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DISEQUILIBRIUM DYNAMICS: AN EMPIRICAL STUDY

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Despite the amount of attention devoted in economics to the study of equilibria, the process by which an equilibrium can be attained is not well understood; Steven Smale called this "the fundamental problem of economic theory." This paper explores the microeconomics of the adjustment process by examining empirically the disequilibrium behavior of firms. Implications for the microeconomic foundations of macroeconomics are stressed.

The data, from German industry, describe the month-by-month price and output changes of individual firms, as well as the firms' own assessments of the levels of their inventories and unfilled orders. Because the data are qualitative, use is made of the multivariate conditional logit model developed by Marc Nerlove and James Press (1973, 1976) and extended by Kawasaki and Zimmermann.

Section I discusses the underlying model of firm behavior and the significance of the inquiry for macroeconomics. In Section II, the econometric techniques are briefly described. In Section III, the empirical results are summarized, and then interpretations of the results are offered in Section IV. The paper concludes with a brief summary.

I. Adjustment Dynamics

This paper investigates empirically the way firms respond to self-perceived disequilibrium. Underlying the analysis is a model of markets in which both buyers and sellers have incomplete information. Because buyers are not fully informed about the price charged by each seller, even small firms face a negatively-sloped demand function: if a firm cuts its price it will not capture the entire market because only some of its potential customers will learn of its lower price (see Kenneth Arrow). Thus the firms, even if they in other ways resemble perfectly competitive firms, have some power to determine the prices they receive for their outputs. Because sellers have imperfect information about their rivals' reactions to changes in their own actions, and because the market demand function fluctuates unpredictably, each seller-firm can only guess about the nature of the demand function it faces. The previous month's price and sales give the firm new information about its perceived demand function; if it observes that it is not in equilibrium, it may accordingly revise its price-and-output decision for the current month.

A first question about firms' responses to disequilibrium is: do the firms' changes in prices and/or outputs move the firms closer to, or still further away from, their equilibrium situations? Paul Samuelson and others have examined theoretically the requirements for the stability of competitive equilibrium; this paper adds some empirical detail to that literature.

Given that the firms' responses tend to eliminate disequilibrium, a second question concerns the path followed during the disequilibrium adjustments. In the reappraisal of Keynesian economics started by Robert Clower and Don Patinkin, attention has been focused on the nature of exchange when markets fail to clear. According to Axel Leijonhufvud, the "revolutionary element" in Keynes's General Theory is that: "In the Keynesian macrosystem the Marshallian ranking of price- and quantity-adjustment speeds is reversed: In the shortest period flow quantities are freely variable, but one or more prices are given, and the admissible range of variation for the rest of the prices is thereby limited."[1] The question of whether real-world dynamics are better described by the Marshallian or the Keynesian system cannot be settled on a priori grounds; this paper addresses this question empirically at the microeconomic level.

One would expect that actual adjustment processes exhibit both price and quantity changes; that neither the Marshallian polar case (fixed quantities in the short run) nor the Keynesian polar case (fixed prices in the short run) is completely realistic. But, in order to build macroeconomic models that are simple enough to be manageable, it is useful (Leijonhufvud, p. 58, argued it is essential) to assume that one of the polar cases holds. A number of short-run macroeconomic models (labelled "neo-Keynesian", "disequilibrium", "fixprice", or "temporary equilibrium" models) have been developed which assume that prices adjust only after quantities have fully adjusted; see, for example, Robert Barro and Herschel Grossman, and Edmond Malinvaud. Malinvaud claimed that it is an "institutional fact" that "short-term quantitative adjustments are much more apparent and influential than short-term price adjustments" (p. 10); that is, that the Keynesian polar case is the more accurate approximation to reality. This paper examines Malinvaud's claim.

The question of whether prices or quantities are more flexible needs to be carefully interpreted. If a firm observes a change in the demand function it faces then its price and output responses are determinate, to the extent that it behaves as in microeconomic theory: it chooses a new price and output so as to equate its new perceived marginal revenue to its marginal cost. What is not theoretically determinate in this process is the timing. If the firm adjusts its output frequently (perhaps by a series of small changes), and price only infrequently (though perhaps by large steps when the adjustments do take place) then the assumption of price fixedness is justified:[2] the fixprice models can be interpreted as describing the situation between price changes. Thus the paper attempts to measure the flexibility of firms' prices and outputs where flexibility is taken to mean frequency, as opposed to size, of changes.

Whether or not prices move quickly enough so that markets always clear is one of the points of division among the protagonists in the debate on the effectiveness of macroeconomic policy (see, for example, Robert Barro, Willem Buiter, Robert J. Gordon, and David Laidler). This paper thus provides some empirical background for this continuing discussion.

There is a third question about the nature of firms' disequilibrium responses. It is widely believed that price responses are asymmetric; that prices more readily rise than fall. Another purpose of this paper is to ask if there is any evidence for the assertion that product prices are more sticky downwards than upwards.

The theoretical literature on disequilibrium adjustments referred to above makes little mention of inventories and unfilled orders. Realistically, as will be seen, these are significant determinants of the adjustment process: their current levels are indicators of the previous periods' excess supply or excess demand. In this paper two alternative measures of firm disequilibrium are considered: the firm's own evaluation of whether the level of its inventories is too high, correct, or too low; and its evaluation of the level of its unfilled orders. Note that these appraisals by the firm implicitly contain information about the firm's optimization procedure. On the basis of its perceived demand function and its cost function, the firm computes an optimal level of inventories (or unfilled orders). The comparison of this optimal level with its current level is what the firm reports as its evaluation of its level of inventories (or unfilled orders). If the current level of inventories (or unfilled orders) is not optimal, the firm must in some way alter its price-and-output decision. We investigate the firm's decision to change price, output, or both in response to stock disequilibrium. (For models in which a firm's profit-maximizing price and output vary with its evaluation of its inventory disequilibrium, see Alan Blinder and Louis Maccini. For analyses of the stability properties of a system in which prices adjust in response to stock disequilibrium, see Werner Hildenbrand and Roy Radner, and Steven Smale.)

II. Estimation with Qualitative Data

We use business-survey data collected by the Ifo-Institut fuer Wirtschaftsforschung, Munich. Using micro-data has the advantage of avoiding the problems of aggregation over firms, which may obscure the true micro-level responses; and the data include the firms' own appraisals of their disequilibrium situations.

As discussed in Section I, the change in price from the previous month (P_t) and the change in production activity from the previous month (Q_t) are assumed to depend on the firm's appraisal of its inventory of finished goods in the previous month (L^*_{t-1}) and its appraisal of its stock of unfilled orders in the previous month (A^*_{t-1}). In the Ifo business survey, firms answered either "increased" (+), "remained unchanged" (=), or "decreased" (-) for P and Q, "too small" (+), "satisfactory" (=), or "too large" (-) for L*, and "too large" (+), "satisfactory" (=), or "too small" (-) for A*. Note that whereas the answers for L* and A* are reversed, the interpretation is the same: "+" indicates an excess demand for both L* and A*, while "-" indicates an excess supply.

The data thus have an unusual feature: all the variables are qualitative. In this situation, standard regression procedures are no longer appropriate. It is hardly justifiable to represent the three categories of a dependent variable (+, =, or -) by arbitrary numbers so as to remove its qualitative nature. Moreover, the error term is now discrete given the value of the independent variables; as a result, the conventional statistical assumption of normality breaks down. In order to be able to analyze these qualitative data, we focus on the probability that the dependent variable takes on any particular value (+, =, or -) instead of on the value (+, =, or -) itself; and we employ the conditional logit model to explain the effects of the independent variables on this probability.

The estimation technique consists of two stages.[3] The first stage uses the multivariate conditional logit model developed by Nerlove and Press (1973, 1976); the specification for our model is given by (where the three categories, +, =, and -, are labelled as 1, 2, and 3):

$$(1) \quad \Pr(P_t = i,\ Q_t = j \mid L^*_{t-1} = k,\ A^*_{t-1} = h)$$

$$= \frac{\exp[S(i,j \mid k,h)]}{\sum_{i'=1}^{3} \sum_{j'=1}^{3} \exp[S(i',j' \mid k,h)]} \quad \text{for } i,j,k,h = 1,2,3,$$

where

$$(2) \quad S(i,j \mid k,h) = \sum_{i'=1}^{3} \alpha^{P}_{i'}\, d_{i'}(i) + \sum_{j'=1}^{3} \alpha^{Q}_{j'}\, d_{j'}(j)$$

$$+ \sum_{i'=1}^{3} \sum_{k'=1}^{3} \beta^{PL^*}_{i'k'}\, d_{i'}(i)\, d_{k'}(k)$$

$$+ \sum_{j'=1}^{3} \sum_{k'=1}^{3} \beta^{QL^*}_{j'k'}\, d_{j'}(j)\, d_{k'}(k)$$

$$+ \sum_{i'=1}^{3} \sum_{h'=1}^{3} \beta^{PA^*}_{i'h'}\, d_{i'}(i)\, d_{h'}(h)$$

$$+ \sum_{j'=1}^{3} \sum_{h'=1}^{3} \beta^{QA^*}_{j'h'}\, d_{j'}(j)\, d_{h'}(h)$$

$$+ \sum_{i'=1}^{3} \sum_{j'=1}^{3} \beta^{PQ}_{i'j'}\, d_{i'}(i)\, d_{j'}(j)\ .$$

Here $S(i,j|k,h)$ can be interpreted as the utility the firm receives when it chooses $P_t = i$ and $Q_t = j$ when $L^*_{t-1} = k$ and $A^*_{t-1} = h$. (See Daniel McFadden.) The variable $d_i(j)$ is a dummy variable which takes on value one when i=j and zero otherwise. The α's and β's denote parameters for the dummy variables. The α terms measure the extent to which the independent variables (L* and A*) fail to explain the dependent variables (P and Q). The term β^{yx}_{ij} is a measure of the influence of the j^{th} category of the independent variable, x, on the occurrence of the i^{th} category of the dependent variable, y. The model is completed by imposing the ordinary analysis-of-variance-type restrictions (that is, with respect to each variable, the α's sum to zero and the β's sum to zero). Although it is possible to estimate separate models for price and output, we estimate a joint model. This approach allows testing the difference between price reactions and output reactions, as well as taking account of the correlation between price and output due to some omitted variables (the latter effects are represented by the (P,Q) interaction in equation (2)).

From the estimates of the α's and β's can be constructed a set of estimated contingency (component probability) tables: for example, the <u>ceteris paribus</u> interaction between inventory evaluations and price changes is represented by a three-by-three matrix, the elements of which are the estimated probabilities that, <u>ceteris paribus</u>, price will rise (or stay the same, or fall) given that the firm reports that inventories are too low (or satisfactory, or too high).

The output of this first stage of the estimation consists of a large number of parameter estimates. For the interaction between inventory evaluations and price changes above, the estimation produces nine estimated probabilities and a nine-by-nine asymptotic covariance matrix. These parameter estimates give detailed category-by-category information on the bivariate relationship. However, the information is scattered over so many parameters that it is difficult to detect whether or not two variables are positively associated, or how strong the association is if it exists. And the comparison between two different bivariate relationships would be even more intractable. The second stage of the estimation summarizes this information by means of two statistical measures (see Kawasaki, and Kawasaki and Zimmermann for details). Firstly, the gamma coefficient (due to Leo Goodman and William Kruskal) is used to summarize, by the use of the above-described component probability tables, the *ceteris paribus* bivariate interaction between each dependent variable (price or output change) and each independent variable (inventory or unfilled-order evaluation). The gamma coefficient is analogous to the usual correlation coefficient in that it takes a value of plus one (minus one) when there is a perfect postive (negative) association and a value of zero when the variables are independent. In addition, we use the difference between a pair of gamma coefficients as a measure of the relative strengths of the two bivariate interactions; such differences can be tested for their statistical significance. Secondly, the phi-square coefficient is used to represent the extent to which changes in the dependent variable fail to be explained by changes in the independent variable; it summarizes the influences on the dependent variable which are not captured in the model (the α's in equation (2)). Phi-square is zero if there are no such extra effects; and the more important such effects are, the larger it is.

III. Estimation Results

The data set consists of 73,336 observations for each variable within 23 time points from February 1977 to December 1978. There are differences in the number of firms between time points due to some firms' failing to report to the survey in some months. For 60,800 observations, where the firms held a stock of both finished-good inventories and unfilled orders, the model (2) was estimated for individual time points with pooling over industries (see Tables 1 and 2), for individual industries with pooling over time, and for the whole sample[4] (see Tables 3 and 4). In the remaining 12,536 observations, the firms held no stock of finished-good inventories. Since the model (2) does not fit such cases, they were treated separately and estimated by a submodel without inventory variables (see Table 5).

It was not possible to estimate the models for all cases due to the existence of sampling zeros in the contingency tables: if there are no observations in certain cells of a cross-classified table, the logit model has no maximum-likelihood estimator. (See Shelby Haberman, pp. 34-38.) For February to April in 1978 and eighteen out of twenty-seven available industry groups, the model (2) could not be estimated. To obtain estimates for all time points, we employed a method due to Yvonne Bishop, Stephen Fienberg, and Paul Holland (pp. 400-433): the three data sets of February to April 1978 were adjusted by the data of the corresponding months of 1977 to avoid empty-cell problems. Due to the lack of reliable external information we did not apply this method to the industry-level data. For the firms without finished-good inventories, there being fewer observations, only three time points, two industry groups, and the whole sample were free of the empty-cell problem. This problem was also the reason why more lagged independent variables, such as L^*_{t-2}, A^*_{t-2}, L^*_{t-3}, A^*_{t-3}, etc., were not included in the models.

The first result is that the firms do respond to inventory or unfilled-order disequilibrium within one month with price and/or output changes. This conclusion follows from a comparison of the model (2), in which the bivariate interactions (P,L*), (Q,L*), (P,A*), (Q,A*), and (P,Q) are all assumed to be present, with the null hypothesis model, in which the only bivariate interaction is (P,Q). Asymptotic chi-square tests of likelihood-ratio values[5] result in every case in rejection of the null hypothesis and thus support the model presented in equation (2). (See the last column of Tables 1 and 3.)

The next result is that inventory disequilibrium and unfilled-order disequilibrium do not explain all of the variations in price and output that occur. This is shown by the phi-square coefficients (reported in the second and third columns of Tables 1 and 3). The phi-square coefficients are all significantly larger than zero but, in all time-point estimates and in all but two industry estimates, are larger for price changes than for output changes. This indicates that there are some remaining effects that are not included in our economic model (such as cost changes and slower responses to disequilibrium) and that these effects are more important for price changes than for output changes.

We measure the flexibility of firms' prices and outputs by the gamma coefficient. (Recall that the gamma coefficient can be thought of as being analogous to a correlation coefficient, except that what is being measured is frequency, rather than size, of change.) The gamma-coefficient estimates are reported in the third through seventh columns of Tables 1 and 3. To address the question of whether prices or outputs are the more flexible, the differences between gamma coefficients were computed and tested for significance; the results are reported in the first four columns of Tables 2 and 4.

Looking firstly at the estimates for individual time-points, with pooling over industries (Table 1), note that most of the gamma coefficients in the twenty-three months are significantly larger than zero: eight for (P,L*), twenty for (Q,L*), eighteen for (P,A*), and twenty-three for (Q,A*). In all cases in which the gamma coefficient is significant, it has the appropriate sign (so that, for example, too low a level of inventories is followed by an increase in output). In comparing the magnitudes of the estimated gamma coefficients, we can conclude that firms react more markedly with output changes than with price changes. Moreover, the reaction to the appraisal of unfilled orders is more marked than the reaction to the appraisal of inventories. In most cases the association between output change and unfilled-orders evaluation is the strongest. These comparisons are made precise by the test of difference between the gammas (Table 2). The difference $\gamma(P,L^*) - \gamma(Q,L^*)$ is mostly negative (and in four cases significant), but in one case positive and significant. The difference $\gamma(P,A^*) - \gamma(Q,A^*)$ is mostly negative and in four cases significant. This supports the claim that quantity adjustments are more important than price adjustments. On the other hand, the difference $\gamma(P,L^*) - \gamma(P,A^*)$ is mostly negative and in seven cases significant, whereas the difference $\gamma(Q,L^*) - \gamma(Q,A^*)$ has the same tendency, but with ten significant occurrences. This indicates that the appraisal of the stock of unfilled orders is more important for the adjustment process of the firm than the appraisal of inventory of finished goods. The question of why unfilled orders have more influence than inventories on firms' decisions is taken up in the next section.

Consider now Table 3, which reports the estimates for individual industries, with pooling over time. For the nine industries for which it was possible to estimate the model, the following number of gamma-coefficients are significantly bigger than zero: one for (P,L*), three for (P,A*), six for (Q,L*), and seven for (Q,A*). From the test for the differences between gamma coefficients (Table 4), as a tendency γ(Q,L*) is bigger than γ(P,L*), significantly in one case. γ(Q,A*) is mostly larger than γ(P,A*), significantly so in five cases. There is also a tendency that γ(P,A*) is larger than γ(P,L*), but this is only significant in one case. Finally, γ(Q,A*) is significantly bigger than γ(Q,L*) in four cases, whereas the other results are not so clear. Thus, consistently with the results of the time-point estimates, firms react more significantly with changes in quantities than with changes in prices and the reaction is stronger to the appraisal of the stock of unfilled orders than to the appraisal of inventory of finished goods. (Note that the industry-level results only refer to 62.3% of the total sample size.) There are differences among the industries. Stone and clay show no short-run response to disequilibrium; machinery, electrical equipment, glass and products, clothing, and iron, tin and other products adjust mainly in quantity in the short run; whereas non-ferrous metals, plastics and products, and especially textile products react in the short run with both prices and quantities. Clothing and non-ferrous metals react only to the appraisal of the stock of unfilled orders.

Finally, as a summary of the results, the model was estimated for the total sample (see the first row of Table 3). We can clearly reject the null hypothesis; all phi-square coefficients and gamma coefficients are significant and consistent with the previous results. γ(Q,A*) is the largest of the gammas and is significantly bigger than γ(P,A*). γ(Q,L*) is bigger than $\gamma(P,L^*)$, but not significantly so. $\gamma(P,A^*)$ is significantly larger than $\gamma(P,L^*)$, and $\gamma(Q,A^*)$ is significantly larger than $\gamma(Q,L^*)$.

As noted at the beginning of this section, the data set contains firms without finished-good inventories, which amount to about one-sixth of the firms in the sample. For these observations the model (2) has to be modified such that all the terms including inventory variables are eliminated. Although estimation was not possible in many cases due to empty cells, the results were similar to those of the model (2) (see Table 5). Chi-square tests in each case supported the model against the null-hypothesis model without the two bivariate interactions (P,A*) and (Q,A*). The phi-square coefficients also showed that there were some remaining effects for price and output which were not included in the model and that these effects were more important for price changes than for output changes. The estimated gamma coefficients, $\gamma(P,A^*)$ and $\gamma(Q,A^*)$, are mostly statistically significant and have correct signs in every case. On the other hand the difference between gammas was significant for only one time point. It thus seems that the magnitude of output response relative to price response for these pure production-to-order firms is not as strong as that of firms with both inventories and unfilled orders.

As a simple measure of the symmetry or asymmetry of absolute price changes, we calculated

$$M(P) = \frac{Pr(+) - Pr(-)}{Pr(+) + Pr(-)} \cdot 100$$

where Pr(+) and Pr(-) are the observed relative frequencies of the answers "price rose" (i.e., "+") and "price fell" (i.e., "-"). The statistic M measures how much more probable is a rise in absolute price than a fall in absolute price, when we neglect the possibility of no change. Note that M depends directly on the answers of the firms and not on any estimated parameters. Values of M are reported in the fifth column of Tables 2 and 4. Between May 1977 and December 1977 more firms lowered their prices than raised their prices. In the time-pooled samples, four industries out of nine had more firms lowering than raising their prices. Absolute prices seem to be flexible downwards.

To examine the question of the asymmetry of price changes in response to disequilibrium, we used the estimated component probability tables. Denote by $Pr^c(+,+)$ the estimated probability of a price rise due to excess demand and $Pr^c(-,-)$ the probability of a price fall due to excess supply, if all other effects are simultaneously removed. (Excess supply and demand are defined firstly by inventory disequilibrium and secondly by unfilled-order disequilibrium.) Possible asymmetries in these reactions can be measured by

$$D(\cdot) = \frac{Pr^c(+,+) - Pr^c(-,-)}{Pr^c(+,+) + Pr^c(-,-)} \cdot 100$$

The last two columns of Tables 2 and 4 report the statistics D(P,L*) and D(P,A*). There is no evidence that prices are sticky downwards in response to disequilibrium.

IV. Discussion of the Results

Firms react to stock disequilibrium within one month with both price and output changes. However, generalizing from the gamma-coefficient estimates, the Keynesian polar case seems to be a closer approximation than the Marshallian polar case to the disequilibrium behavior of the firms in this sample. In the short run, quantities tend to be more flexible than prices in the sense that firms, in the face of disequilibrium, more frequently react by adjusting the next month's output than by adjusting the next month's price.

This support for the Keynesian position is only qualified support, in two respects. Firstly, although prices adjust less often than outputs, prices do adjust significantly frequently in response to inventory or unfilled-order disequilibrium. Secondly, in some industries the price reaction is comparable to (though never significantly stronger than) the output reaction; while in the time-point estimates there is an occasional price gamma coefficient which is comparable to the corresponding output gamma coefficient (though only once, for January 1978 for inventories, is it significantly larger).

As an empirical footnote to the theoretical literature on the stability of competitive equilibrium (Samuelson, Hildenbrand and Radner), it is of interest to note that the firms (with the exception of members of the stone and clay industry[6]) react, with a one-month time lag, to disequilibrium by changing price and/or output in the stabilizing direction. The importance of these disequilibrium adjustments is seen from the prevalence of disequilibrium states: in about sixty percent of the observations firms were in disequilibrium with respect to inventories, unfilled orders, or both.[7]

The results over time (Table 1) appear to be consistent with the following interpretation.[8] Each firm changes its output whenever there is an inventory or unfilled-order disequilibrium, but changes its price only when the disequilibrium persists long enough that the change in demand or costs which causes it seems to be a permanent change. With such behavior, for several periods there would be no price response to disequilibrium. If the demand or cost changes are to some degree correlated across firms, then pooling over firms would produce the varying pattern of price responses over time shown in the fourth and sixth columns of Table 1. In contrast, note that the output responses (shown in the fifth and seventh columns of Table 1) exhibit a more stable pattern over time; this is consistent with firms changing outputs in each time period in which they face a disequilibrium.[9]

Both price and output flexibility vary markedly across industries (Table 3); presumably this reflects inherent differences among these industries. According to Arthur Okun, prices tend not to be flexible in markets in which products are heterogeneous, information about prices is difficult or costly to obtain, and there is a continuing relationship between buyer and seller; in contrast, prices are flexible when the product is homogeneous, information flows rapidly, and the market mechanism is impersonal. From Table 3, the following markets have, in the short run, inflexible prices: stone and clay; machinery; electrical equipment; iron, tin and other products; glass and products; and clothing. The following markets exhibit short-run price flexibility; non-ferrous metals; textiles; plastics and products. The extent to which these markets do or do not satisfy Okun's criteria must remain the subject of further, more detailed, research. The classification into flexible-price and fixed-price industries seems to be unrelated to the degree of concentration of the industries: in both categories there are industries whose whose ten largest firms account for less than ten percent of total sales, as well as industries whose ten largest firms account for more than forty-five percent of industry sales. (This is contrary to the frequently-made claim that there is some relationship between concentration and price inflexibility.) Similarly, this classification seems to be unrelated to the degree of capacity utilization in each industry.

The sharpness of the results depends upon which measure of disequilibrium is used: both price and output react more markedly to a non-optimal level of unfilled orders than to a non-optimal level of inventories. This seems surprising if unfilled orders are regarded simply as negative inventories. That they should not be so regarded has been pointed out by Victor Zarnowitz and Thomas Courchene; the commodities of which firms hold inventories are different from the commodities for which firms have unfilled orders (for example, standardized rather than custom-made commodities). Assume either that firms have U-shaped average-cost curves or that firms incur adjustment costs whenever they change their rates of production. To the extent that a firm produces to stock, it can use inventories to smooth out demand fluctuations and thereby hold production costs almost constant. To the extent that a firm produces to order, it does not have as much flexibility to adapt to demand changes (all it can do apart from changing price or output is to vary its customers' waiting times). Thus commodities produced to order should exhibit both more price variability and more output variability than commodities produced to stock; this would explain why firms respond more markedly to unfilled-order disequilibrium than to inventory disequilibrium.[10] Note also, consistently with this, that the results of Table 5 seem to indicate that firms without finished-goods inventories have at least as strong a price response as firms with both inventories and unfilled orders.

The data generate one puzzle. It has been claimed that a market will be characterized by the holding of inventories rather than unfilled orders if commodity produced is homogeneous and if there is little demand uncertainty (see Zarnowitz). These are also among Okun's criteria for a market to exhibit price flexibility. But, from Table 3, the markets in which inventory disequilibrium is of comparable importance to unfilled-order disequilibrium tend not to be the markets in which prices are relatively flexible.

There is no evidence that prices are less flexible downwards than upwards. Faced with too high a level of inventories, firms are just as likely to cut their prices as they are to raise prices when inventories are too low. During a period of inflation, it should be expected that our measure of the asymmetry of price changes, M(P), should tend to be positive. (In 1977 the rate of inflation in German manufacturing industries was 2.7 per cent, while in 1978 it was 1.1 per cent.) However, from Tables 1 and 3, for eight out of twenty-three time periods and for four of the nine industries M(P) is negative, meaning there were more price cuts than price rises; this seems to be inconsistent with prices being sticky downwards.

George Stigler and James Kindahl argued that price stickiness is an illusion: the prices at which transactions actually take place can vary freely even though list prices may be inflexible. It is therefore important to note that the prices in the Ifo data are transactions prices, not list prices.[11]

Despite the importance of the question of price versus output flexibility, there exists relatively little relevant empirical work. Some related studies of firms' disequilibrium behavior may be mentioned. Otto Eckstein and Gary Fromm, using U.S. data aggregated to the industry level, found that both prices and outputs reacted within three to six months to changes in costs and demand. George Hay found, for two U.S. industries, that a temporary increase in demand, with costs held constant, caused only small price increases and was mostly absorbed by output increases. M. D. Steuer and A. P. Budd found, for five U.K. firms, that prices as a function of time followed a step function, being constant for a year or more. Kenneth Coutts *et al*, using U.K. data aggregated to the industry level, concluded that prices are determined by costs and are unrelated to demand. Finally, Gernot Nerb, using a time series of aggregated West German Ifo-business data, found that when firms' plans cannot be realised, they tend to keep actual prices at the planned levels and adjust outputs.

A number of differences between these studies and the present study should be noted. Firstly, these studies did not use information about a large number of individual firms, but only aggregated data or data for a few large firms. In the sample considered in this paper, some firms raised and some firms lowered their prices in each month. If data aggregated to the industry level had been used, many of these price changes would have cancelled each other out, and prices would therefore have appeared more inflexible than they actually were. Secondly, the questions addressed were different: they were not primarily concerned with the short-run effect of inventory or unfilled-order disequilibrium. Thirdly, and perhaps most important, the present study, unlike the others (with the exception of Nerb), had direct information about the firms' optimization decisions (via their assessments of the state of their inventories and unfilled orders).

V. Conclusion

This paper examined two hypotheses believed to be true by many economists. The first hypothesis is that, in the short run, quantities are more flexible than prices; the second hypothesis is that prices are more sticky downwards than upwards.

The short-run responsiveness of firms' prices and outputs to stock disequilibrium was measured. While firms use both price and output changes in their immediate responses to disequilibrium, a firm is more likely to react immediately with an output change than with a price change. Thus the first hypothesis is vindicated and some empirical basis is provided for the continuing debate on the effectiveness of active macroeconomic policies. The second hypothesis is not supported by the data: prices appear to be no more inflexible downwards than upwards.

Additional points to emerge from this study are: firstly, in all but one of the industries for which the model could be estimated, an inventory or unfilled-order disequilibrium was followed within one month by a price and/or an output change; secondly, the immediate response to disequilibrium was always in the stabilizing direction; thirdly, in about sixty per cent of the observations, firms perceived themselves to be in a state of disequilibrium; fourthly, particular markets could be characterized as flexible-price or fixed-price markets (this classification was unrelated to the degree of concentration of the industries); fifthly, prices and outputs were more markedly affected by unfilled-order disequilibrium than by inventory disequilibrium.

REFERENCES

K. J. Arrow, "Toward a Theory of Price Adjustment" in M. Abramovitz, ed., The Allocation of Economic Resources, Stanford, 1959.

P. Balestra and M. Nerlove, "Pooling Cross-Section and Time Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas," Econometrica, July 1966, 34, 565-612.

R. B. Barro, "Second Thoughts on Keynesian Economics," American Economic Review: Papers and Proceedings, May 1979, 69, 54-59.

________ and H. I. Grossman, "A General Disequilibrium Model of Income and Employment," American Economic Review, March 1971, 62, 82-93.

Y. M. M. Bishop, S. E. Fienberg and P. W. Holland, Discrete Multivariate Analysis: Theory and Practice, Cambridge, Mass., 1975.

A. S. Blinder, "Inventories and Sticky Prices: More on the Microfoundations of Macroeconomics," NBER Working Paper No. 620, January 1981.

C. J. Bliss, "The Reappraisal of Keynes' Economics: An Appraisal" in Michael Parkin and A. R. Nobay, eds., Current Economic Problems, Cambridge, 1975.

W. E. Buiter, "The Macroeconomics of Dr. Pangloss: A Critical Survey of the New Classical Macroeconomics," Economic Journal, March 1980, 90, 34-50.

R. W. Clower, "The Keynesian Counterrevolution: A Theoretical Appraisal" in F. H. Hahn and F. P. Brechling, eds., The Theory of Interest, London, 1965.

T. J. Courchene, "An Analysis of the Price-Inventory Nexus with Empirical Application to the Canadian Manufacturing Sector," International Economic Review, October 1969, 10, 315-336.

K. Coutts, W. Godley and W. Nordhaus, Industrial Pricing in the United Kingdom, Cambridge, 1978.

O. Eckstein and G. Fromm, "The Price Equation," American Economic Review, December 1968, 58, 1159-1183.

L. A. Goodman and W. H. Kruskal, Measures of Association for Cross Classifications, New York, 1979.

R. J. Gordon, "Output Fluctuations and Gradual Price Adjustment," Journal of Economic Literature, June 1981, 19, 493-530.

S. J. Haberman, The Analysis of Frequency Data, Chicago, 1974.

G. A. Hay, "Production, Price and Inventory Theory," American Economic Review, June 1970, 60, 531-545.

J. J. Heckman, "Statistical Models for Discrete Panel Data," unpublished paper, University of Chicago, December 1978.

W. Hildenbrand and R. Radner, "Stochastic Stability of Market Adjustment in Disequilibrium" in J. R. Green and J. A. Scheinkman, eds., General Equilibrium, Growth, and Trade: Essays in Honor of Lionel McKenzie, New York, 1979.

S. Kawasaki, Application of Log-Linear Probability Models in Econometrics, Ph.D. Thesis, Northwestern University, 1979.

________, J. McMillan, and K. F. Zimmermann, "Inventories and Price Inflexibility," Discussion Paper, University of Western Ontario, January 1982.

________, and K. F. Zimmermann, "Measuring Relationships in the Log-Linear Model by Some Compact Measures of Association," Statistische Hefte, 1981, 22, 94-121.

D. Laidler, "On Says Law, Money and the Business Cycle," Research Report No. 8106, University of Western Ontario, May 1981.

A. Leijonhufvud, On Keynesian Economics and the Economics of Keynes, New York, 1968.

L. J. Maccini, "On the Theory of the Firm Underlying Empirical Models of Aggregate Price Behavior," International Economic Review, to appear.

E. Malinvaud, The Theory of Unemployment Reconsidered, London, 1977.

D. McFadden, "Conditional Logit Analysis of Qualitative Choice Behavior" in P. Zarembka, ed., Frontiers in Econometrics, New York, 1973.

G. Nerb, Konjunkturprognose mit Hilfe von Urteilen und Erwartungen der Konsumenten und der Unternehmer, Munich, 1975.

M. Nerlove and S. J. Press, "Univariate and Multivariate Log-Linear and Logistic Models," Rand Corporation, Report R-1306-EDA/NIH, 1973, Santa Monica.

________ and ________, "Multivariate Log-Linear Probability Models for the Analysis of Qualitative Data," Discussion Paper No. 1, Center for Statistics and Probability, Northwestern University, 1976.

A. M. Okun, "Inflation: Its Mechanics and Welfare Costs," Brookings Papers on Economic Activity, 1975, 6, 351-390.

Organisation for Economic Cooperation and Development, Main Economic Indicators, Paris, August 1981.

D. Patinkin, Money, Interest and Prices, New York, 2nd edition, 1965.

G. Ronning, "Logit, Tobit and Markov Chains: Three Different Approaches to the Analysis of Aggregate Tendency Survey Data," in W. H. Strigel, ed., Business Cycle Analysis, Farnborough, 1980.

P. A. Samuelson, Foundations of Economic Analysis, Cambridge, Mass. 1948.

S. Smale, "Some Dynamical Questions in Mathematical Economics" in <u>Systèmes Dynamiques et Modèles Economiques</u>, Paris, 1977.

M. D. Steuer and A. P. Budd, "Price and Output Decisions of Firms: A Critique of E. S. Mills' Theory," <u>Manchester School</u>, March 1968, <u>36</u>, 1-25.

G. J. Stigler and J. K. Kindahl, <u>The Behavior of Industrial Prices</u>, New York, 1970.

V. Zarnowitz, "Unfilled orders, Price Changes, and Business Fluctuations," <u>Review of Economics and Statistics</u>, November 1962, <u>44</u>, 367-394.

FOOTNOTES

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[1]Leijonhufvud, p. 52; the emphasis is Leijonhufvud's. It should be noted that Leijonhufvud's thesis has been criticized as misrepresenting Keynes: according to Christopher Bliss, Keynes's system requires only that wages, and not product prices, adjust slowly. See also Edmond Malinvaud (pp. 31-32 n. 26). Moreover, according to Paul Samuelson (p. 264), Marshall sometimes adopted the assumption described here as "Keynesian". For the sake of brevity, however, we will follow the standard practice and use "Keynesian" to denote the hypothesis that all prices adjust slowly, and "Marshallian" the hypothesis that quantities adjust slowly.

[2]Compare with Malinvaud: "In the long run goods, services or types of labour that are more and more in demand, and cannot be more and more supplied at constant real costs, will undoubtedly tend to experience an upward shift in their prices in comparison with those that are in the opposite situation; but such a shift will occur mainly as a result of differences in the relative magnitude of price rises when they take place, and this does not usually happen at very frequent intervals" (p. 9).

[3]The estimation technique is described in more detail in an appendix to the discussion-paper version of this paper; this will be supplied on request.

[4]Pooling over time and/or over industry might cause one problem in estimation: the error terms of the model may be correlated, while the likelihood function used here assumes statistical independence among the error terms. Thus the parameter estimates might be affected by this misspecification. Although these matters have been extensively studied in the case of quantitative variables (see for example Pietro Balestra and Marc Nerlove), this research for qualitative variables is still in its infancy. James Heckman studied some general structures of such models in the framework of the probit model. However, it is, at least now, computationally unrealistic to estimate such a multivariate model with twenty-three time points as model (2).

[5]The likelihood-ratio value is defined as -2[log LV(M) - log LV(I)], where LV(M) is the value of the maximized log-likelihood function of the model and LV(I) the value of the maximized log-likelihood function of the null-hypothesis model.

[6]The lack of any short-run responsiveness of the firms in the stone and clay industry can perhaps be explained by the special circumstances prevailing in that industry. In 1977-78, the industry suffered a severe crisis; capacity utilization and profits were unusually low. (For more details, see Ifo-Schnelldienst No. 7, 1977, pp. 5-10 and No. 25, 1978, pp. 3-7.) Thus these firms, being persistently in a situation of excess supply, might have chosen prices and outputs without regard to their short-run situations.

[7]The general economic climate during the two years discussed here was rather neutral; the index of leading indicators followed a slight upward trend through the midpoint of its cycle: see the Organisation for Economic Cooperation and Development, p. 48.

[8]A related hypothesis is considered in more detail in Kawasaki, McMillan, and Zimmermann (1982).

[9]In addition, it should be pointed out that monthly data always exhibit much seasonal variation, especially for prices (see Gert Ronning on seasonal patterns in the Ifo data).

[10]Under this hypothesis, price and/or output would only change when the stock disequilibrium exceeds some threshold level (this threshold being lower for unfilled orders than for inventories). This would necessitate adding, to statements made above about price and quantity responding to disequilibrium, the qualifying phrase "provided the disequilibrium exceeds its threshold level."

[11]The firms in the survey answered the question: "Our domestic selling prices (net) for the product, taking into account changes in payment terms, in comparison to last month are (increased, remained the same, decreased)."

Table 1: Parameter Estimates February 1977 - December 1978, all Industries [a]

Year	Month	Number of observations	ϕ^2-coefficients [1)] P_t	Q_t	γ-coefficients [1)] $P_tL^*_{t-1}$	$Q_tL^*_{t-1}$	$P_tA^*_{t-1}$	$Q_tA^*_{t-1}$	P_tQ_t	LRT [b]
1977	2	2707	0.817 *	0.674*	0.200	0.371 *	0.212	0.424*	0.370 *	359.816
			(14.21)	(8.48)	(1.45)	(4.14)	(1.63)	(5.84)	(4.68)	
	3	2712	0.852 *	0.776*	0.188	0.243 *	0.365 *	0.653*	0.482 *	404.789
			(13.94)	(9.12)	(1.64)	(2.38)	(2.75)	(7.84)	(7.00)	
	4	2641	1.147 *	0.769*	0.420 *	0.338 *	0.385 *	0.521*	0.150	328.712
			(17.89)	(9.75)	(3.06)	(4.30)	(2.26)	(8.27)	(1.33)	
	5	2499	1.393 *	0.820*	0.471 *	0.313 *	0.281 *	0.518*	0.374 *	264.586
			(19.32)	(9.38)	(3.06)	(3.51)	(2.35)	(6.92)	(3.92)	
	6	2540	1.475 *	0.926*	0.342 *	0.413 *	0.258 *	0.459*	0.435 *	291.734
			(21.82)	(9.70)	(2.77)	(4.76)	(1.83)	(5.56)	(4.19)	
	7	2586	1.508 *	0.665*	-0.024	0.308 *	0.478 *	0.452*	0.295 *	264.898
			(19.33)	(8.17)	-(0.14)	(3.59)	(3.68)	(6.11)	(2.73)	
	8	2457	1.522 *	0.597*	-0.064	0.192 *	0.897 *	0.518*	0.275 *	287.563
			(20.44)	(6.75)	(-0.38)	(2.28)	(7.00)	(7.28)	(2.58)	
	9	2731	1.344 *	0.564*	-0.026	0.147	0.183	0.635*	0.241 *	378.694
			(19.81)	(7.07)	(-0.18)	(1.73)	(1.42)	(9.49)	(2.68)	
	10	2716	1.448 *	0.698*	0.335 *	0.258 *	0.209	0.595*	0.188 *	343.656
			(20.26)	(7.61)	(2.30)	(3.02)	(1.47)	(7.89)	(1.80)	
	11	2716	1.456 *	0.704*	0.351 *	0.356 *	0.244	0.508*	0.296 *	328.727
			(22.10)	(7.75)	(2.47)	(4.27)	(1.79)	(6.55)	(2.89)	
	12	2702	1.549 *	0.635*	0.163	0.129	0.517 *	0.524*	0.187 *	300.268
			(22.21)	(7.33)	(1.02)	(1.50)	(3.16)	(7.39)	(1.75)	
1978	1	2584	0.895 *	0.596*	0.375 *	-0.025	0.334 *	0.411*	0.046	206.101
			(12.69)	(8.26)	(2.75)	(-0.28)	(2.34)	(5.16)	(0.62)	
	2 [c]	2632	1.210 *	0.379*	0.559 *	0.205 *	0.466 *	0.465*	0.511 *	298.891
			(16.77)	(7.62)	(2.52)	(2.31)	(1.78)	(5.45)	(5.74)	
	3 [c]	2637	1.124 *	0.689*	0.229 *	0.409 *	0.598 *	0.465*	0.248 *	220.070
			(13.13)	(8.02)	(1.69)	(4.10)	(2.52)	(5.26)	(3.01)	
	4 [c]	2703	1.089 *	0.661*	-0.029	0.273 *	0.739 *	0.352*	0.301 *	255.125
			(11.27)	(8.38)	(-0.20)	(3.10)	(2.66)	(4.14)	(3.62)	
	5	2722	1.181 *	0.693*	0.239	0.227 *	0.390 *	0.456*	0.231 *	314.656
			(16.86)	(7.97)	(1.46)	(2.63)	(2.12)	(5.39)	(2.35)	
	6	2716	1.440 *	0.702*	0.014	0.402 *	0.201	0.303*	0.402 *	284.063
			(21.68)	(8.12)	(0.10)	(4.74)	(1.16)	(3.17)	(4.44)	
	7	2645	1.435 *	0.671*	-0.069	0.317 *	0.522 *	0.361*	0.257 *	217.539
			(20.46)	(7.72)	(-0.46)	(3.85)	(3.37)	(4.24)	(2.34)	
	8	2620	1.452 *	0.708*	0.179	0.229 *	0.313 *	0.470*	0.038	231.922
			(24.09)	(8.26)	(1.11)	(2.74)	(2.20)	(6.20)	(0.35)	
	9	2640	1.413 *	0.689*	0.183	0.267 *	0.160	0.402*	0.450 *	246.633
			(22.41)	(8.69)	(1.25)	(3.10)	(1.09)	(4.27)	(4.90)	
	10	2636	1.486 *	0.700*	0.000	0.278 *	0.498 *	0.476*	0.327 *	257.634
			(21.99)	(8.53)	(0.00)	(2.80)	(3.05)	(5.04)	(3.16)	
	11	2633	1.497 *	0.969*	-0.034	0.209 *	0.536 *	0.684*	0.505 *	274.742
			(22.45)	(9.78)	(-0.22)	(2.16)	(3.65)	(7.20)	(5.55)	
	12	2625	1.335 *	0.582*	-0.112	0.267 *	0.508 *	0.410*	0.548 *	262.790
			(21.48)	(6.49)	(-0.78)	(3.25)	(3.22)	(5.38)	(5.20)	

a) t-Values in parentheses. * indicates significance at least at the 5% level (one-side test).

b) Likelihood-ratio chi-square value, degrees of freedom: 20

c) Data adjusted by the data of the corresponding month of 1977 to avoid empty-cell problems.

Table 2: Difference Tests Between γ-Coefficients and Price Flexibility Statistics, Results Corresponding to Table 1[a]

Year	Month	γ(P,L*)- -γ(P,A*)	γ(P,L*)- -γ(Q,L*)	γ(P,A*)- -γ(Q,A*)	γ(Q,L*)- -γ(Q,A*)	M (P)	D(P,L*)	D(P,A*)
1977	2	-0.012 (-0.05)	-0.171 (-1.01)	-0.213 (-1.37)	-0.054 (-0.37)	58.7	- 7.6	- 4.4
	3	-0.177 (-0.88)	-0.055 (-0.34)	-0.288 * (-1.79)	-0.411 * (-2.74)	52.9	-11.8	5.2
	4	0.035 (0.14)	0.083 (0.52)	-0.136 (-0.75)	-0.183 (-1.44)	46.3	- 3.7	-20.1
	5	0.190 (0.84)	0.158 (0.86)	-0.238 (-1.62)	-0.205 (-1.43)	-4.4	-13.2	- 2.9
	6	0.084 (0.37)	-0.070 (-0.45)	-0.201 (-1.19)	-0.046 (-0.32)	-29.5	- 5.2	-12.0
	7	-0.503 * (-1.92)	-0.332 (-1.63)	0.026 (0.77)	-0.145 (-0.97)	-31.6	- 8.4	3.0
	8	-0.572 * (-2.18)	-0.256 (-1.31)	-0.010 (-0.06)	-0.327 * (-2.37)	-39.0	7.3	4.9
	9	-0.210 (-0.85)	-0.173 (-0.50)	-0.451 * (-3.03)	-0.488 * (-3.89)	-38.0	- 5.2	- 7.6
	10	0.126 (0.49)	0.077 (0.44)	-0.386 * (-2.33)	-0.337 * (-2.45)	-44.9	-17.9	- 6.0
	11	0.108 (0.41)	-0.005 (-0.03)	-0.264 * (-1.57)	-0.500 * (-5.43)	-40.6	- 3.4	- 7.5
	12	-0.354 (-1.29)	0.034 (0.182)	-0.007 (-0.04)	-0.395 * (-2.74)	-25.3	- 6.7	-10.9
1978	1	0.041 (0.19)	0.400 * (2.46)	-0.077 (-0.48)	-0.864 * (-2.83)	41.4	- 5.1	- 0.9
	2	0.934 (0.266)	0.354 (1.451)	0.001 (0.003)	-0.357 (1.349)	38.2	-16.2	- 6.8
	3	-0.369 (-1.290)	-0.180 (-1.29)	0.132 (0.524)	-0.394 * (-3.601)	40.4	- 1.4	- 1.3
	4	-0.765 * (-2.416)	-0.298 * (-1.843)	0.388 (1.327)	-0.079 (-0.516)	48.3	- 4.4	-13.6
	5	-0.151 (-0.55)	0.012 (0.06)	-0.067 (-0.32)	-0.230 (-1.51)	43.3	- 9.3	-10.1
	6	-0.187 (-0.70)	-0.388 * (-2.31)	-1.103 (-0.51)	0.099 (0.64)	26.5	- 4.2	-24.0
	7	-0.992 * (-2.29)	-0.386 * (-2.17)	0.162 (0.89)	-0.044 (-0.29)	18.7	21.9	2.1
	8	-0.134 (-0.50)	-0.050 (-0.27)	-0.157 (-0.98)	-0.241 * (-1.71)	13.4	-19.3	- 2.5
	9	0.023 (0.09)	-0.084 (-0.48)	-0.242 (-1.33)	-0.134 (-0.87)	13.8	-32.3	14.8
	10	-0.498 * (-1.81)	-0.278 (-1.40)	0.020 (0.10)	-0.200 (-1.23)	35.3	-15.1	-12.0
	11	-0.570 * (-2.27)	-0.243 (-1.28)	-0.143 (-0.83)	-0.475 (-3.07)	22.3	21.3	- 7.7
	12	-0.620 * (-2.47)	-0.379 * (-2.13)	0.098 (0.54)	-0.143 (-0.94)	48.0	-10.9	1.6

a) t-Values in parentheses. * indicates significance at least at the 5% level (one-side test).

Table 3: Parameter Estimates of the Total Sample and of Different Industries Using Time-Pooled Data[a]

	Number of observations[c]	ϕ^2-coefficients P_t	Q_t	γ-coefficients $P_t\ L^*_{t-1}$	$Q_t\ L^*_{t-1}$	$P_t\ A^*_{t-1}$	$Q_t\ A^*_{t-1}$	$P_t\ Q_t$	LRT[b]
Total sample	60800	1.258 * (90.17)	0.687 * (40.71)	0.199 * (6.95)	0.249 * (14.09)	0.324 * (10.96)	0.475 * (29.73)	0.310 * (16.98)	6080.880
Stone and clay	2023 (17.8)	1.572 * (22.26)	0.898 * (7.57)	0.359 (1.53)	0.138 (1.27)	-0.101 (-0.39)	-0.023 (-0.15)	0.511 * (5.34)	209.086
Non-ferrous metals	675 (49.3)	1.016 * (6.39)	1.076 * (7.66)	0.108 (0.67)	0.088 (0.53)	0.448 * (2.66)	0.370* (2.24)	0.306 * (2.13)	126.737
Machinery	8182 (17.5)	1.398 * (40.32)	0.738 * (11.73)	0.082 (0.73)	0.236 * (5.08)	0.175 (1.33)	0.476 * (9.93)	0.216 * (2.59)	536.899
Electrical equipment	7666 (47.8)	1.170 * (29.79)	0.673 * (14.03)	0.109 (1.59)	0.464 * (10.57)	0.041 (0.51)	0.340 * (6.26)	0.207* (3.69)	737.742
Iron, tin and other products	4195 (14.2)	1.386 * (35.32)	0.697 * (8.13)	0.223 (1.55)	0.358 * (6.78)	0.044 (0.26)	0.396* (6.60)	0.269* (2.32)	382.648
Glass and Products	815 (50.1)	0.915 * (6.44)	1.176 * (9.26)	0.141 (0.82)	0.322 * (1.83)	0.182 (1.01)	0.015 (0.07)	0.054 (0.27)	102.675
Textile products	7799 (9.7)	1.281 * (20.63)	0.724 * (13.22)	0.555 * (4.65)	0.333 * (5.06)	0.422* (6.32)	0.583 * (12.94)	0.546 * (15.48)	1327.578
Clothing	2607 (6.9)	1.431 * (21.66)	0.746 * (5.98)	-0.295 (-1.65)	0.031 (0.30)	0.022 (0.11)	0.668 * (11.4)	0.372 * (2.37)	294.328
Plastics and products	3926 (12.0)	1.332 * (19.90)	0.437 * (7.80)	0.170 (1.50)	0.141 * (2.12)	0.498 * (5.12)	0.433 * (6.99)	0.216 * (3.60)	453.914

a) t-values in parentheses. * indicates significance at least at the 5% level (one-side test).

b) Likelihood-ratio chi-square value, degrees of freedom: 20

c) In parentheses: Percentage of the sales of the 10 biggest (in the case of clothing of the 6 biggest) firms of the total sales 1977. (Source: Monopolkommission, Drittes Hauptgutachten 1978/79, Bundestagsdrucksache Nr. 8/4404, 1980).

Table 4: Difference Tests Between γ-Coefficients and Price Flexibility Statistics, Results Corresponding to Table 2.[a]

	γ (P, L*)- γ (P, A*)	γ (P, L*)- γ (Q, L*)	γ (P, A*)- γ (Q, A*)	γ (Q, L*)- γ (Q, A*)	M (P)	D (P, L*)	D (P, A*)
Total sample	-0.126 * (-2.56)	-0.050 (-1.43)	-0.151 * (-4.36)	-0.226 * (-7.66)	20.2	-11.5	- 6.0
Stone and clay	0.459 (1.05)	0.221 (0.82)	-0.078 (-0.24)	0.161 (0.65)	35.6	-38.9	-27.5
Non-ferrous-metals	-0.34 (-1.18)	0.02 (0.08)	0.079 (0.32)	-0.281 (-0.95)	-30.7	13.0	-26.6
Machinery	-0.093 (-0.47)	-0.155 (-1.27)	-0.301 * (-2.14)	-0.239 * (-2.97)	67.3	- 3.6	-18.5
Electrical equipment	0.068 (0.5)	-0.355 * (-4.23)	-0.299 * (-2.97)	0.125 (1.43)	21.3	- 9.8	- 4.2
Iron, tin and other products	0.179 (0.66)	-0.135 (-0.87)	-0.352 * (-1.93)	-0.037 (-0.37)	70.8	-23.2	-22.6
Glass and products	-0.041 (-0.13)	-0.181 (-0.74)	0.167 (0.57)	0.307 (0.83)	-24.1	-20.8	8.1
Textile products	0.132 (0.91)	0.221 (1.56)	-0.161 * (-1.86)	-0.25 * (-2.77)	-24.2	- 8.9	- 0.9
Clothing	-0.317 (-1.03)	-0.326 (-1.51)	-0.646 * (-3.06)	-0.637 * (-4.52)	78.8	-14.3	0.0
Plastic and products	-0.329 * (-1.86)	0.029 (0.22)	0.065 (0.56)	-0.292 * (-2.61)	-24.2	-14.8	0.8

a) t-values in parentheses. * indicates significance at least at the 5% level (one-side test).

Table 5: Parameter Estimates for Firms Without Inventories[a]

	Number of Observations	Gamma Coefficients $\gamma(P,A^*)$	$\gamma(Q,A^*)$	Differences in Gammas $\gamma(P,A^*) - \gamma(Q,A^*)$	Measures of Symmetry in Price Changes M(P)	D(P,A*)
Total Sample	12,536	.475* (7.69)	.496* (7.98)	-.021 (-.294)	37.0	-15.0
Time Points						
1977/2	1,366	.198 (1.15)	.626* (6.82)	-.428* (-2.14)	56.3	-21.3
1977/5	923	.468* (2.49)	.343* (2.80)	.125 (.536)	38.1	- .462
1977/8	609	.267 (.981)	.454* (3.477)	-.187 (-.591)	-20.6	- 9.73
Industries						
Textile	403	.531* (4.59)	.562* (3.82)	-.030 (-.159)	- 7.83	- 4.45
Printing	2,265	.375* (2.57)	.301* (4.41)	.074 (.450)	68.73	- 5.19

a) t-values in parentheses. * indicates significance at the 5% level (one-side test).