NBER WORKING PAPER SERIES

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Working Paper No. 2057

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 1986

The research reported here is part of the NBER's research program in Economic Fluctuations. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

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ABSTRACT

There has been a significant interest on a theoretical level in the application of supergames to oligopoly behavior. Implications for pricing behavior in trigger-strategy models in response to aggregate demand are of particular importance for public policy considerations. We contrast the predictions for the movements of industry prices over the business cycle of two such models--put forth by Edward Green and Robert Porter and by Julio Rotemberg and Garth Saloner--and test the predictions using a panel data set of U.S. manufacturing industries.

Our principal findings are four. First, the levels of price-cost margins of concentrated, homogeneous-goods industries, while higher than those of unconcentrated counterparts, appear to be closer to those predicted by a single-period Cournot-Nash equilibrium than monopoly. Second, there is little evidence to support the idea that price-cost margins of these industries have different cyclical patterns from other industries apart from effects by level of industry concentration. Maximum price declines for concentrated industries give little support for the occurrence of price wars during either recessions or booms. Finally, consistent with the predictions of the Rotemberg-Saloner model, the industries with high price-cost margins have more countercyclical price movements than those exhibited by other industries. That gradual price adjustment is quantitatively important for those industries, suggests, however, that other factors may lie beind the apparent rigidity of prices.

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I. INTRODUCTION

Whether oligopolists are able to achieve collective outcomes approaching that of a monopolist is an issue of considerable debate in theoretical industrial economics; its relevance for public policy is clear. Recent theoretical work on oligopoly supergames has demonstrated that, for a wide range of situations, oligopolists may be able to approximate cooperative outcomes in games which are (structurally) noncooperative.[1]

In this paper we focus on two recent and innovative supergames models involving trigger strategies and generating predictions about the cyclical behavior of prices--those of Green and Porter [1984] and Rotemberg and Saloner [1986].

In the model of Green and Porter, demand shifts are imperfectly observed by oligopolists and output does not vary as long as price remains above the trigger price. Since all adjustments occur through price unless a reversion occurs, prices and price-cost margins should be **procyclical** with the possibility of occasional very sharp price declines. It is possible that firms might actually expand production during a recession, dampening cyclical downswings.

In contrast, Rotemberg and Saloner assume that demand shifts are perfectly observable and versions of their model predict that price-cost margins should be **countercyclical.** That is, oligopolists behave more competitively during booms. Thus, a shift in demand toward goods produced by oligopolists may cause an increase in the output of all sectors, bringing about a boom. The opposite can occur if demand shifts away from oligopolistic sectors. The assumptions and predictions of these two models are further described in the next section of the paper.

An empirical test of the predictions of these models in particular, and oligopoly supergames in general, is best undertaken with panel data. Using information on four-digit-S.I.C. level manufacturing industries over the period from 1958 to 1981, we focus on a subset of industries having structural characteristics closely resembling those cited by Green and Porter and Rotemberg and Saloner. While oligopoly supergames predict that prices and margins will on average be above the Cournot levels, this need not be true for all time periods (see for example Green and Porter [1984]). It is desirable, therefore, to examine several years of data for any given industry. The use of longitudinal data also allows for tests that distinguish between individual models employing trigger strategies.

In section III we examine whether the price-cost margins of any industry ever approach collusive levels in any time period covered by the available data. We find that margins for our sample of highly concentrated industries are on average higher than margins in unconcentrated industries, but they more closely resemble the predicted levels of a single-period Cournot equilibrium than that of monopoly. This finding alone, however, is not conclusive evidence that oligopolists never engage in the quasi-cooperative arrangements implied by trigger equilibria strategies. There are many reasons why the sustainable outcomes in such games may not be on the profit-possibility frontier.

In section IV we examine the cyclical behavior of margins and prices for a subset of highly concentrated oligopolistic industries exhibiting above average price-cost margins over the 1958-1981 period. Census price-cost margins are procyclical for concentrated industries, although less so for high-margin than low-margin industries. We find no evidence for reversions from cooperative to Cournot behavior as in Green and Porter. Finally, price movements among highly concentrated, high price-cost margin industries are countercyclical.

II. TRIGGER STRATEGY EQUILIBRIUM

The basic concept of trigger strategies was first discussed by Luce and Raiffa [1957] with respect to repeated games based on the Prisoner's Dilemma. An excellent overview of the literature that followed and a description of the conditions for trigger-strategy equilibria are given by Friedman [1986, chapter 3]. Simply put, these equilibria are agreements, possibly including the joint-profit maximizing outcome, which can be enforced by the threat of retaliation in the event of defection. That is, in response to a violation, all players agree to revert to a (single-period) noncooperative equilibrium. Because the threat involves playing noncooperative strategies, it must be credible; the equilibrium is subgame perfect (in the sense described by Selten [1975]).

Recent work involving infinite and finite-horizon supergames has demonstrated that trigger strategies are viable under a wide range of conditions. Friedman [1985] derives the conditions under which **finite-horizon** trigger strategies exist. He also shows that where trigger strategies do not exist, the discontinuity between infinite and finite horizons can be smoothed if the players no longer seek perfect optimization in their strategies. Furthermore, if players are "close" to behaving optimally, then trigger-strategy "epsilon-equilibria" are possible if games have sufficiently long but finite horizons (see Radner [1980]).

We now turn to two well known models involving trigger strategies. Green and Porter [1984] examine an oligopoly situation where the industry is presumed to be stable (mature), products are homogeneous, and all available information is public knowledge except for each firm's knowledge about its own present and past output levels. Firms cannot perfectly observe the level of industry demand in each period and the output choices of their competitors; they agree on a "trigger price" to which they compare the market price when they make their production decision. If the market price remains above the trigger price, all firms agree to produce at a cooperative level. If, however, the price drops below the trigger price, all firms agree to revert to the one-shot (Cournot) equilibrium for some fixed period of time. A firm which considers a secrete expansion of output above the collusive level must trade off immediate profit gains with the increased probability that the market price might fall below the trigger price, thereby increasing the likelihood of an industry reversion and lower profits.[2] Alternatively, Porter [1985] describes how firms could focus on market shares instead of a trigger price; in this case, large enough deviations of actual from allocated market shares would trigger a price war.

In the Green-Porter model, reversionary episodes sometimes will occur simply because of low demand. They emphasize that such reversions are not defections by any of the participants from the supergame. Rather, in the uncertain environment of their model, reversions are necessary to keep the equilibrium subgame-perfect; that is, to provide incentives for all firms to choose rationally to produce at cooperative levels in normal times.

One testable prediction of the Green-Porter model involves the cyclical behavior of prices and price-cost margins. Output is fixed in their model unless a reversion occurs. If all demand shocks are unobservable, prices and margins should be procyclical.[3] While changes in cost are not considered by Green and Porter, economy-wide inflation should not affect the cooperative output level. All that has to be updated is the nominal value of the trigger price. Shocks which increase costs will reduce profit margins until the cooperative output is updated, but prices will continue to be procyclical. If, however, some demand shocks are observable and others are not, a definitive test of the Green-Porter model with respect to the cyclical behavior of prices may not be possible.

A second testable prediction of the Green-Porter model is that of periodic sharp declines in industry price. Green and Porter [1984, p. 94] emphasize that according to their model industries having the appropriate characteristics will exhibit price instability if oligopoly members are colluding and that such episodes play an essential role in the maintenance of an ongoing scheme of collusive incentives.

Rotemberg and Saloner [1986] present a second supergame model employing trigger strategies and generating predictions about oligopoly price behavior over the business cycle. As in Green and Porter, the major departure of this model from the earlier literature is allowing for industry shifts in demand. The major distinction between the two models is that Rotemberg and Saloner assume that demand shifts are observable. In most other respects, including the set of industry characteristics (homogeneous products, etc.) the models are alike.

Changes in industry demand cause firm payoffs to be nonstationary. It is this nonstationarity that Rotemberg and Saloner exploit. They do so by assuming that firms know the new level of demand before selecting their level of the choice variable in each period. Once choice variables are selected, they cannot be adjusted until the following period.

In this environment, the rewards for cheating on a collusive agreement will be different from period to period, in general varying positively with the state of demand. The future punishment that can be inflicted on a cheater, however, is independent of current demand if variations in demand are assumed to be independently and identically distributed. Thus, in periods of sufficiently high demand, the rewards from cheating on at least some collusive agreements may exceed any future punishments. The likelihood of such an episode, of course, depends on the length of the period for which a firm can cheat on its competitors before retaliation can begin.[4]

Rotemberg and Saloner suggest a method by which oligopolies may keep firms from defecting. For periods of high demand, firms agree to choose a price (quantity) low enough (high enough) such that the rewards from defection are sufficiently reduced to keep cooperation the optimal strategy. This is possible since industry demand is observable to the oligopoly. Their strongest results are for the case in which prices are the strategic variable and marginal costs are constant. In this case, increases in demand beyond a certain point actually lower the oligopoly's prices monotonically. Their results are somewhat weaker when quantity is the strategic variable, but they do present examples where increases in demand again lead to more competitive behavior.

The testable prediction of the Rotemberg and Saloner model is that the Lerner index is countercyclical; in booms oligopolies reduce the spread between price and marginal cost to lower the per unit gain from cheating. They present some rudimentary evidence that this may in fact be the case in some industries. They also point out the practical difficulties in testing their hypothesis using traditional measures of the price-cost margin if movements in marginal cost and average variable cost over the business cycle are not highly correlated. An alternative test is to assume that marginal cost is procyclical and to test for the cyclical behavior of price.

In the sections which follow, we provide some simple tests of the predictions of these models for industry price-cost margins and prices for a selected sample of manufacturing industries.

III. LEVELS OF PRICE-COST MARGINS FOR SELECTED INDUSTRIES

One straightforward test of trigger-strategy models is to examine whether the Census price-cost margin of any industry ever approaches collusive levels in any time period covered by our panel. For industries producing undifferentiated products, expressions can be derived relating the price-cost margin (Lerner index) to industry structural conditions for different types of industry behavior.

It is well known that[5] for a given industry, a **firm's** price-cost margin (PCM) can be expressed as:

$$(1) \qquad \frac{P - MC_i}{P} = \frac{s_i(1+\nu_i)}{\varepsilon},$$

where s_i is the ith firms market share, ν_i is its conjectural variation (the ith firm's guess about the output response of all other firms), and ε is the industry demand elasticity. Reference points of interest are the monopoly outcome, PCM = $1/\varepsilon$, and the Cournot outcome, PCM = s_i/ε.

We do not have firm data and it is extremely difficult to estimate marginal cost. However, industry expressions can be derived by aggregating equation (1) across firms. If marginal cost is assumed to equal average variable cost for each firm, then such an aggregation will yield[6]

$$(2) \qquad \frac{P - AVC}{P} = \frac{\sum s_i^2 (1+\nu_i)}{\varepsilon},$$

where AVC is the industry-weighted average variable cost. The left-hand side of equation (2) can also be expressed as the ratio of gross profits to revenue. The interesting reference points again are the monopoly outcome,

$$(3) \qquad \frac{P - AVC}{P} = \frac{1}{\varepsilon},$$

and the Cournot outcome,

$$(4) \qquad \frac{P - AVC}{P} = \frac{\sum s_i^2}{\varepsilon} = \frac{H}{\varepsilon},$$

where H is the Herfindahl index of concentration.

Three points should be made about equations (3) and (4). First, the difference between the predicted margins in equations (3) and (4) (collusion versus Cournot) is very large. In manufacturing industries, Herfindahl indices above 0.35 are rare, while values much above 0.4 are no longer observed.[7] Secondly if MC differs from AVC, (P - AVC)/P will result in a biased estimate of market power; this estimate will be biased upward if marginal cost exceeds average variable cost, but the opposite bias is theoretically also possible. Finally, if ε is large enough, then values of (P - AVC)/P considerably less than unity are consistent with collusion.

This final point, as well as the differences between predicted margins in equations (3) and (4), are illustrated in Table I. For both the Cournot outcome and the monopoly outcome, margins are calculated for selected values of the Herfindahl index and the demand elasticity ε. It is apparent that elasticities must be quite high for the monopoly PCM to be less than 0.50. It is also apparent that for the Cournot outcome, PCMs are not likely to exceed 0.30.

We now turn to an examination of actual price-cost margins for four-digit-S.I.C.-level Census manufacturing industries.[8] While Census price-cost margins are only approximations to the Lerner index, they are flow measures that are relatively free of accounting distortions. Detailed descriptions of the data can be found in Domowitz, Hubbard, and Petersen [1986a], [1986b].[9] The full data set contains information on 312 manufacturing industries over the period from 1958 to 1981. To focus on trigger-strategy models, we delineate a subsample of fifty-seven industries in Table II. The common characteristics of these industries are: (i) they are "producer-goods" industries;[10] (ii) they have been recognized as Census industries at least since 1958; (iii) they have four-firm concentration ratios[11] above 0.50 in 1972; and (iv) they are not listed as "miscellaneous" or as "not elsewhere classified." The object of (i) - (iv) was to select mature, homogeneous-goods oligopolies operating in well defined markets. These industries approximate the structural characteristics cited by Green and Porter and Rotemberg and Saloner.

For each industry, Table II reports the following information: (i) the Census four-firm concentration ratio and the Weiss-Pascoe adjusted concentration ratio in 1972, (ii) the average value and the standard deviation of the Census price-cost margin over the period from 1958 to 1981, and (iii) the minimum and maximum values of the price-cost margin. In addition, Table II is divided into "high PCM" industries -- those with average PCMs greater than the mean for producer-goods industries, and corresponding "low PCM" industries. We will make use of this division of industries by level of PCM later in the paper. One would expect that the high-PCM industries are the ones most likely to be collusive -- and thus to behave as per trigger-strategy models.

Unfortunately, we are unable to include Herfindahl values for the industries in Table II. Nelson [1963] reports Herfindahl's for many of the Table II industries, but they are out of date. As a point of reference, Nelson's numbers indicate that industries with four-firm concentration ratios between 0.80 and 0.90 (highly concentrated) have Herfindahl's that cluster between 0.25 and 0.30.

Not unexpectedly, the industries in Table II have, on average, higher PCMs than the average for all producer-goods industries in our panel, which is[12] 0.250. However, the difference is not that great; the average PCM for the fifty-seven industries in Table II is 0.289. If we divide Table II into high-PCM and low-PCM industries, thirty-nine fall into the former category, with an average PCM of 0.333. Within this high-PCM group, only five have averages over 0.400 (flavoring extracts, industrial gases, hydraulic cement, electric lamps, and photographic equipment). The largest average PCM is 0.506. Even an examination of each industry's maximum PCM over the 1958-81 time period does not reveal many particularly large margins; in only five instances does a maximum PCM exceed 0.500, the largest recorded margin being 0.605.

There are several explanations for the patterns in Table II. One possibility is that oligopolists are rarely able to engage in quasi-cooperative arrangements such as trigger strategies. A second explanation is that **credible** punishments are not large enough to permit margins much above a one-shot equilibrium level; that is, trigger strategies may not generally permit outcomes near the profit frontier.[13] Oligopolists also may face much more elastic industry demand curves than generally believed. A final explanation is, of course, that the threat of entry, perhaps from import competition or from the backward integration of major buyers of producer goods, may keep margins at levels close to noncooperative levels for even very concentrated industries.

IV. RESPONSES OF MARGINS AND PRICES TO DEMAND CHANGES

We turn now to tests of the cyclical predictions of the trigger-strategy models described in section II. The Green-Porter model predicts that oligopoly prices and margins will be procyclical while the Rotemberg-Saloner model predicts that price-cost margins will be countercyclical. We therefore present evidence on the cyclical behavior of both price and the price-cost margin for several categories of industries, including highly concentrated producer-goods industries having comparatively high margins.

While we present evidence on the cyclical behavior of price-cost margins, we place much greater emphasis on the corresponding cyclical behavior of prices. The reasons for this are as follows. With respect to the Green-Porter model, the cyclical behavior of the price-cost margin is probably a poor indicator of the cyclical behavior of price if in fact output and average variable cost are not constant. With respect to the Rotemberg-Saloner model, there are a number of reasons why the cyclical behavior of (P - AVC)/P may be a misleading indicator of the cyclical behavior of (P - MC)/P. During industry downturns, marginal cost may fall below AVC because of labor hoarding. Rotemberg and Saloner (p. 400) point out that measurements of labor costs may include a fixed cost component. Finally, concentrated industries tend to be more unionized, and most of the evidence indicates that the union-non-union wage differential is countercyclical.[14]

Cyclical Movements in Price-Cost Margins

In previous studies (see Domowitz, Hubbard and Petersen [1986a], [1986b]), we found that PCMs were more "procyclical" in concentrated industries and in producer-goods industries than in consumer-goods industries. In this paper, we extend our previous work by examining the cyclical behavior of margins across several categories of industries as outlined in section III. These categories are: (i) all industries, (ii) industries for which C4 < 50, (iii) consumer-goods industries for which C4 > 50, (iv) producer-goods industries for which C4 > 50, (v) above-average PCM producer-goods industries for which C4 > 50, and (vi) below-average PCM producer-goods industries for which C4 > 50. This partitioning of our sample by concentration is sensible given the models we are interested in testing.[15]

For each category of industries, we model the PCM as a function of industry measures of concentration, capital-output ratio, advertising-sales ratio, and capacity utilization in manufacturing[16] (as a measure of aggregate demand). That is,

$$(5) \qquad PCM_{it} = \beta_0 + \beta_1 C4_{it} + \beta_2 (K/Q)_{it} + \beta_3 (A/S)_{it} + \beta_4 CU_t + \varepsilon_{it},$$

where i and t denote the industry and time period, respectively. OLS and fixed-effects[17] estimation results for equation (5) appear in Table III.

The effects of industry variables on the price-cost margin are consistent with our previous results (see the interpretation there in light of standard structure-conduct-performance models). With respect to the impact of changes in capacity utilization on margins, our principal findings are two. First, margins are procyclical in all categories, though demand effects in unconcentrated industries are negligible, with more pronounced cyclical impacts in concentrated and producer-goods industries. Second, price-cost margins in concentrated, high-PCM industries ("trigger-strategy" industries) are less procyclical than margins in concentrated, low-PCM industries. It will be easier to interpret this result after the evidence on the cyclical behavior of price and cost is presented.

Price Wars and the Cyclical Responses of Industry Prices

For reasons discussed in section II, we are interested in both the cyclical behavior of industry prices and in any evidence for the existance of price wars, either during recessions or otherwise. We begin with the latter issue.

It is straightforward to compute expressions for both the percentage change in the PCM and in the industry price following a reversion from monopoly to Cournot behavior. Using equations (3) and (4) and assuming constant marginal cost, the predicted percentage change in the PCM is $(1-H)*100$ and the predicted change in industry price is $[(1-H)/(\varepsilon-H)]*100$. These expressions imply quite dramatic changes following a reversion. For example, if $H = 0.30$ and $\varepsilon = 2$, the predicted percentage change in price is approxi-mately forty percent.

To analyze the prediction of the Green-Porter model of large, discrete price decreases in periods of low demand, we report in Table IV price changes[18] for thirty-nine "high-PCM" industries for 1961, 1970, 1975, and 1980, the four points in time when capacity utilization in manufacturing fell below eighty percent. The sharpest declines occurred in 1970 and 1975, when capacity utilization fell by ten percent and thirteen percent respectively. These price changes are all expressed relative to the rate of change for all manufacturing industries on average in 1961, 1970, 1975, and 1980. While many industries do indeed exhibit declines, (fifteen in 1970 and ten in 1975) these relative price decreases are quite small -- certainly less than what would normally be expected from an industry reverting from a collusive to either a Cournot or a Bertrand outcome in the middle of a recession.

Of course, we can not be sure how an economy-wide recession affects demand in any given industry; that is, output movements in individual industries could "lead" or "lag" the business cycle. Large declines in demand also occur for some industries in non-recession years. Such demand shocks may be more difficult to observe and therefore more likely to trigger the sort of reversion predicted by the Green-Porter model. We therefore report in Table IV maximum price declines (and the years they occurred) for the thirty-nine "high-PCM" industries. Incidences of large price declines appear to be quite rare. In only two instances (corn wet milling and X-ray apparatus) were there relative price declines exceeding twenty percent.

The evidence in Table IV does not lend much support for oligopoly price wars, at least not at the Census four-digit level of disaggregation. We should point out, however, some qualifications. Our data are annual, so that price wars of short duration would not show up in Table IV. Punishments resulting from such short reversions, however, would be very small and probably would not deter cheating. Another consideration is that if margins are not greatly elevated by trigger strategies for any of the reasons mentioned in the previous section, then a price war (or a reversion to a one-shot equilibrium) may result in only a modest decline in price.

We turn now to an assessment of the cyclical behavior of prices. In the Green-Porter model, prices increase continuously with increases in industry demand, although prices could fall discontinuously during downturns in demand if a reversion occurs. In the Rotemberg-Saloner model, prices fall continuously when demand increases beyond a certain point.

To pursue differences across categories of industries in response of price changes to cyclical fluctuations, we begin with a simple markup model of pricing. The target industry price P* is determined as a markup over unit cost C:

$$P^*_{it} = (1 + \lambda_{it})\, C_{it}. \tag{6}$$

Variation in P* arises both from changes in unit cost and from the cyclical nature of the markup, λ. This simple formulation does not violate any of the main features of either the Green-Porter or the Rotemberg-Saloner model. The average markup, $\bar{\lambda}_i$, presumably depends on such industry specific features as the magnitude of credible punishments.

Letting lower case variables denote logs, we can reexpress equation (6) as:

$$p^*_{it} \simeq \lambda_{it} + c_{it} \tag{7}$$

Taking first differences of equation (7), we obtain:

$$\Delta p^*_{it} \simeq \Delta\lambda_{it} + \Delta c_{it} \tag{8}$$

We assume that the markup λ can be expressed as:

$$\lambda_{it} = \gamma_i + \gamma_1 t + \gamma_2 CU_t \tag{9}$$

where γ_i is the time-invariant industry component, γ_1 allows for the possibility of a secular time trend and γ_2 is the cyclical component. Differencing equation (9) and substituting into equation (8) we obtain[19]:

$$(10) \qquad \Delta p^*_{it} = \gamma_1 + \gamma_2 \, \Delta CU_t + \gamma_3 \, \Delta c_{it} + \varepsilon_{it}$$

We note that differencing cost removes any fixed-cost component that may inadvertantly be entering into the computation of variable cost.[20] The coefficient on cost in equation (10) is unrestricted in the empirical work reported below, rather than set to unity, as in equation (8). Although this may entail a loss of efficiency in estimation if the restriction indeed holds, our measure of cost is not perfect, and a unit coefficient may not be appropriate.

We can extend this cyclical markup model to capture the idea that differences in price adjustment across industries may also reflect sticky prices due to costs of adjustment (Rotemberg [1982]) or nominal contracts (Hubbard and Weiner [1985]). If Δp^*_{it} is the target industry price adjustment, and $\Delta p_{it} = (1-\gamma_4) \, \Delta p^*_{it} + \gamma_4 \, \Delta p_{it-1}$, then equation (10) can be rewritten as[21]:

$$(11) \qquad \Delta p_{it} = \alpha_1 + \alpha_2 \, \Delta CU + \alpha_3 \, \Delta c_{it} + \alpha_4 \, \Delta p_{it-1} + \varepsilon_{it}.$$

Results from estimating (10) and (11) using instrumental variables[22] appear in Table V.

With respect to **all** concentrated producer-goods industries (high-PCM as well as low-PCM industries) price movements are countercyclical. That is, the coefficient on ΔCU is negative although only marginally statistically significant. If we partition the sample into high and low-PCM industries, however, differences appear. It is the high-PCM ("trigger-strategy") subsample for which countercyclical price movements are statistically significant and economically important. Concentrated producer-goods industries with low average PCMs have procyclical price movements although the coefficient on ΔCU is measured with a large standard error. This pattern is robust to whether or not a lagged dependent variable is included. The coefficients on ΔCU in the specifications including the lagged rate of change of prices imply that a 10-percentage-point increase in the aggregate rate of capacity utilization lowers the rate of change of prices in the high-PCM, concentrated, producer-goods industries by approximately 1.3 percentage points, and raises the rate of change of prices in the low-PCM counterparts by 1 percentage point.

We considered two tests of the robustness of the results presented in Table V. The first was to add an industry specific measure of demand variation to equations (10) and (11). Demand variation coming from ΔCU is quite in keeping with the flavor of the Rotemberg-Saloner model and is consistent with a strict interpretation of the imperfectly observed demand assumption in the Green-Porter model. While it is difficult to construct good proxies for industry specific demand variation, we entered such a measure in equation (10) and (11). The coefficient on this variable was estimated with large standard errors across categories, while the qualitative conclusions reported above went unchanged.[23]

As a supplementary test, we examined the cyclical behavior of cost itself. We have found that concentrated producer-goods industries have more procyclical price-cost margins and that concentrated high PCM industries have countercyclical prices. These results lead one to expect that costs must be more countercyclical for concentrated, producer-goods industries, and in particular for the high-PCM category. While a formal study of cost behavior is well beyond the scope of this paper, preliminary results indicate that average variable cost is considerably more countercyclical for our concentrated, high-PCM category of industries.[24]

The results in Tables II-V shed some light on the two trigger-strategy models described in the paper. The absence of large discrete price declines during the period covered by our data combined with the countercyclical price findings casts some doubt on the empirical validity of the Green-Porter model. Our price findings are qualitatively consistent with the predictions of the Rotemberg-Saloner model, as long as marginal cost is not countercyclical. However, the movements in prices estimated here cannot be described as large.

Interestingly, prices are "stickier" for the trigger-pricing subsample as well (in the sense of a significantly higher coefficient on the lagged rate of change in prices), indicating the need for additional research on sources of possible differences in **dynamic** price adjustment. That source of price rigidity may well be quantitatively more important than the differences in contemporaneous adjustment to cyclical movements.

V. CONCLUSIONS AND IMPLICATIONS

There has been a significant interest on a theoretical level in the application of supergames to oligopoly behavior. Implications for pricing behavior in trigger-strategy models in response to demand changes are of particular importance for public policy considerations. We contrast the predictions of two such models put forth by Green and Porter [1984] and Rotemberg and Saloner [1986], and test the predictions using a panel data set of U.S. manufacturing industries.

Our principal findings are four. First, the levels of price-cost margins of concentrated, producer-goods industries, while higher than those of unconcentrated counterparts, appear to be closer to those predicted by a single-period Cournot-Nash equilibrium than monopoly. Second, there is little evidence to support the idea that price-cost margins of these industries have different cyclical patterns from other industries apart from effects by level of industry concentration. Maximum price declines for concentrated industries give little support for the occurrence of price wars during either recessions or booms. Finally, consistent with the predictions of the Rotemberg-Saloner model, the industries with high price-cost margins have more countercyclical price movements than those exhibited by other industries. That gradual price adjustment is quantitatively important for those industries, suggests, however, that other factors may lie behind the apparent rigidity of prices.

These conclusions suggest two promising extensions for future research. First, the results for interindustry differences in responses of PCMs and prices to changes in aggregate demand suggest that countercyclical cost movements are likely to be important in producer-goods industries (say sticky real wages traceable to union bargaining agreements). Second, decomposing manufacturing industries into subgroups based on industry concentration or type of good produced, it is possible to test whether predictions of models of price adjustment based on costs of adjustment, contracting, or strategic considerations are consistent with the data. These extensions overlap substantially with recent theoretical concerns of both industrial economists and macroeconomists.

Notes

[1]Until recently, it was generally thought that finitely repeated games of the "Prisoners' Dilemma" variety were inherently similar to a single-period game (see the review in Friedman [1986]).

[2]For each firm's cooperative output level to be the noncooperative action, the marginal expected loss in future profits from triggering a Cournot reversion must exactly balance the marginal gain from cheating on the agreement.

[3]Assuming that demand shifts are so imperfectly observed that output changes never occur unless there is a reversion is extreme. Relaxing this assumption, however, and permitting a partial response (i.e., by allowing output to be somewhat procyclical) would not change the basic prediction that prices should be procyclical with periodic sharp declines.

[4]If such a period were very short, defection would never be desirable.

[5]See for example Waterson [1984, pp. 18-20].

[6]Multiplying equation (1) by q_i/Q and summing across all firms in the industry yields:

$$\frac{\sum P \cdot q_i - \sum MC_i \cdot q_i}{PQ} = \frac{\sum s_i^2(1 + \nu_i)}{\varepsilon}.$$

If marginal cost equals average variable cost, than the above expression can be rewritten as:

$$\frac{\pi + F}{PQ} = \frac{H}{\varepsilon},$$

where F is fixed cost and the left-hand side of the equation is the ratio of gross profits to sales.

[7]Consider as an example the automobile industry, one of the most concentrated industries in the United States. The approximate market shares of General Motors, Ford, Chrysler and American Motors are: 0.5, 0.25, 0.20, and 0.05. The Herfindahl index for this configuration of market shares is 0.355. Nelson [1963] reports Herfindahl values for most of the existing four-digit Census industries between 1947-1956. None of the Herfindahl's exceed 0.30. Nelson was unable, however, to report H values for a few of the most concentrated industries (e.g., aluminum).

[8]The PCM is defined as

$$PCM = \frac{\text{Value of Sales} + \Delta\text{Inventories} - \text{Payroll} - \text{Cost of Materials}}{\text{Value of Sales} + \Delta\text{Inventories}},$$

which is identical to (Value Added - Payroll)/(Value Added + Cost of Materials) given the Census's definition of value added.

[9]The Census of Manufactures and the Annual Survey of Manufactures (published by the U.S. Bureau of the Census) are the primary sources of information used in constructing the panel data base. Other possible sources were not used because of definitional problems, the short time period covered, or stringent confidentiality restrictions. Data for most industries go back to at least 1958, and for some industries even as far back as 1947, allowing for a panel of substantial length. Census definitional issues are discussed in Domowitz, Hubbard, and Petersen [1986a], [1986b]. The data are described therein, with the exception of the capital stock series, which has been modified to reflect a more realistic depreciation schedule.

[10]The producer-goods/consumer-goods classification is taken from Ornstein [1975]. Ornstein's classification is based on the percentage of shipments of output for final demand in four categories: consumption, investment, materials, and government. If fifty percent or more of an industry's output went to consumption, it was classified as a consumer-goods industry, if fifty percent or more went to investment plus materials, it was classified as a producer-goods industry.

[11]We used the four-firm concentration ratios constructed by Weiss and Pascoe [1981]. They adjusted the concentration ratio for all Census industries for 1972 for inappropriate product groupings and geographic fragmentation.

[12]This result is consistent with the findings of several cross-sectional studies of small differences in measures of profitability between concentrated and unconcentrated industries. For recent examples, see Salinger [1984] and Alberts [1984].

[13]A necessary condition in the Rotemberg-Saloner model is that the magnitude of the punishment be a binding constraint on margins and prices. Oligopolists then have to lower prices to keep cheating incentives in line with punishments when industry demand increases.

[14]For an overview of the evidence, see chapter three of Freeman and Medoff [1984].

[15]Rotemberg and Saloner note that their theory says nothing about the volatility of price as concentration increases, only that once an industry becomes an oligopoly it becomes more likely that it will cut prices in a boom.

[16]Data on capacity utilization in manufacturing are taken from the Economic Report of the President [1986].

[17]An important potential qualification of the OLS results is that the coefficient estimates may be biased by the omission of individual industry effects. With panel data, we can account for unobservable persistent industry differences; here we interpret "persistent" as time-invariant and reestimate the model using the standard fixed-effects within-group estimator.

[18]Industry output price deflators are obtained from the four-digit-S.I.C.-level data base constructed by the Penn-SRI-Census project and updated and extended at the National Bureau of Economic Research.

[19]Since the equation is in first differences, fixed unobservable industry effects in setting prices have been removed. A natural way to interpret equation (10) statistically, as well as equation (11) which follows, is to view the original equation as one in the log levels of the variables, which also includes a time-invariant industry component and a secular time trend. Equations (10) and (11) are then the estimating equations for the fixed-effects differencing estimator.

[20]The percentage change in unit labor costs is defined as the excess of the percentage growth in wage rates over the percentage growth in output per worker-hour. Industry specific data on the materials prices are not available. Assuming a constant ratio of materials to output, the percentage change in unit materials costs can be expressed as the percentage change in the total cost of materials less the percentage change in industry output.

[21]Given the interpretation of (11) as a fixed-effects estimating equation, we note the problems associated with the use of a lagged dependent variable, as exposited, for example, in Nickell (1986). The bias in coefficient estimates is sharply reduced as the number of time-periods grows, and may be considered negligible for the case here, given the length of our sample in the time-dimension.

[22]The endogenous variable is cost, of course. The instrument list included the (current-period) percentage change in the aggregate industrial production index, as well as percentage changes in cost and output prices lagged two periods. The first lag of the last two variables was not used, due to the nature of the error term under the fixed-effects interpretation given in footnote 13. Ordinary least squares estimation of (6) and (7) yielded results which were quite similar to those reported here. The main effect of using an instrumental-variables scheme was to enlarge the standard errors of the estimated coefficient on the percentage change in cost.

[23]We constructed the percentage rate of change in industry output ($\dot{Q}/Q$) as a proxy for industry demand fluctuations. Industry output Q was constructed as the quotient of the sum of current-dollar value added and cost of materials and the industry-specific output deflator. The percentage rate of change of output was orthogonalized with respect to changes in the aggregate rate of capacity utilization. An instrumental variables procedure was employed to eliminate the potential simultaneous equations bias inherent in regressing the change in prices on change in output.

The results from adding $\dot{Q}/Q$ to the model in equation (11) are given below. The results for all unconcentrated industries (C4 < 50), concentrated low-PCM industries, and concentrated, high-PCM industries, respectively, are:

$$\Delta p_{it} = \underset{(0.001)}{0.007} + \underset{(0.016)}{0.021}\,\Delta CU_t + \underset{(0.016)}{0.807}\,\Delta c_{it} + \underset{(0.009)}{0.143}\,\Delta p_{it-1} - \underset{(0.012)}{0.068}(\dot{Q}/Q)_{it}; \quad \bar{R}^2 = 0.84$$

$$\Delta p_{it} = \underset{(0.002)}{0.003} + \underset{(0.065)}{0.118}\,\Delta CU_t + \underset{(0.071)}{0.786}\,\Delta c_{it} + \underset{(0.033)}{0.112}\,\Delta p_{it-1} + \underset{(0.060)}{0.051}(\dot{Q}/Q)_{it}; \quad \bar{R}^2 = .80$$

$$\Delta p_{it} = \underset{(0.003)}{0.005} - \underset{(0.043)}{0.129}\,\Delta CU_t + \underset{(0.040)}{0.551}\,\Delta c_{it} + \underset{(0.022)}{0.313}\,\Delta p_{it-1} + \underset{(0.030)}{0.027}(\dot{Q}/Q)_{it}; \quad \bar{R}^2 = .77$$

[24] We estimated Δc as a linear function of the lagged percentage change in cost and ΔCU. The results for all unconcentrated industries (C4 < 50), concentrated, low-PCM industries, and concentrated, high-PCM industries, respectively, are:

$$\Delta c_{it} = \underset{(0.001)}{0.036} + \underset{(0.015)}{0.169}\, \Delta c_{it-1} - \underset{(0.030)}{0.217}\, \Delta CU_t; \quad \bar{R}^2 = 0.07$$

$$\Delta c_{it} = \underset{(0.005)}{0.044} + \underset{(0.051)}{0.086}\, \Delta c_{it-1} - \underset{(0.111)}{0.404}\, \Delta CU_t; \quad \bar{R}^2 = 0.06$$

$$\Delta c_{it} = \underset{(0.003)}{0.038} + \underset{(0.030)}{0.129}\, \Delta c_{it-1} - \underset{(0.065)}{0.644}\, \Delta CU_t; \quad \bar{R}^2 = 0.14$$

References

ALBERTS, W. W., 1984, 'Do Oligopolists Earn "Noncompetitive" Rates of Return?', The American Economic Review, 74, 4, pp. 624-632.

DOMOWITZ, I., HUBBARD, R. G., and PETERSEN, B. C., 1986a, 'Business Cycles and the Relationship Between Concentration and Price-Cost Margins', Rand Journal of Economics, 17, pp. 1-17.

DOMOWITZ, I., HUBBARD, R. G., and PETERSEN, B. C., 1986b, 'The Intertemporal Stability of the Concentration-Margins Relationship', Journal of Industrial Economics, 35, 1, pp. 13-34.

FREEMAN, R. B. and MEDOFF, J. L., 1984, What Do Unions Do?, New York: Basic Books, Inc., Publishers.

FRIEDMAN, J. W., 1985, 'Cooperative Equilibria in Finite Horizon Noncooperative Supergames', Journal of Economic Theory, 35, pp. 390-398.

FRIEDMAN, J. W., 1986, Game Theory with Applications to Economics, New York: Oxford University Press.

GREEN, E. J., and PORTER, R. H., 1984, 'Noncooperative Collusion Under Imperfect Price Information', Econometrica, 52, pp. 87-100.

HUBBARD, R. G., and WEINER, R. J., 1985, 'Nominal Contracting and Price Flexibility in Product Markets', Working Paper No. 1738, National Bureau of Economic Research.

LUCE, D., and RAIFFA, H., 1957, Games and Decisions, New York: Wiley and Sons.

ORNSTEIN, S. I., 1975, 'Empirical Uses of the Price-Cost Margin', Journal of Industrial Economics, 24, pp. 105-117.

NELSON, R. L., 1963, Concentration in the Manufacturing Industries of the United States, New Haven: Yale University Press.

NICKELL, S., 1986, 'Biases in Dynamic Models with Fixed Effects', Econometrica, 45, pp. 1417-1426.

PORTER, R. H., 1985 'Incidence and Duration of Price Wars', Journal of Industrial Economics, 33, 4, pp. 415-426.

RADNER, R., 1980, 'Collusive Behavior in Noncooperative Epsilon-Equilibria of Oligopolies with Long but Finite Lives', Journal of Economic Theory, 22, pp. 136-154.

ROTEMBERG, J. J., 1982, 'Sticky Prices in the United States', Journal of Political Economy, 90, pp. 1187-1212.

ROTEMBERG, J. J., and SALONER, G., 1986, 'A Supergame-Theoretic Model of Price Wars During Booms', American Economic Review, 76, pp. 390-407.

SALINGER, M., 1984, 'Tobin's q, Unionization, and the Concentration-Profits Relationship', Rand Journal of Economics, 15, pp. 159-170.

SELTEN, R., 1975, 'Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games', International Journal of Game Theory, 4, pp. 25-55.

WATERSON, M., 1984, Economic Theory of the Industry, Cambridge: Cambridge University Press.

WEISS, L. W., and PASCOE, G., 1981, 'Adjusted Concentration Ratios in Manufacturing', Mimeograph.

TABLE I
Implied PCMs for Selected Demand Elasticities and Herfindahl Indices

Monopoly Outcome*

ϵ	1.00	1.25	1.50	1.75	2.00
PCM	1.00	0.80	0.67	0.57	0.50

Cournot Outcome**

ϵ	1.00	1.25	1.50	1.75	2.00
H					
0.15	0.15	0.12	0.10	0.09	0.08
0.20	0.20	0.16	0.13	0.11	0.10
0.25	0.25	0.20	0.17	0.14	0.13
0.30	0.30	0.24	0.20	0.17	0.15
0.35	0.35	0.28	0.23	0.20	0.18

Note: *Based on equation (3) in text.
**Based on equation (4) in text; entries in the matrix are PCM values; H denotes the Herfindahl index.

TABLE II
Price-Cost Margins for Concentrated Producer-Goods Industries

Industry (SIC)	C4	Adjusted C4	Average PCM	Standard Deviation of PCM	Minimum PCM (Year)	Maximum PCM (Year)
High-PCM Industries						
Flour (2045)	68	62	0.306	0.030	0.232 (1978)	0.348 (1970)
Corn Wet Milling (2046)	63	63	0.290	0.042	0.191 (1973)	0.345 (1960)
Flavoring Extracts (2087)	66	62	0.483	0.033	0.413 (1975)	0.528 (1979)
Manufactured Ice (2097)	32	86	0.392	0.030	0.317 (1971)	0.444 (1973)
Pressed and Molded Pulp Goods (2646)	75	75	0.332	0.049	0.165 (1980)	0.389 (1977)
Alkalines and Chlorine (2812)	72	60	0.369	0.038	0.299 (1980)	0.422 (1975)
Industrial Gases (2813)	65	78	0.503	0.059	0.423 (1958)	0.605 (1970)
Inorganic Pigments (2816)	52	52	0.365	0.063	0.269 (1978)	0.447 (1964)
Synthetic Rubber (2822)	62	54	0.279	0.057	0.170 (1981)	0.356 (1969)
Organic Fibers (2824)	74	70	0.380	0.093	0.231 (1975)	0.493 (1958)
Explosives (2892)	67	69	0.272	0.077	0.126 (1970)	0.380 (1980)
Carbon Black (2895)	74	74	0.393	0.114	0.160 (1980)	0.514 (1968)
Tires & Tubes (3011)	73	73	0.273	0.030	0.227 (1964)	0.334 (1973)
Reclaimed Rubber (3031)	78	74	0.277	0.068	0.171 (1970)	0.500 (1979)
Flat Glass (3211)	92	83	0.362	0.042	0.296 (1981)	0.446 (1972)
Products of Purchased Glass (3231)	43	54	0.270	0.019	0.242 (1970)	0.318 (1960)
Cement, Hydraulic (3241)	26	73	0.436	0.045	0.339 (1981)	0.490 (1959)
Brick and Structural Tile (3251)	17	65	0.292	0.037	0.217 (1960)	0.352 (1977)
Gypsum Products (3275)	80	79	0.356	0.068	0.237 (1976)	0.446 (1963)
Mineral Wool (3296)	71	72	0.337	0.032	0.291 (1963)	0.413 (1977)
Primary Aluminum (3334)	79	69	0.315	0.047	0.208 (1981)	0.390 (1968)
Turbines (3511)	90	80	0.276	0.041	0.206 (1969)	0.340 (1960)
Internal Combustion Engines (3519)	50	74	0.241	0.021	0.197 (1960)	0.276 (1971)
Elevators (3534)	55	52	0.323	0.069	0.186 (1980)	0.421 (1969)
Ball Bearings (3562)	53	70	0.274	0.014	0.239 (1969)	0.295 (1981)
Scales, Balances (3576)	50	63	0.335	0.055	0.267 (1962)	0.436 (1980)
Transformers (3612)	59	69	0.271	0.022	0.231 (1972)	0.313 (1959)
Switchgear (3613)	51	62	0.321	0.031	0.261 (1961)	0.384 (1981)
Motors & Generators (3621)	47	55	0.270	0.026	0.230 (1961)	0.316 (1977)
Carbon and Graphite Product (3624)	80	79	0.350	0.019	0.314 (1972)	0.398 (1975)
Sewing Machines (3636)	84	80	0.306	0.082	0.128 (1958)	0.433 (1972)
Electric Lamps (3641)	90	87	0.450	0.016	0.416 (1958)	0.474 (1975)
Telephone Apparatus (3661)	89	88	0.266	0.030	0.178 (1968)	0.308 (1978)
Storage Batteries (3691)	57	58	0.260	0.040	0.194 (1960)	0.350 (1966)
Primary Batteries (3692)	92	91	0.373	0.043	0.288 (1981)	0.446 (1972)
X-Ray Apparatus (3693)	54	52	0.324	0.044	0.251 (1961)	0.415 (1972)

TABLE II (continued)
Price-Cost Margins for Concentrated Producer-Goods Industries

Industry (SIC)	C4	Adjusted C4	Average PCM	Standard Deviation of PCM	Minimum PCM (Year)	Maximum PCM (Year)
Engine Electrical Equipment (3694)	65	76	0.284	0.016	0.244 (1980)	0.315 (1976)
Environmental Controls (3822)	57	57	0.333	0.028	0.287 (1979)	0.377 (1961)
Photographic Equipment (3861)	74	86	0.458	0.053	0.350 (1958)	0.537 (1971)
Low-PCM Industries						
Tobacco (Drying) (2141)	67	66	0.051	0.014	0.031 (1963)	0.078 (1978)
Man-Made Fiber, Finishing Plants (2262)	56	56	0.195	0.021	0.161 (1974)	0.232 (1968)
Thread Mills (2284)	62	58	0.192	0.027	0.155 (1978)	0.255 (1974)
Tire Cord and Fabric (2296)	84	81	0.111	0.022	0.073 (1959)	0.153 (1974)
Sanitary Food Containers (2654)	46	56	0.250	0.019	0.203 (1980)	0.276 (1968)
Fiber Cans (2655)	54	52	0.213	0.013	0.190 (1960)	0.238 (1974)
Cellulosic Fiber (2823)	96	70	0.250	0.090	0.109 (1978)	0.361 (1966)
Ready-Mix Concrete (3273)	6	51	0.233	0.013	0.207 (1961)	0.258 (1969)
Electrometallurgical Product (3313)	74	88	0.216	0.050	0.105 (1958)	0.326 (1974)
Malleable-Iron Foundries (3322)	52	51	0.212	0.036	0.126 (1958)	0.265 (1976)
Primary Copper (3331)	72	60	0.138	0.044	0.047 (1975)	0.281 (1969)
Primary Zinc (3333)	66	57	0.160	0.047	0.074 (1971)	0.276 (1964)
Copper Rolling and Drawing (3351)	39	51	0.143	0.024	0.108 (1975)	0.202 (1966)
Metal Coating (3479)	15	72	0.248	0.032	0.192 (1972)	0.306 (1981)
Construction Machinery (3531)	43	63	0.244	0.033	0.133 (1960)	0.280 (1978)
Blast Furnaces and Steel Mills (3312)	45	51	0.202	0.026	0.151 (1981)	0.238 (1965)
Aircraft (3721)	66	82	0.218	0.059	0.130 (1959)	0.328 (1976)
Aircraft Engines (3722)	60	60	0.226	0.042	0.157 (1960)	0.303 (1979)

Note: The adjusted concentration ratio is that reported in Weiss and Pascoe [1981].

TABLE III
Cyclical Sensitivity of PCMs by Category of Industry

Dependent Variable: PCM

OLS Results

	Industries					
	All	C4 < 50	C4 > 50(C)	C4 > 50(P)	C4 > 50(PH)	C4 > 50(PL)
Constant	0.107 (0.017)	0.131 (0.019)	0.173 (0.061)	-0.040 (0.048)	0.087 (0.051)	-0.032 (0.058)
C4	0.110 (0.0005)	0.092 (0.008)	0.143 (0.029)	0.185 (0.020)	0.127 (0.023)	-0.006 (0.023)
A/S	1.064 (0.031)	1.106 (0.052)	1.125 (0.053)	0.433 (0.088)	0.224 (0.077)	1.755 (0.380)
K/Q	0.030 (0.002)	0.027 (0.003)	-0.041 (0.013)	0.055 (0.005)	0.024 (0.005)	0.065 (0.010)
CU	0.096 (0.021)	0.077 (0.022)	0.039 (0.070)	0.197 (0.056)	0.165 (0.059)	0.227 (0.067)
$\bar{R}^2$	0.275	0.169	0.467	0.183	0.086	0.147

Fixed-Effects Results

	Industries					
	All	C4 < 50	C4 > 50(C)	C4 > 50(P)	C4 > 50(PH)	C4 > 50(PL)
C4	0.123 (0.010)	0.136 (0.012)	0.133 (0.030)	0.122 (0.029)	0.199 (0.041)	0.007 (0.032)
A/S	0.003 (0.054)	-0.327 (0.084)	0.077 (0.089)	0.225 (0.121)	0.208 (0.133)	1.010 (0.840)
K/Q	-0.017 (0.003)	-0.007 (0.004)	-0.003 (0.010)	-0.044 (0.007)	-0.051 (0.008)	-0.008 (0.012)
CU	0.078 (0.010)	0.066 (0.012)	0.118 (0.034)	0.116 (0.028)	0.103 (0.039)	0.161 (0.038)
$\bar{R}^2$	0.037	0.041	0.059	0.065	0.080	0.047

Note: C, P, PH, and PL denote consumer-goods industries, producer-goods industries, high-PCM producer-goods industries, and low-PCM producer-goods industries, respectively. C4 refers to the Weiss-Pascoe adjusted measure (see footnote 7). Standard errors are in parentheses.

TABLE IV
Price Increases and Decreases in High-PCM Industries

Industry (SIC)	Maximum Price Decrease	(Year)	%ΔP 1961	1970	1975	1980
Flour (2045)	-10.4%	(1976)	0.9%	0.4%	7.6%	-5.5%
Corn Wet Milling (2046)	-22.2	(1976)	3.5	4.0	2.9	2.4
Flavoring Extracts (2087)	-19.4	(1976)	0.1	-2.0	3.9	2.3
Manufactured Ice (2097)	-9.7	(1980)	0.2	1.0	0.8	-9.7
Pressed and Molded Pulp Goods (2646)	-3.9	(1974)	-2.6	0.2	-3.0	-2.2
Alkalines & Chlorine (2812)	-10.0	(1979)	-0.6	-3.0	35.1	1.2
Industrial Gases (2813)	-11.6	(1977)	0.0	4.6	11.3	0.1
Inorganic Pigments (2816)	-4.8	(1980)	-0.6	-3.3	3.0	-4.8
Synthetic Rubber (2822)	-6.4	(1974)	0.2	-3.2	0.1	4.6
Organic Fibers (2824)	-14.2	(1974)	-1.4	-3.9	-13.3	-3.1
Explosives (2892)	-3.9	(1959)	3.3	-1.7	6.0	-3.7
Carbon Black (2895)	-7.5	(1978)	-3.0	-2.5	27.6	8.0
Tires and Tubes (3011)	-4.8	(1962)	-0.4	2.6	0.6	-1.0
Reclaimed Rubber (3031)	-6.8	(1980)	0.5	-3.5	-1.7	-6.8
Flat Glass (3211)	-15.3	(1974)	-2.5	1.9	-5.5	-7.7
Products of Purchased Glass (3231)	-16.2	(1959)	-1.1	-0.7	-1.0	-6.2
Cement, Hydraulic (3241)	-9.1	(1959)	0.4	5.5	7.2	-5.9
Brick and Structural Tile (3251)	-10.7	(1959)	1.1	0.6	-0.1	-7.8
Ceramic Tile (3253)	-13.6	(1974)	0.6	-3.4	-2.4	-10.2
Gypsum Products (3275)	-12.7	(1980)	2.6	-6.9	-6.1	-12.7
Mineral Wool (3296	-9.4	(1979)	-5.4	2.9	13.0	-3.8
Primary Aluminum (3334)	-19.1	(1972)	-4.3	1.8	-5.0	5.5
Turbines (3511)	-9.5	(1974)	-9.1	5.6	15.0	3.5
Elevators (3534)	-6.5	(1974)	1.2	5.6	7.8	-4.6
Ball Bearings (3562)	-7.6	(1965)	-1.5	1.7	4.0	0.5
Scales, Balances (3576)	-9.6	(1974)	0.8	-0.2	0.0	-5.7
Transformers (3612)	-8.3	(1969)	-4.4	2.0	5.7	-6.4
Switchgear (3613)	-5.4	(1972)	0.8	2.0	5.9	-1.9
Motors and Generators (3621)	-6.1	(1974)	-2.7	3.3	4.1	-3.8
Carbon and Graphite Product (3624)	-5.0	(1976)	-0.4	0.5	17.6	-0.9
Sewing Machines (3636)	-9.4	(1974)	1.4	1.3	4.9	-8.6
Electric Lamps (3641)	-8.8	(1974)	0.3	0.4	10.7	-5.0
Telephone Apparatus (3661)	-11.2	(1974)	-1.7	1.1	11.8	-6.0
Storage Batteries (3691)	-10.6	(1980)	0.9	3.2	3.1	-10.6
Primary Batteries (3692)	-15.4	(1974)	-0.8	-1.7	5.8	-10.6
X-Ray Apparatus (3693)	-20.0	(1959)	-0.6	3.0	4.5	-1.5
Engine Electrical Equipment (3694)	-11.9	(1959)	-0.2	1.6	7.0	-4.4
Environmental Controls (3822)	-18.1	(1959)	2.0	12.4	0.8	-7.4
Photographic Equipment (3861)	-12.8	(1974)	1.1	-1.5	-1.1	4.9

Note: Price increases and decreases are relative to those for all industries on average.

TABLE V

Cyclical Sensitivity of Prices by Category of Industry

Dependent Variable: $\%\Delta p_{it}$

	Constant	$\%\Delta p_{it-1}$	$\%\Delta c_{it}$	ΔCU_t	$\bar{R}^2$
All Industries	0.010 (0.0007)	---	0.817 (0.012)	-0.034 (0.011)	0.820
	0.005 (0.001)	0.227 (0.007)	0.718 (0.013)	0.016 (0.012)	0.812
C4 < 50	0.009 (0.0008)	---	0.864 (0.014)	-0.021 (0.013)	0.839
	0.004 (0.001)	0.184 (0.009)	0.781 (0.016)	0.028 (0.014)	0.831
C4 > 50(C)	0.009 (0.003)	---	0.810 (0.053)	-0.047 (0.040)	0.788
	0.005 (0.003)	0.455 (0.033)	0.503 (0.060)	-0.074 (0.042)	0.777
C4 > 50(P)	0.011 (0.002)	---	0.718 (0.033)	-0.053 (0.031)	0.782
	0.006 (0.002)	0.284 (0.019)	0.584 (0.035)	-0.032 (0.032)	0.776
C4 > 50(PH)	0.012 (0.002)	---	0.685 (0.040)	-0.106 (0.040)	0.764
	0.005 (0.002)	0.347 (0.023)	0.518 (0.042)	-0.127 (0.040)	0.768
C4 > 50(PL)	0.011 (0.003)	---	0.768 (0.056)	0.039 (0.048)	0.828
	0.008 (0.004)	0.174 (0.032)	0.672 (0.062)	0.098 (0.052)	0.814

Note: C, P, PH, and PL denote consumer-goods industries, producer-goods industries, high-PCM producer-goods industries, and low-PCM producer-goods industries, respectively. Standard errors are in parentheses.