the output-growth equation, three additional regressors to the monetary and fiscal system entered: The *Wharton* index of capacity utilization (K), the prime-age male unemployment rate (U), and the productivity growth rate in manufacturing (plus 100), labelled (q).

Our fitted equations were, therefore:

$$\ln \frac{P_t}{P_{t-1}} = a_0 + \sum_{i=0}^{6} a_{1i} \ln \frac{M_{t-i}}{M_{t-i+1}} + \sum_{0}^{6} a_{2i} \ln \frac{(G/T)_{t-i}}{(G/T)_{t-i+1}} + \sum_{0}^{6} a_{3i} \ln \frac{(p_m/p)_{t-i}}{(p_m/p)_{t-i+1}} + \sum_{0}^{6} a_{4i} \ln \frac{W_{t-i}}{W_{t-i+1}} \tag{5}$$

$$\ln \frac{Y_t}{Y_{t-i}} = b_0 + \sum_{i=0}^{6} b_{1i} \ln \frac{M_{t-i}}{M_{t-i+1}} + \sum_{0}^{6} b_{2i} \ln \frac{(G/T)_{t-i}}{(G/T)_{t-i+1}} + \sum_{0}^{6} b_{3i} K_{t-i} + \sum_{0}^{6} b_{4i} \ln U_{t-i} + \sum_{0}^{6} b_{5i}\, q_{t-i} \tag{6}$$

from which, defining g as the difference between them, we have at once:

$$\begin{aligned} g = {} & (a_0 - b_0) + \sum_{i=0}^{6} (a_{1i} - b_{1i}) \ln \frac{M_{t-i}}{M_{t-i+1}} + \\ & + \sum_{0}^{6} [a_{2i} - b_{2i}) \ln \frac{(G/T)_{t-i}}{(G/T)_{t-i+1}} + \sum_{0}^{6} a_{3i} \ln \frac{(p_m/p)_{t-i}}{(p_m/p)_{t-i+1}} + \\ & + \sum_{0}^{6} a_{4i} \ln \frac{W_{t-i}}{W_{t-i+1}} - \sum_{0}^{6} b_{3i} \ln K_{t-i} - \sum_{0}^{6} b_{4i} \ln U_{t-i} - \sum_{0}^{6} b_{5i} \ln q_{t-i}\,. \end{aligned} \tag{7}$$

In the fitting of (5 - 6), variables were adjusted by the *Cochrane-Orcutt* procedure to reduce the effects of autocorrelated errors in residuals. The closeness of our *Durbin-Watson* (*D-W*) coefficients values to 2.0 (in Table 1) reflects the use of this procedure. We could not compute reliability measures for the first three (difference) terms of (7); for the others, we may use the estimates from (5) or (6).

Variables discarded from (5) and/or (6), and thence from (7), include:

Deflated export prices, (p_x/p).

Unemployment percentages for the entire labor force.

Growth of employment (N_t/N_{t-1}) for the entire labor force.

Time trends.

These experiments in adding and dropping variables comprised our only concession to "data mining." We did not experiment with algebraic alternatives to log linearity, with lag distributions extending back beyond six quarters, or with expected values of any variables.

Table 1 a - b assembles the results of fitting equations (5 - 6) respectively. On this table, expressions like (a_1, b_2 ...) are sums of the coefficients for lags of different lengths, and correspond to $\left(\sum_{i=0}^{6} a_{li}, \sum_{0}^{6} b_{2i}, \ldots\right)$ in the equations as written.

The fits are reasonably good, with R^2 in the 0.75 - 0.9 range after corrections for the loss of degrees of freedom. The exceptions are the price-rise equations for the earlier sub-period (1952. 1 - 1964. 4) which fit badly.

Neither set of equations, unfortunately, is uniform between sub-periods. It appears for both price-change and income-growth equations that the later sub-period, with the surprisingly higher R^2 — "surprising" because of the shocks of the early 1970's — dominantes the "full period" equations.

In the price-rise equations, the real wage term is more significant and has expected (positive) sign in the first sub-period, but the real-import-price term does not. This result is reserved, not surprisingly, in the second sub-period, and also in the full-period equations. In the income growth equations (2), the lagged productivity term, although derived only from manufacturing industries, dominates the lagged capacity and unemployment terms, which are marginally significant and sometimes have wrong (negative) signs. This result ran counter to the writer's prior expectations, and also to the expectations of many writers who expect idle capacity and unemployment to concentrate the effects of expansion on the output side in stagflation situations. (Productivity dominance also fails to hold in the initial sub-period.)

Nothing in these regressions suggested to the writer that any one of the four alternative monetary concepts used fit significantly better or worse than the others. In general, the monetary base and $M1$, being narrower concepts, gave results similar to each other. The same result held, somewhat less closely, for the two broader concepts, $M2$ and $M3$. (An early attempt to fit equation (7) directly rather than as the difference [(5) - (6)], had suggested the still-broader liquid-assets concept inferior to the others; it was not used here.)

Table 1: **Estimates of Coefficients for Equations (5 - 6)**

Table 1 a Price Rises — Equation (5)

	a_0	a_1	a_2	a_3	a_4	R_2	DW
Full Period							
M 1	0.00465 (2.05314)	0.38440 (3.39322)	— 0.02837 (— 1.07257)	2.93224 (4.79999)	— 0.18052 (— 0.67599)	0.80463 (0.77457)	2.1046 2.2160
M 2	0.00530 (1.96527)	0.17991 (1.79352)	— 0.05217 (— 1.62546)	0.24876 (5.06250)	— 0.18443 (— 0.60220)	0.78843 (0.75588)	2.2160
M 3	0.00622 (2.02702)	0.09002 (0.73043)	— 0.04927 (— 1.43880)	0.26519 (4.92059)	— 0.17758 (— 0.54514)	0.78102 (0.74733)	2.2636
Base	— 0.00653 (2.74015)	0.23804 (2.44539)	— 0.04714 (01.71245)	0.20340 (4.23352)	— 0.29548 (— 1.02511)	0.80168 (0.77117)	2.1750
Sub-Period I (1952.1 - 1964.1)							
M 1	— 0.00216 (— 0.68694)	— 0.22922 (— 1.10071)	— 0.04810 (— 1.58159)	— 0.09944 (— 0.53022)	1.07950 (2.92414)	0.40684 (0.16958)	1.8540
M 2	0.00448 (0.15998)	— 0.16085 (— 1.46287)	— 0.01903 (— 0.61187)	— 0.01169 (— 0.07283)	0.80469 (2.50167)	0.39820 (0.15748)	1.9069
M 3	0.00153 (0.46253)	— 0.17722 (— 1.37963)	— 0.01837 (— 0.61759)	0.00173	0.79510	0.39620	1.9087
Base	0.000368 (0.11282)	— 0.20067 (— 1.96577)	— 0.01862 (— 0.52571)	0.06696 (0.43713)	0.72579 (2.24637)	0.43498 (0.20897)	1.8563
Sub-Period II (1965.1 - 1976.4)							
M 1	0.01335 (4.43938)	0.17082 (0.93113)	— 0.67523 (— 2.20115)	0.13578 (3.39187)	— 0.92737 (— 3.34249)	0.85688 (0.80781)	1.9281
M 2	0.01558 (5.01954)	— 0.12177 (— 0.62110)	— 0.12177 (— 2.26162)	— 0.08148 (— 2.99220)	0.19031 (— 1.48308)	— 0.59202 (0.78870)	1.9887
M 3	0.01582 (6.20174)	— 0.17805 (— 1.20118)	— 0.09801 (— 2.51921)	0.22534 (3.39641)	— 0.47293 (— 1.26730)	0.84605 (0.79327)	1.9763
Base	0.01401 (3.20758)	0.12617 (0.40440)	— 0.08197 (— 2.78097)	0.12338 (1.92078)	— 0.95151 (— 3.59850)	0.85942 (0.81122)	1.9167

Table 1 b Income Growth — Equation (6)

	b_0	b_1	b_2	b_3	b_4	b_5	R_2	DW
Full Period								
M 1 ……	− 0.00151 (− 0.66840)	0.29238 (2.28694)	− 0.02102 (− 0.56326)	0.04597 (0.27055)	− 0.15406 (− 0.63307)	1.14774 (5.01981)	0.79039 (0.74847)	2.1201
M 2 ……	− 0.00230 (− 1.11659)	0.27805 (3.01032)	− 0.05105 (− 1.28613)	− 0.00222 (− 0.01638)	− 0.01825 (− 0.78752)	1.05575 (5.50373)	0.80218 (0.76262)	2.1326
M 3 ……	− 0.00312 (− 1.25938)	0.29944 (2.68635)	− 0.04084 (− 1.01826)	0.00218 (0.01504)	− 0.02179 (− 0.88281)	0.99686 (5.11553)	0.79380 (0.75256)	2.1127
Base …..	− 0.00118 (− 0.57989)	0.22397 (2.22465)	− 0.03438 (− 0.77107)	0.02608 (0.16747)	− 0.01646 (− 0.66923)	1.15447 (5.35299)	0.79204 (0.75087)	2.0965
Sub-Period I (1952.1 - 1964.1)								
M 1 ……	0.01021 (1.49830)	0.23212 (0.32387)	0.19929 (1.48823)	1.00080 (1.52160)	0.10055 (1.14837)	− 0.35766 (− 0.52250)	0.77763 (0.65409)	2.1916
M 2 ……	0.00790 (1.48262)	0.44074 (0.92835)	0.14807 (1.16732)	0.79429 (1.47717)	0.07945 (1.06108)	− 0.52298 (− 0.62124)	0.79514 (0.68134)	2.2239
M 3 ……	0.00671 (0.92563)	0.46092 (0.80632)	0.17287 (1.32347)	0.93739 (1.67041)	0.09680 (1.25182)	− 0.66986 (− 0.77301)	0.78560 (0.66650)	2.2102
Base …..	0.01221 (2.53052)	0.13055 (0.34427)	0.20953 (1.59761)	1.20953 (2.31222)	0.10904 (1.52880)	− 0.63299 (− 0.82070)	0.80439 (0.69572)	2.1963
Sub-Period II (1965.1 - 1976.4)								
M 1 ……	0.00482 (1.07451)	0.36906 (0.16134)	− 0.06345 (− 1.28301)	0.10698 (0.85773)	− 0.02869 (− 1.45052)	0.74190 (2.27837)	0.90755 (0.86422)	2.3301
M 2 ……	0.00618 (1.11124)	− 0.07749 (− 0.08551)	− 0.06294 (− 1.60189)	0.06968 (0.55549)	− 0.03707 (− 1.75561)	0.64508 (1.87558)	0.91079 (0.86898)	2.3833
M 3 ……	0.00626 (1.27993)	− 0.02291 (− 0.13885)	− 0.06215 (− 1.59389)	0.09291 (0.67808)	− 0.03128 (− 1.41469)	0.65226 (1.86546)	0.91005 (0.86789)	2.3726
Base …..	0.00490 (0.74090)	0.02810 (0.10189)	− 0.05682 (− 1.41546)	0.15101 (0.95848)	− 0.02317 (− 1.10166)	0.71364 (1.53533)	0.90630 (0.86238)	2.331

a) Figures in parentheses are *t*-ratios, except in R^2 column, where they are R^2-values computed for loss of degrees of freedom. The *Durbin-Watson* (*D-W*) figures are shown after correction by the Cochrane-Orcutt procedure.

Equation (3), for the g variable, is estimated in Table 2. As has been said above, it is this equation rather than (5) or (6) which professes to advance the *Friedman* argument, and to estimate the factors responsible for dividing the effects of economic impulses between price and output changes. In this table, coefficients g_i of equation (3) are defined as follows from those of [(5) - (6)]:

$$g_0 = a_0 - b_0 \ ; \quad g_1 = a_1 - b_1 \ ; \quad g_2 = a_2 - b_2$$
$$g_3 = a_3 \ ; \quad g_4 = a_4$$
$$g_5 = -b_3 \ ; \quad g_6 = -b_4 \ ; \quad g_7 = -b_5$$

As can be seen, we do not estimate the g-variable directly and independently. An early draft of this study did so, but serious identification problems arose. (Readers and seminar audiences wished to know, and we could not explain, whether the coefficients of g represented price-change effects as in (5), oppositely-signed income-change effects as in (6), or some combination of both.)

IV. Some Tentative Interpretations

A dash of *ad hockery* is difficult to avoid in interpreting the behavior of small reduced-form models like this one over relatively short periods. Our interpretations of the results for our discriminant g are therefore more than usually tentative.

(1) The explanatory pattern for g varies more sharply between subperiods than we had hoped. This pattern would probably show similarly wide if not wider variation across regions or countries, when and if cross-section studies were attempted over single time periods.

(2) The fits are more satisfactory for the later sub-period (1965.1 - 1974.4) than for the earlier and retrospectively less disturbed earlier one (1952.1 - 1964.4). This later sub-period seems to dominate the fits for the full period. At the same time, such variables as wage changes, capacity utilization, and unemployment all performed more nearly as expected in the earlier sub-period.

(3) Constant terms g_0 represent effects of lags longer than 6 quarters, expectations rational or otherwise, and omitted variables. Values were fortunately low except in the first sub-period.

(4) Two insights associated with *Friedman*'s monetarium are confirmed, or at least not disconfirmed. Over the relatively short 18-month

Table 2: **Coefficients of g**

	Constant	Money Growth g_1	Defizit Growth g_2	Import Prices g_3	Real wages g_4	Capital Utilization g_5	Unemploy-ment g_6	Produc-tivity g_7
Full Period								
M 1	0.00616	0.09202	− 0.00735	2.93224	− 0.18052	− 0.04097	0.15106	− 1.14774
M 2	0.00760	− 0.10014	− 0.00112	0.24876	− 0.18443	0.00222	0.01825	− 1.05575
M 3	0.00934	− 0.20958	− 0.00845	0.26519	− 0.17758	− 0.00218	0.02179	− 0.99686
Base	− 0.00535	0.01407	− 0.01276	0.20340	− 0.29548	− 0.02608	0.01646	− 1.15447
First Sub-Period								
M 1	− 0.01237	− 0.46134	− 0.24739	− 0.09944	1.07950	− 1.00080	− 0.10055	0.35766
M 2	− 0.00745	− 0.60159	− 0.16710	− 0.01169	0.80469	− 0.79429	− 0.07945	0.52298
M 3	− 0.00518	− 0.63814	− 0.19124	− 0.00173	0.79510	− 0.93739	− 0.09680	0.66936
Base	− 0.00853	− 0.33122	− 0.22315	0.06696	0.72579	− 1.07063	− 0.10904	0.63299
Second Sub-Period								
M 1	0.00853	− 0.19824	− 0.56178	0.13578	− 0.92737	− 0.10698	0.02869	− 0.74190
M 2	0.00940	− 0.10428	− 0.01854	0.19031	− 0.59202	− 0.06968	0.03707	− 0.64508
M 3	0.00956	− 0.15514	− 0.03596	0.22534	− 0.47293	− 0.09291	0.03128	− 0.65225
Base	0.00911	0.09807	− 0.03235	0.12388	− 0.95151	− 0.15101	0.02317	− 0.71364

Note: For *t*-statistics of e_3 through e_7 see Table 1.

lag periods studied here, and in environment of significant underemployment of both labor and productive equipment, the effects of monetary expansion are somewhat larger on output than on price. This result is contrary to the cruder but not to the "modern" *(Friedman)* version of the quantity theory of money. In addition, the output effects of changing fiscal deficits seem insignificantly larger than their price effects, contrary to the conventional view of Keynesian fiscalism but again in accordance with the monetarist thought.

(5) Our results do not help in judging the empirical appropriateness of alternative definitions of money. *Friedman* prefers $M2$; other monetarists, such as *Karl Brunner* and *Allan Meltzer,* prefer the monetary base; the conventional concept has been $M1$; this study does not contribute anything to the controversy.[9]

(6) The large productivity terms g_7 ($= - b_5$) are the principal factors moderating price pressures and concentrating on output effects. This confirms the popular argument that "production" is a better basis for inflation control than is "recession." It does not, however, seem to hold in the first sub-period.

(7) Import price, rising faster than the general deflator, have become an important source of inflationary pressure only in the second subperiod (and perhaps only in the oil-dominated second half). Their previous effects seem to have been negligible and in the "wrong" direction.

V. Post-Sample Observations

Our sample period ended with the year 1976. Outside this period, our empirical estimating equations (5 - 6) were applied to data for the 4 quarters of 1977 and 1978, 8 quarters in all. Table 3 presents the results in units of each equation's standard error of estimate S^2. High arithmetical values (above 2.0 in absolute value) suggest low reliability.

The main body of the post-sample fits passed this not-too-exacting test without difficulty. There were, however, three "bad" quarters, 1978.2 for both price rise and output growth, 1977.1 for output growth

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[9] Readers of an earlier draft have pointed out, however, that $M\,1$ and the monetary base tend to be more significant statistically in price-rise equations than do $M\,2$ or $M\,3$.

Table 3

Extensions Beyond Sample Period (to 1978.4)

	Deviations in Standard Units			
	1977.1	1977.2	1977.3	1977.4
Price Change Equations — Full Period				
M 1	0.106	1.468	– 1.122	0.025
M 2	– 0.623	1.107	– 1.105	0.303
M 3	– 0.213	1.320	– 0.783	0.576
Base	– 0.612	1.076	– 0.968	0.333
Output Change Equations — Full Period				
M 1	2.702	1.146	0.681	– 0.755
M 2	2.383	1.041	0.532	– 0.775
M 3	2.341	0.919	0.480	– 0.898
Base	2.807	0.972	0.420	– 1.110
Price Change Equations — 2nd Sub-Period				
M 1	– 0.173	0.818	– 1.916	– 0.665
M 2	– 0.580	0.992	– 1.274	0.0519
M 3	– 0.742	1.233	– 1.075	0.580
Base	– 0.782	0.843	– 1.822	– 0.607
Output Change Equations — 2nd Sub-Period				
M 1	2.621	1.252	0.605	– 1.578
M 2	2.513	1.054	0.325	– 1.871
M 3	2.512	1.118	0.392	– 1.862
Base	2.102	0.853	0.284	– 1.738

	1978.1	1978.2	1978.3	1978.4
Price Change Equations — Full Period				
M 1	– 0.104	2.970	0.536	2.032
M 2	0.247	3.238	0.753	2.355
M 3	0.414	3.364	0.994	2.468
Base	– 0.061	2.674	0.196	1.747
Output Change Equations — Full Period				
M 1	1.152	2.975	– 0.236	0.539
M 2	1.127	2.861	– 0.434	0.411
M 3	0.969	2.773	– 0.439	0.296
Base	1.034	3.336	0.161	0.527
Price Change Equations — 2nd Sub-Period				
M 1	– 0.616	2.767	– 0.101	1.518
M 2	0.063	3.299	0.338	1.774
M 3	0.335	3.570	0.303	2.002
Base	– 1.085	1.954	– 0.996	0.888
Output Change Equations — 2nd Sub-Period				
M 1	1.301	3.374	– 1.082	– 0.150
M 2	0.936	3.101	– 1.279	– 0.021
M 3	0.981	3.151	– 1.196	– 0.020
Base	1.306	3.411	– 1.039	– 0.0039

only, and 1978.4 for price rise only. In all these cases the actual values were higher than the observations, and the equations were underestimates. These results on the price side are not inconsistent with the widespread view that inflation was in some sense higher than expected during the calendar year 1978. No equally simple explanation seems available for the outlying output figures of 1977.1 and 1978.2.

Zusammenfassung

Preis- und Output-Änderungen: Eine kurzfristige Drei-Gleichungs-Analyse

Gegenstand der vorliegenden empirischen Untersuchung ist die Analyse der relativen zeitlichen und intensitätsmäßigen Ausprägung von Preis- und Mengenreaktionen aufgrund monetärer und realer Veränderungsimpulse. Dabei wird auf diesbezügliche Ergebnisse *Milton Friedmans* Bezug genommen, nach denen die anfänglichen Wirkungen der Veränderungsimpulse primär den Output betreffen, während Preisänderungen in der Regel später erfolgen. Der empirische Untersuchungsgegenstand sind die USA für den Zeitraum der Jahre 1952 bis 1976, für den Quartalswerte benutzt werden und der in zwei Subperioden zerlegt wird.

Die in Frage stehenden Differentialwirkungen werden mit Hilfe einer sogenannten g-Variablen ermittelt, der logarithmischen Differenz zwischen den Wachstumsraten des Preisniveaus und der realen Veränderung des Bruttosozialprodukts. Als Veränderungsimpulse, also unabhängige Variable der Schätzungen, werden neben verschiedenen Geldmengegrößen nicht-monetäre Variable für den Fiskalimpuls, die Unterbeschäftigung, die Arbeitsproduktivität usw. in die Untersuchungen einbezogen. Bei den Schätzungen wird das Almonverfahren zur Bestimmung der Lags verwandt, die sieben, nach einem Polynom zweiten Grades verteilte, Quartale umfassen.

Unter den Ergebnissen ist hervorzuheben, daß die Effekte des Fiskalimpulses auf den realen Output kaum bedeutender sind als auf das Preisniveau, während die Wirkungen von Geldmengenvariationen eher den realen Output als das Preisniveau betreffen. Daneben zeigt sich, daß — im Gegensatz zu früheren Perioden — in der jüngeren Vergangenheit von den Importpreisen ein erheblicher Druck auf die Inflationsrate in den USA ausgeübt wird.

Summary

Price Change and Output Change: A Short-Run Three-Equation Analysis

This empirical study sets out to analyse the relative magnitudes of price and quantity reactions in terms of time and intensity to monetary and real change impulses. Reference is made to the pertinent results obtained by *Milton Friedman*, which show that the initial impact of change-inducing impulses primarily affects output, while price change follow later as a rule. The empirical study covers the USA in the period from 1952 to 1976 and uses quarterly values; this period is broken down into two subperiods.

The differential effects in question are determined with the aid of a so-called g variable, the logarithmic difference between the growth rates of the price level and the real change in the GNP. In addition to various money-supply magnitudes, non-monetary variable for the fiscal impulse, underemployment, labour productivity, etc. are introduced as change-inducing impulses. For the estimates, the Almon method is used to determine the lags, which embrace seven quarters distributed in accordance with a second-degree polynomial.

Among the conclusions, one deserving special mention is that the effects of the fiscal impulse on real output are hardly more significant than those on the price level, while the impact of money supply variations is more likely to affect real output than the price level. Furthermore, it proves that — in contrast to earlier periods — in the recent past import prices have excerted a substantial pressure on the inflation rate in the USA.

Résumé

Changement du prix et de la production: une analyse à trois équations à court terme

L'objet de cet examen empirique est l'analyse de l'expression relative dans le temps et en intensité des réactions de prix et de masse sur base d'impulsions modificatrices monétaires et réelles. A ce sujet on se réfère aux résultats de *Milton Friedman* en cette matière, selon lequel les effets initiaux des impulsions modificatrices concernent en premier lieu l'output, tandis que les modifications de prix interviennent en règle générale ultérneurement. L'objet de l'examen empirique sont les Etats-Unis pendant la période des années 1952 à 1976, pour laquelle des valeurs trimestrielles sont utilisées et qui est sous-divisée en deux périodes.

Les effets différentiels mis en question sont établis à l'aide de ce qu'on appelle les variables-g., la différence logarithmique entre taux de croissance du niveau des prix et la modification réelle du produit intérieur brut. Comme impulsion modificatrice, c. à. d. variantes indépendantes des estimations, outre différentes grandeurs le la masse monétaire, des variables non-monétaires sont prises en considération dans l'examen pour l'impulsion fiscale, le sous-emploi, la productivité du travail etc. Lors des estimations le procédé d'Almon est utilisé pour la détermination des lags, qui comprend sept trimestres, divisés selon un polynôme du second degré.

Parmi les résultats il faut souligner que les effets de l'impulsion fiscale sur l'output réel sont à peine plus significatifs que sur le niveau des prix, tandis que les effets de variations de la masse monétaire concernent plutôt l'output réel que le niveau des prix. Il s'avère d'autre part que — contrairement à des périodes précédentes — dans le passé récent les prix à l'importation ont exercé une pression considérable sur le taux d'inflation aux Etats-Unis.