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No. 38 July 1985

Seasonal and Cyclical Variations in Relationship among Expectations, Plans and Realizations in Business Test Surveys

H. KÖNIG* and M. NERLOVE **

Internal Paper

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1. Introduction

Business test data are widely used for the construction of leading indicators and the forecasting of economic time series. In general the data are aggregated by industry group and balances between the numbers of firms reporting increases and those reporting decreases are taken. Elsewhere we have argued that relationships found at the macrolevel must be validated at the microlevel (König and Nerlove, 1982/83) to avoid the problem of spurious correlation. Many studies using the individual data have been undertaken in recent years (see Nerlove, 1983, for a summary of work up to 1981) which show strong but variable relationships between ex ante variables and corresponding ex post realizations at the microlevel. (See also Kawasaki, McMillan and Zimmermann, 1983, and Flaig and Zimmermann, 1983) The variations appear to be attributable to seasonal or to business cycle factors affecting all firms at a given point of time but varying over time. In the investigation on which we report here, we have analysed both the extent of seasonal and cyclical variability and how such variables affects the structure of relationship between ex post and ex ante variables related to production, prices, and demand at the microlevel.

The paper is divided into two parts: In the first part, we show using aggregated time series on total numbers of firms reporting increases, decreases and no change, that considerable seasonal and cyclical variability exists in the series themselves. In this connection, however, we also show that cyclical variability in the balance may be an artifact resulting from taking the difference between the series of aggregates of firms reporting increases with that of those reporting decreases, in the sense that no such variability may exist in the latter. Seasonal variability appears to exist to some degree in all of the series despite the phrasing of the ex ante questions designed to elicit responses in which the seasonal component to removed.[1)]

In the second part of the paper we estimate log-linear probability models for ex post realizations of prices (P), production (Q) and demand (D) and the corresponding ex ante anticipations, (P*, Q*, and D*, respectively) in which we introduce explicit seasonal and cycle phase indicators. Our general conclusion is that, while there is considerable seasonal and cyclic variability in the parameters of such models, it is largely confined to the so-called "main effects" and does not much affect the bivariate relations between the ex post and ex ante values of the three variables in question.

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1) The exact wording of the relevant questions is reproduced in Appendix A.

2. Descriptive Statistics

2.1. Time Series of German Business Test Data and Seasonal Frequency Distribution for French and German Data.

In this section we present some empirical evidence on cyclical and seasonal behavior for German and French firms' responses with respect to production, Q, and production plans, Q*, price realizations, P, and anticipations, P*, demand expectations, D*, and realizations, D. For German firms the time series consist of monthly data for the period January 1975 - December 1983; for French firms the surveys available cover the period 1974 - June 1978, during which the surveys were conducted three times per year (March, June, and November), and the period October 1978 - October 1981, during which the surveys were conducted four times per year (January, March, June, and October).

For German firms we present monthly time series on the above variables for the share of firms reporting positive and negative changes respectively and for so-called balances, i.e. the difference between the shares of positive and negative changes. In addition, we use spectral estimates to discuss cyclical and seasonal pattern. For both German and French firms we provide frequency distributions for a given yearly date of the survey for the whole period, the sample size for German firms amounting to about 45,000 observations per month over the whole period, for French firms varying between 7,500 - 10,000 observations for each survey date of the two subperiods.

With respect to German data two points should be noted: (i) For production plans, price anticipations, and demand expectations, firms are asked to adjust for seasonal influences. Responses on corresponding realizations, however, are supposed to be not seasonally adjusted by the firm.[1] (ii) Responses for ex post variables - production realizations, demand and actual price changes - reflect changes in the month of the survey compared to the preceeding month. Responses with respect to ex ante variables cover expected/planed changes for the next three month for production and prices, and six month for demand (erwartete Geschäftslage).

1) See Appendix A for the exact wording of the questionaire.

Figure 1 presents time series for the percentage of German firms in the Ifo-business test reporting positive and negative changes of prices and the corresponding balances. In the same way, responses with respect to price anticipations are shown in figure 2.

Responses on positive price changes indicate influences of seasonal factors, concentrated in the month January - April. For responses on negative price changes seasonal components cannot be observed but there seems to exist a cyclical effect: the percentage of firms reporting price decreases declining during upswings of the "reference cycle" of the Bundesbank. There also may exist a phase-shift with respect to turning points showing that the share of negative responses already declines before the end of a recession phase.

Price anticipations display a similar pattern: seasonal effects dominating positive changes and cyclical movements prevailing in the share of negative responses.

Figure 3 presents time series for production. The evidence suggests that a marked seasonality exists in all categories of responses, the share of firms reporting negative changes being large in January, July, August and December. Seasonal effects are less pronounced in production plans (see Figure 4). Figures 5 and 6 for changes in demand and demand expectations reveal almost identical pattern as the corresponding series of production and production plans, the percentage of firms reporting no changes, however, being much smaller.

Figures 7-9 graph the seasonal frequency distributions for German firms for the whole period. As can be seen in Figure 7, plus changes of prices exhibit a distinct seasonal pattern whereas the percentage of minus changes is almost identical over the whole year. Anticipated price increases are still more characterized by the seasonal component having a maximum in December and thereafter declining until August.

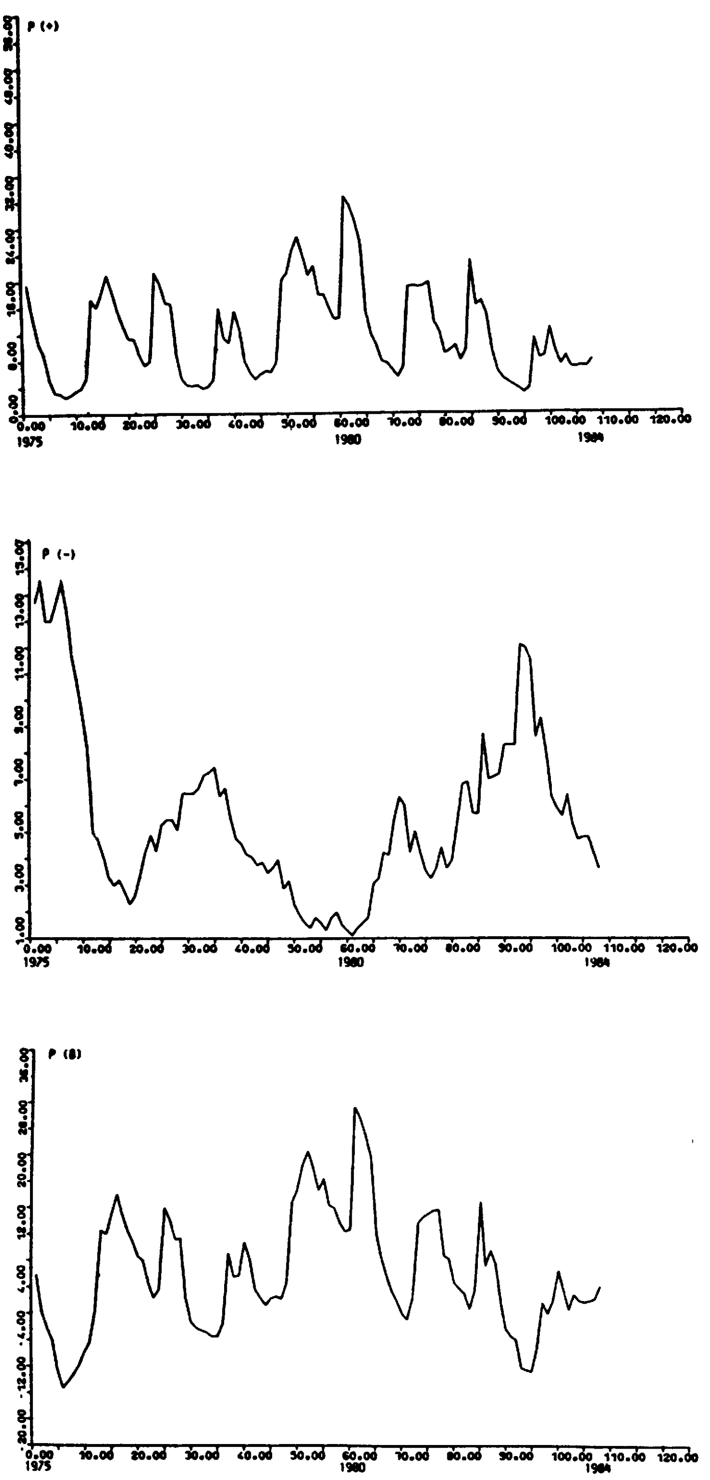

Fig. 1: Price Realizations, German Firms 1975 - 1983

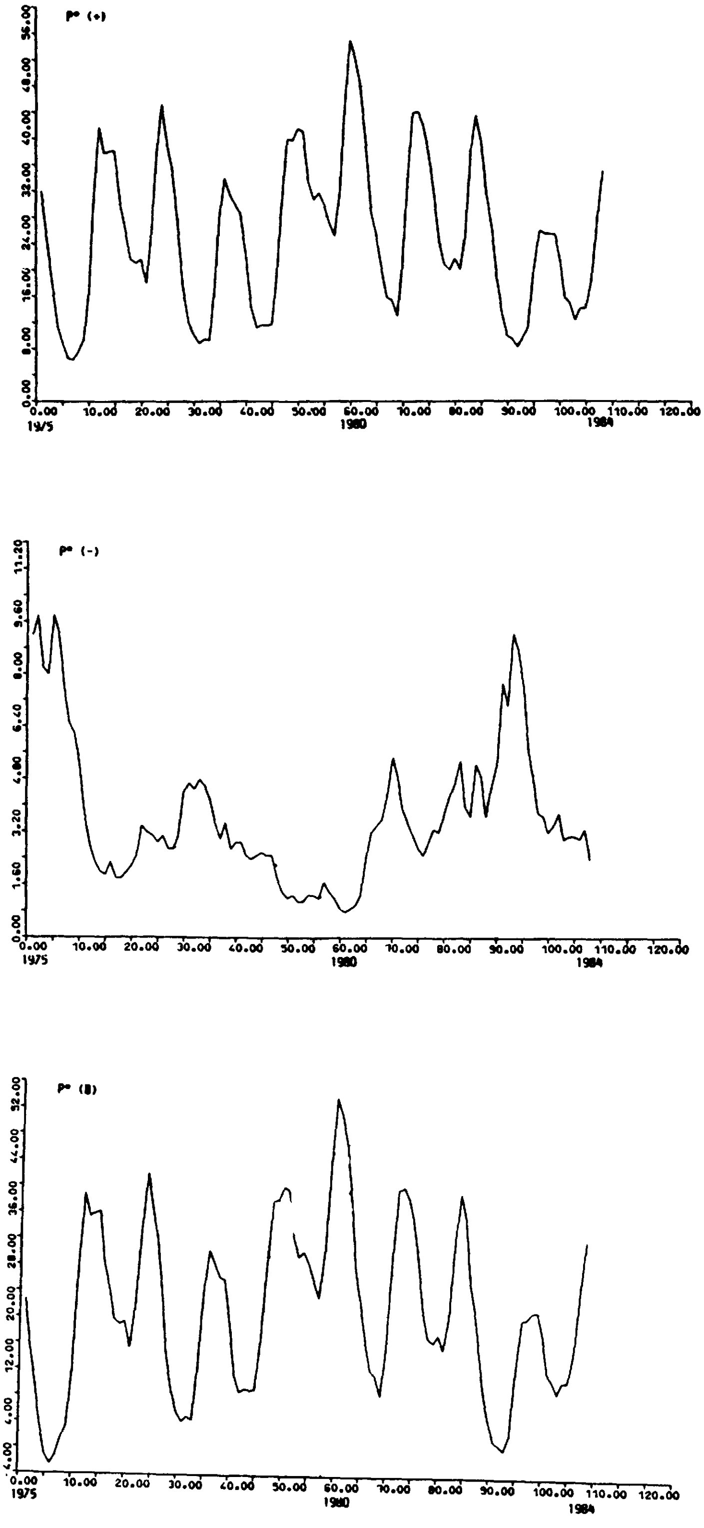

Fig. 2: Price Anticipations, German Firms 1975 - 1983

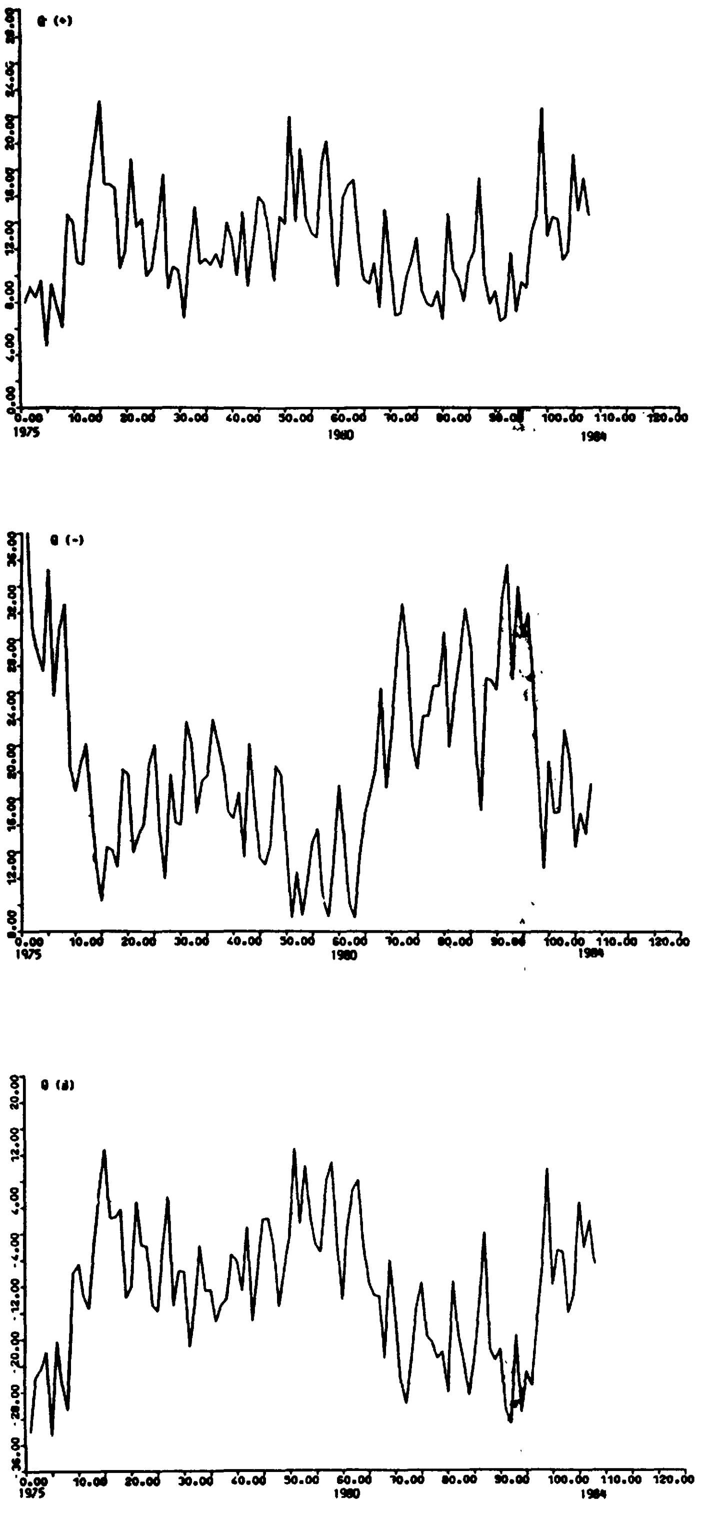

Fig. 3: Production Realizations, German Firms 1975 - 1983

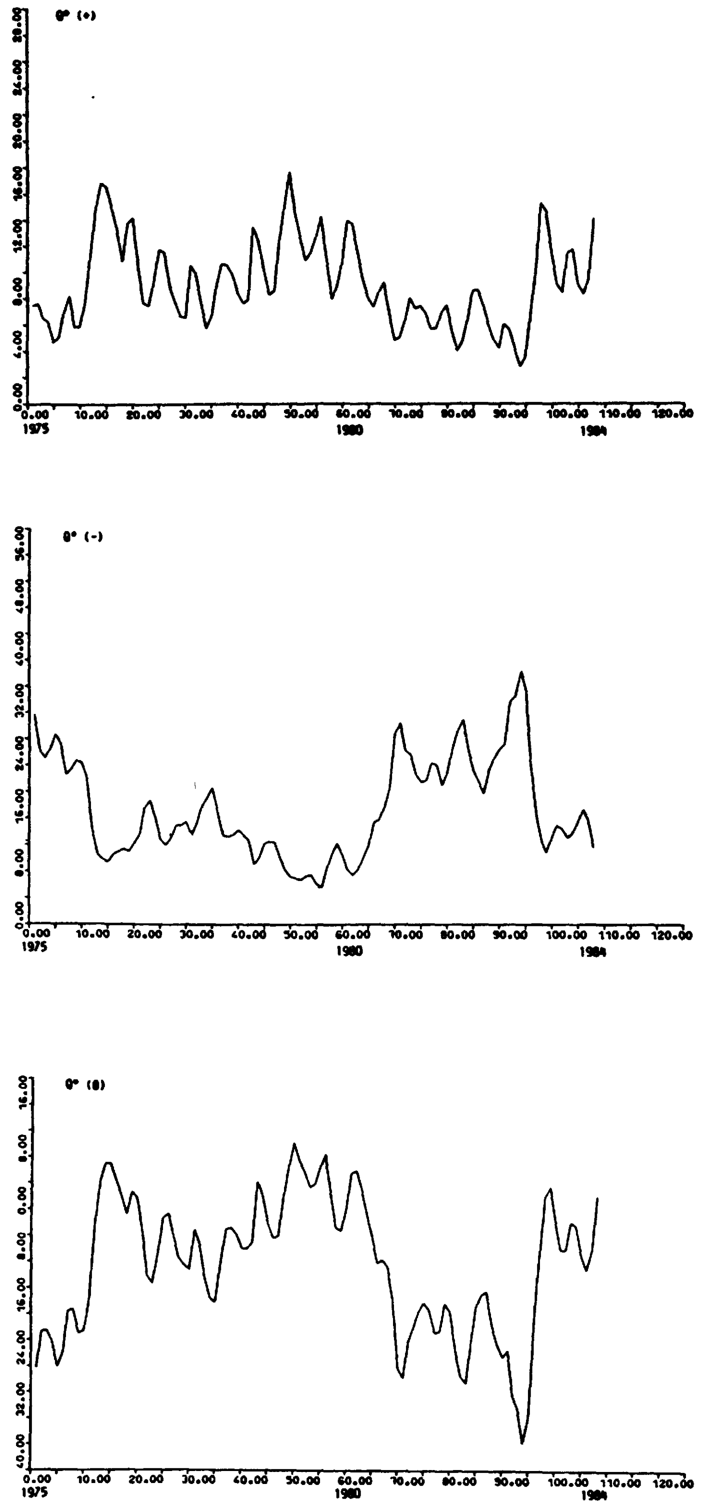

Fig. 4: Production Plans, German Firms 1975 - 1983

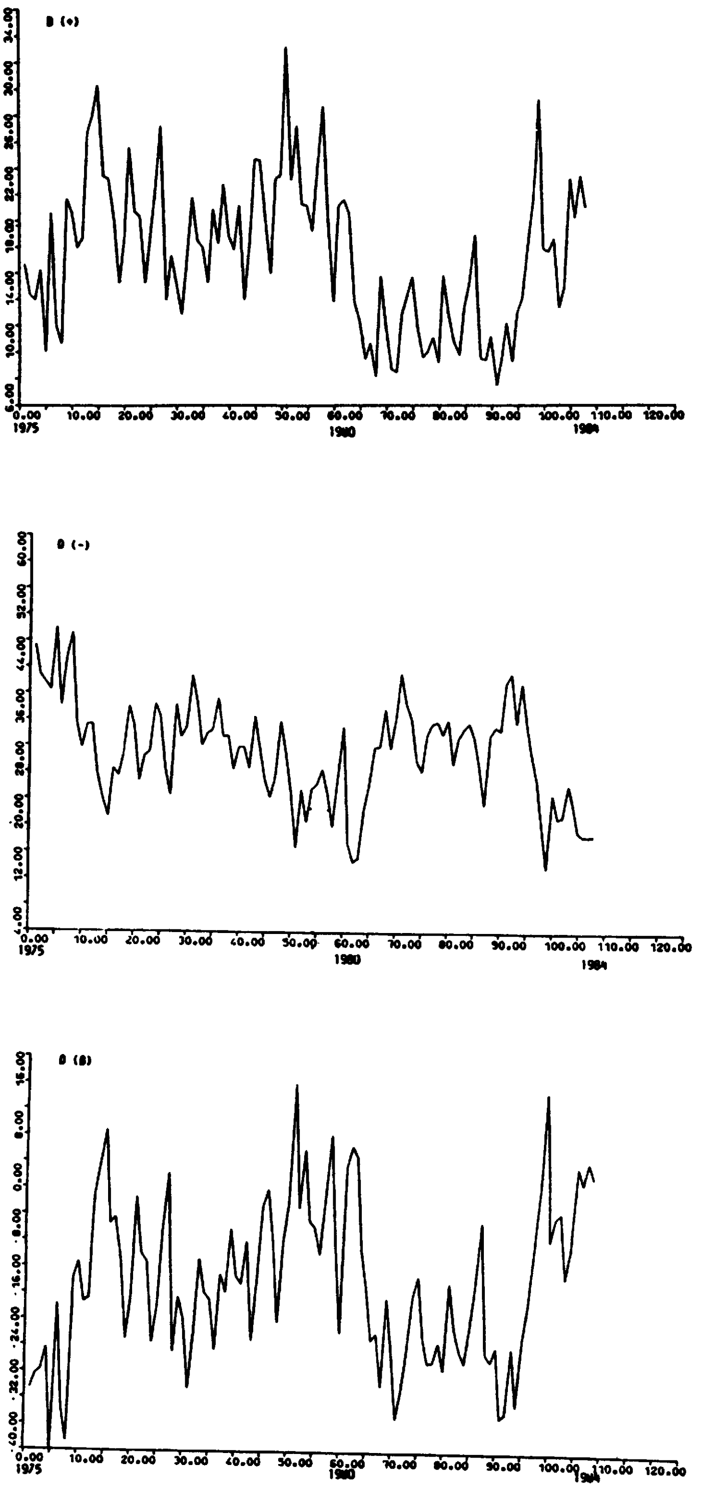

Fig. 5: Demand Realizations, German Firms 1975 - 1983

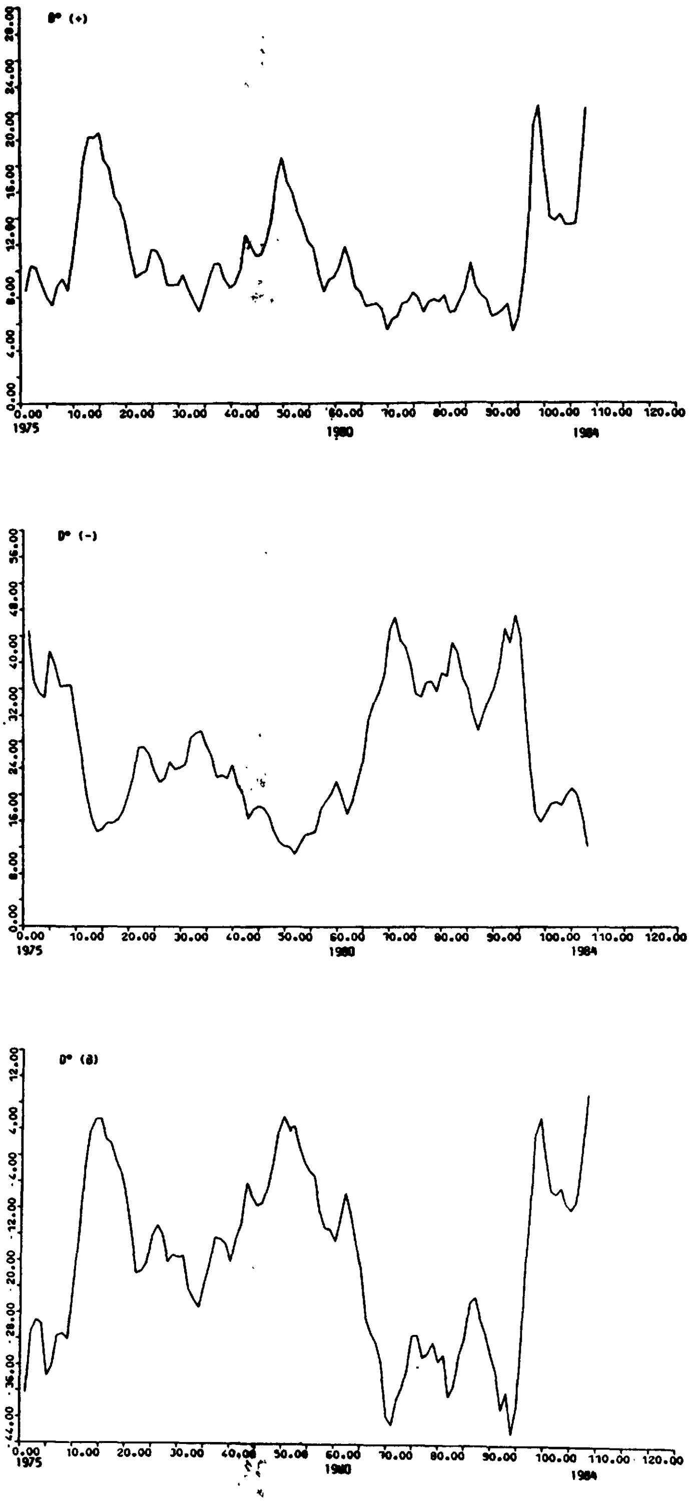

Fig. 6: Demand Expectations, German Firms 1975 - 1983

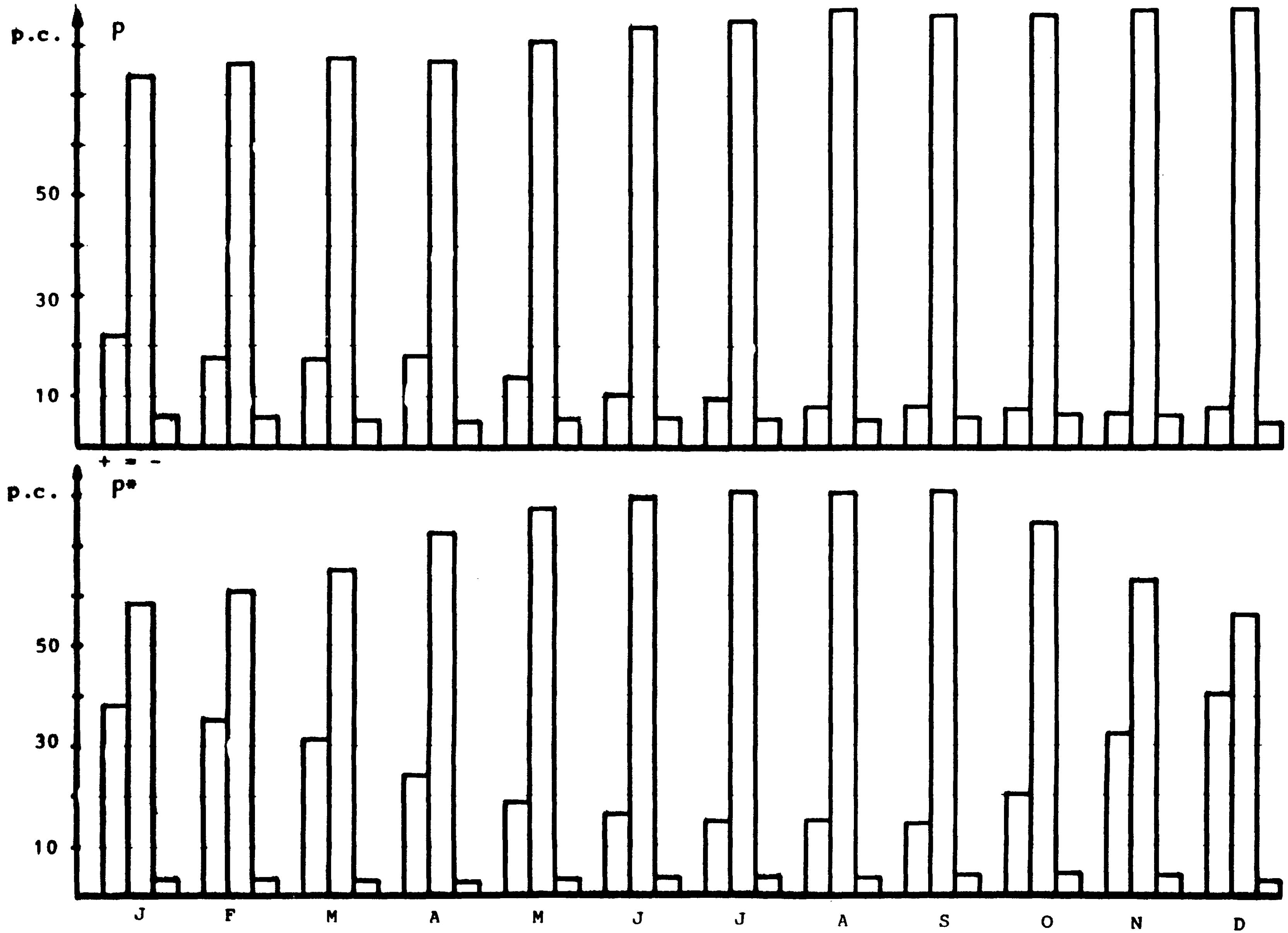

Fig. 7: Seasonal Frequency Distributions of Price Realizations and Price Anticipations, German Firms 1975-1983

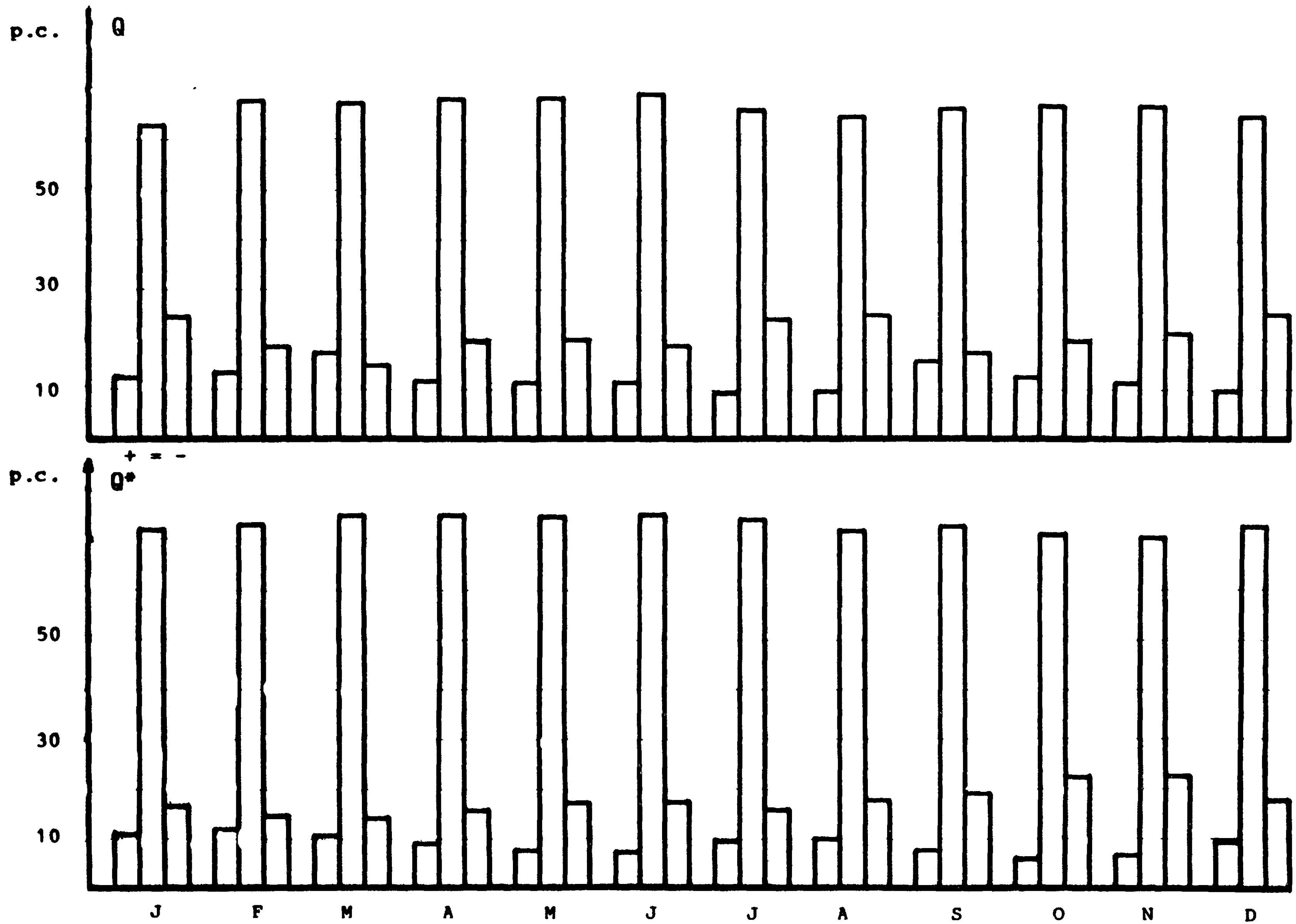

Fig. 8: Seasonal Frequency Distributions of Production Realizations and Production Plans, German Firms 1975-1983

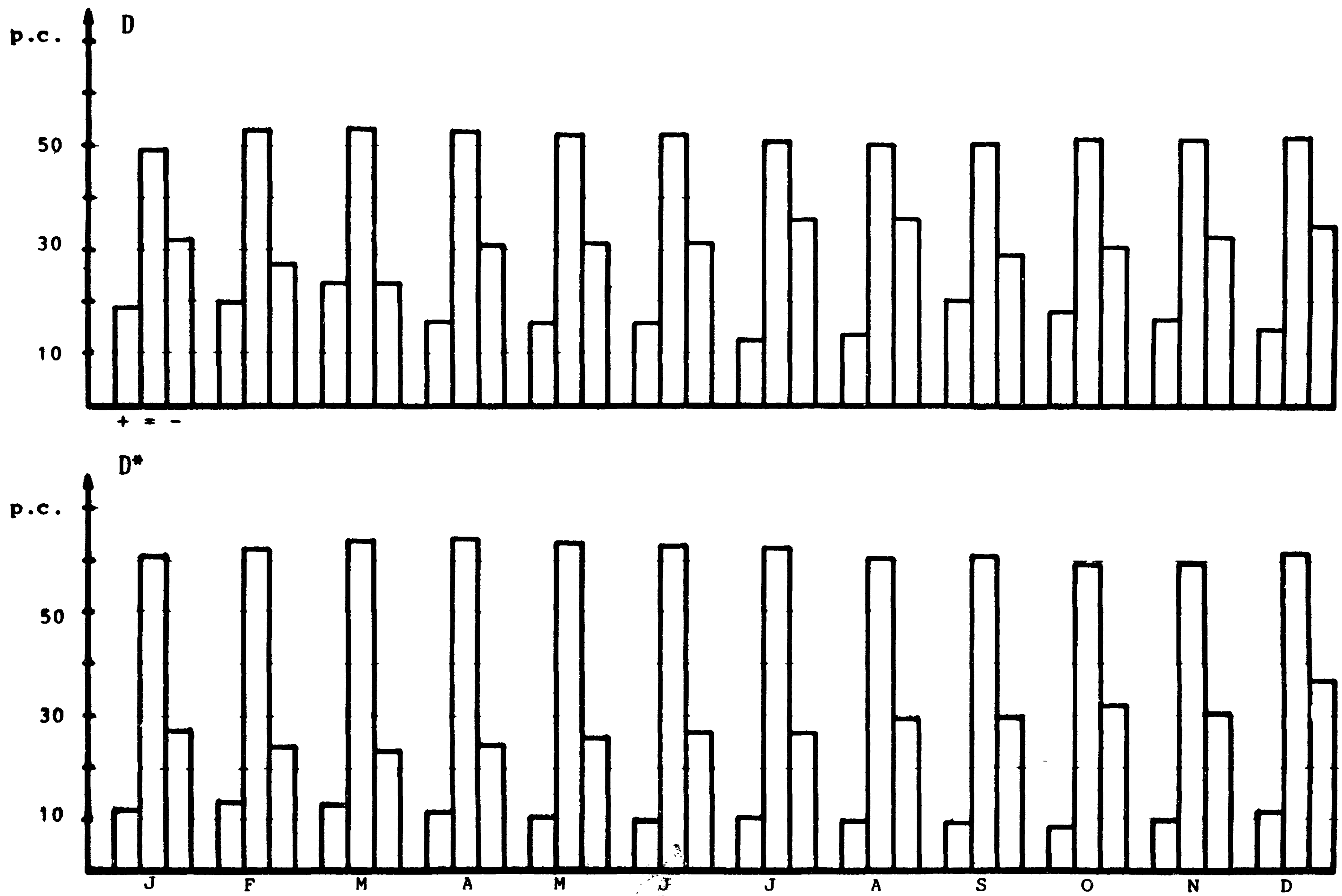

Fig. 9: Seasonal Frequency Distributions of Demand Realizations and Demand Expectations, German Firms 1975-1983

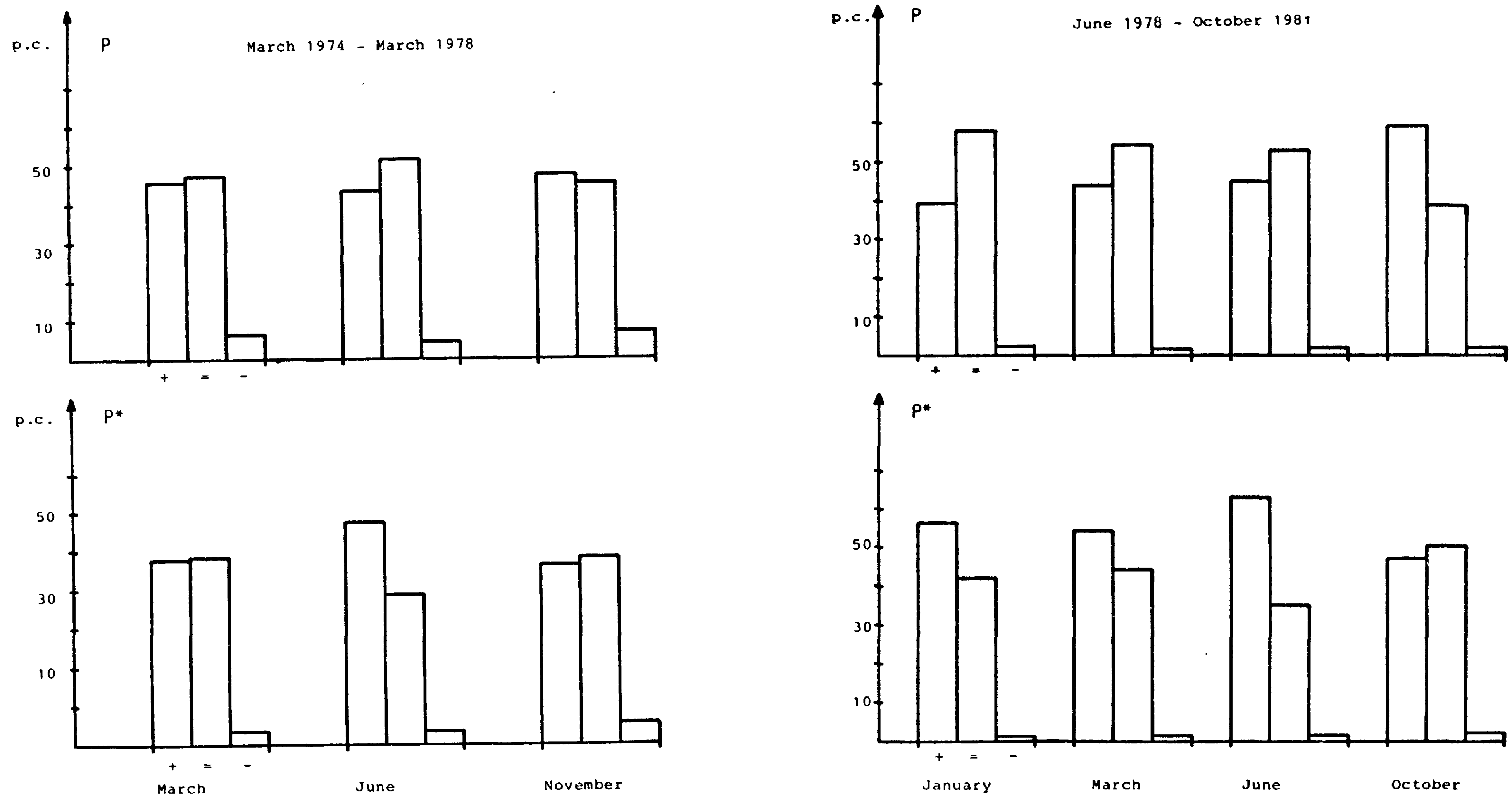

Fig. 10: Seasonal Frequency Distributions of Price Realizations and Price Anticipations, French Firms 1974-1978 and 1978-1981

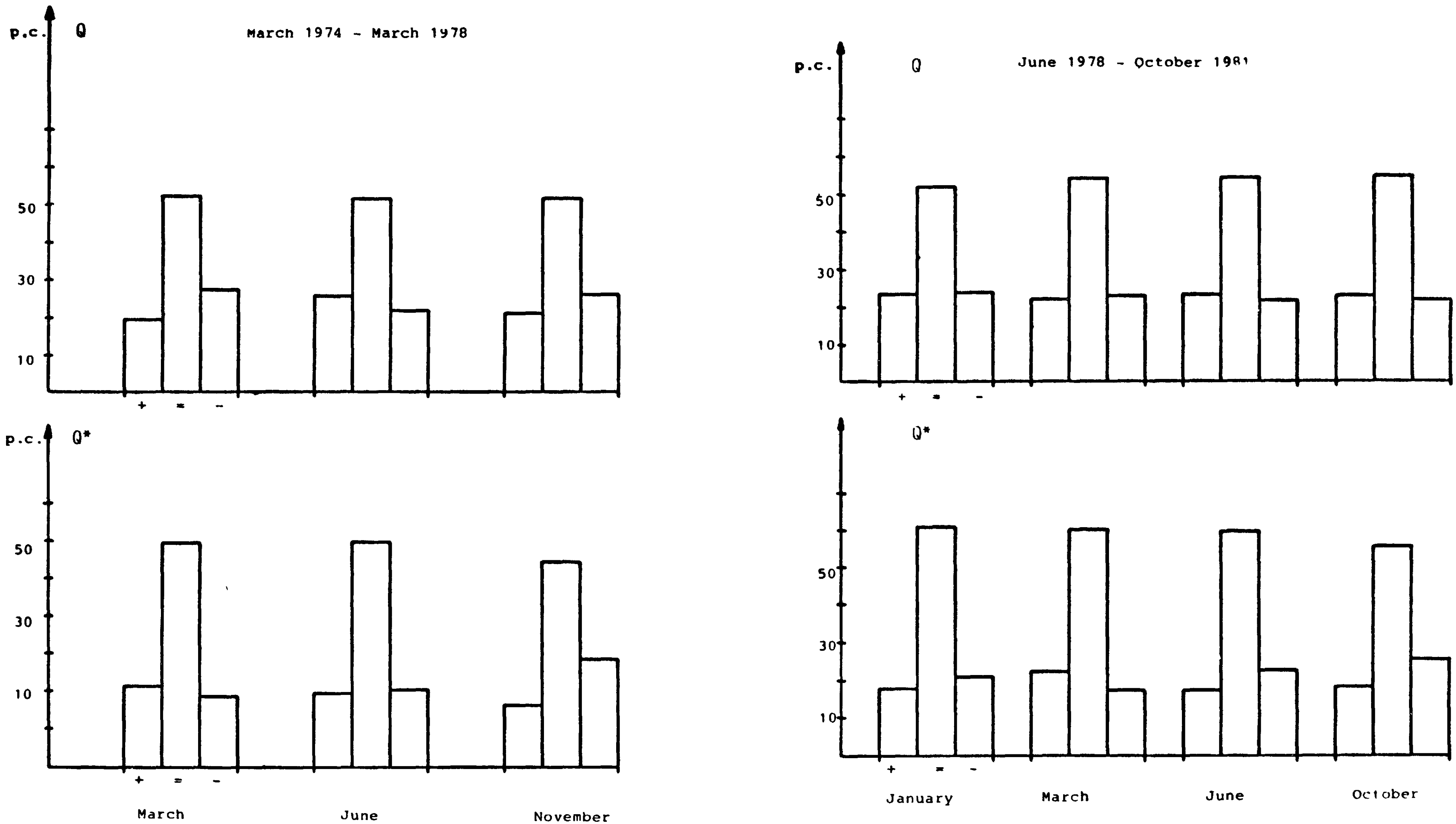

Fig. 11: Seasonal Frequency Distributions of Production Realizations and Production Plans, French Firms 1974-1978 and 1978-1981

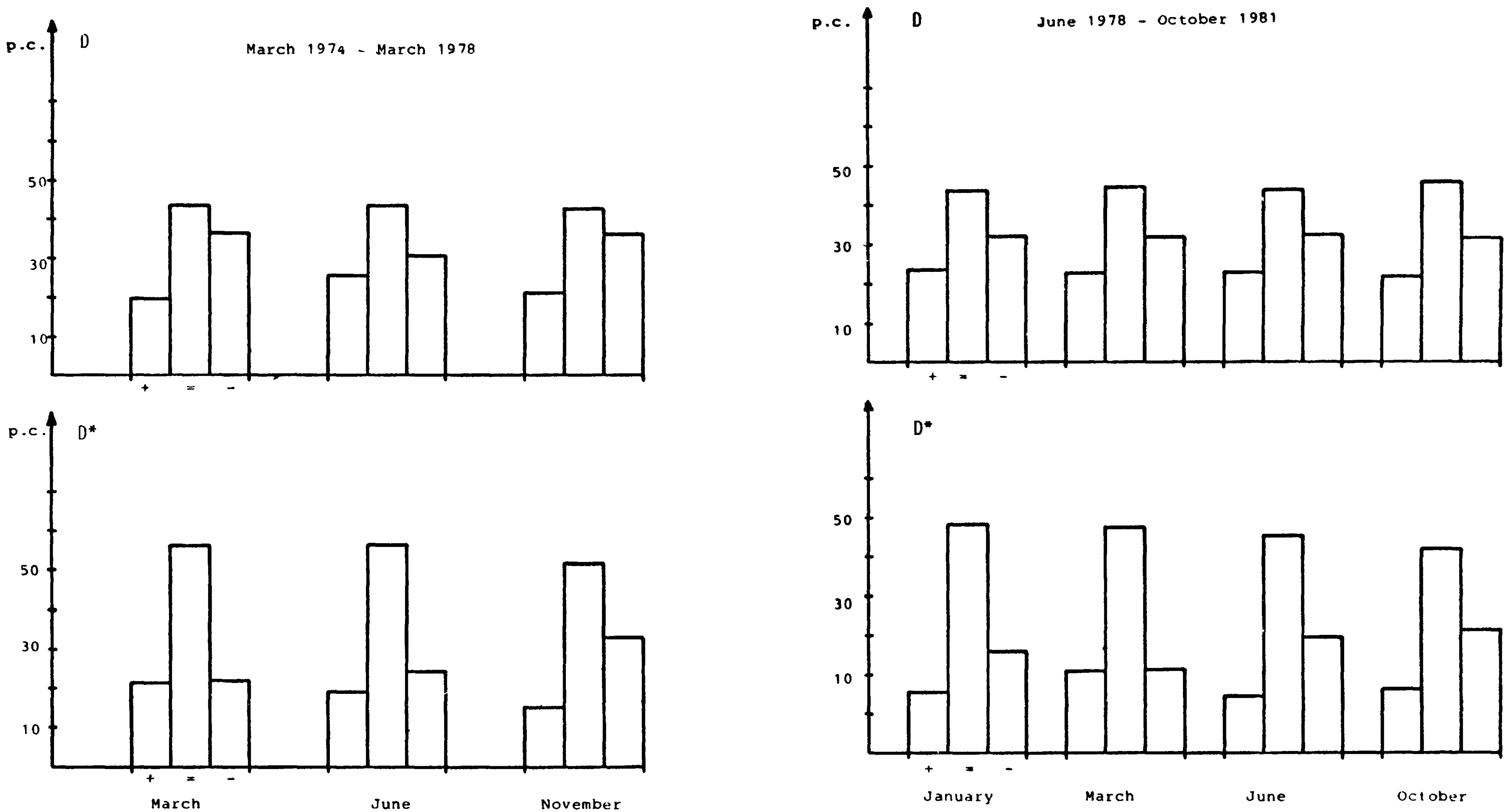

Fig. 12: Seasonal Frequency Distribution of Demand and Realizations and Demand Expectations, French Firms 1974–1978 and 1978–1981

For production changes both Q-plus and Q-minus also show seasonality although less marked than in production realizations due to the fact that firms are asked to exclude seasonal effects. An almost identical pattern as for production and production plans can be observed for demand and demand expectations, the percentage of no changes, however, much less than in the corresponding frequency distributions of the production data.

Frequency distributions of changes in price realizations and price anticipations for French firms are presented in figure 10. For the first period distributions for price realizations display only a weak seasonality; for the second period, however, we observe a significant increase in P-plus responses in November. Price anticipations in both period are characterized by a high share of P*-plus responses in June.

Figure 11 presents the frequency distributions of production and production plans. For the former we observe a seasonal pattern in the first period but not in the second period. Production plans, however, exhibit in both periods seasonality.

For demand and demand expectations Figure 12 shows only weak seasonal pattern with respect to demand in the first period but none in the second whereas production plans exhibit in both periods seansonality.

In summary we may state that for both German and French firms in most variables we find seasonal patterns, even in those responses of German firms which should be deseasonalized individually according to the questionaire.

Spectral Analyses of the German Series

Figures 12-17 graph the estimated spectral densities for the German firms over the period January 1975 - December 1983 (108 observations) for the plus and minus categories and for the corresponding balances for the variables P, P*, Q, Q*, and D, D*. A lag window of length 48 was used for all series. Seasonal frequencies for monthly data are 0.0833, 0.1667, 0.2500, 0.3333, 0.4167, and 0.5000. We make the following observations:

Price realizations. There are marked seasonal peaks in the spectral density of the P-plus series but not in the P-minus series. (The seasonal in the P-plus series is thus, of course, reflected - inversely - in the P-equals series, the spectral density for which is not reproduced here.) The P-balance series shows marked seasonality which thus appears to be due to the seasonalty in the P-plus series. In the next section we show that while firms tend to raise prices only at certain times during the year, lower prices, presumably due to discounting, may occur at any time of year.

Price anticipations. The relation between the spectral densities found for the price-realization variables are largely repeated for the price-anticipations variables except that a marked peak occurs in the P*-minus density at 0.2500 which corresponds to a quarterly cycle. The spectral density for P*-balance is similar to that for P*-plus.

There is no evidence of cyclical peaks at any non-seasonal frequencies in either plus or minus price series nor in the corresponding balances.

Production realizations. There are marked seasonal peaks at the frequencies 0.1667, 0.2500, 0.3333, and 0.5000 but none at 0.0833 or 0.4167 in the Q-plus series. There is, however, a peak apparent at 0.0208 (corresponding to a cycle of slightly more than 48 months in length), which we may interpret as a business cycle effect. The seasonal peaks are apparent in the Q-minus series, but there is no evidence of the cyclical peak found near origin for the spectral density of the Q-plus series. The spectral density for the Q-balance series reproduces the pattern for the Q-minus series. Thus, the business cycle effect observable in the Q-plus series is eliminated in the balances but seasonal influences remain at some but not all of the seasonal frequencies.[1)]

Production plans. Seasonality is much less marked in the Q*-plus series than in the corresponding *ex post* series, but we do observe quite marked peak at 0.1667 (corresponding to a six-month cycle. The Q*-minus exhibits virtually no evidence of seasonality). Given that the question asked explicitly requests respondents to eliminate seasonal fluctuations in their answers, it is not surprising that we find relatively little evidence of seasonality but rather that we find any. The six-month cycle is repeated in the Q*-balance series.

Demand realizations. There is evidence of marked seasonality in the D-plus series and in the D-minus series. This is reproduced in the D-balance series but now, remarkably, a peak appears at 0.0208 (48 month) which is not present in either of the two series used to construct the balances of demand realizations. In Appendix B we show how such an artifact can occur.

Demand expectations. There is no evidence of seasonality in the D*-plus series although a small peak occurs at 0.208 (48 months). The D*-minus series and the D* balance series show no evidence of either cyclical or seasonal effects. Again, this is not surprising in view of the fact that respondents are asked to seasonally adjust their replies.

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1) It is easy to show that, when two series one of which contains a cyclical component are differenced, the cyclical component may be eliminated. We show in Appendix B that the converse may also occur.

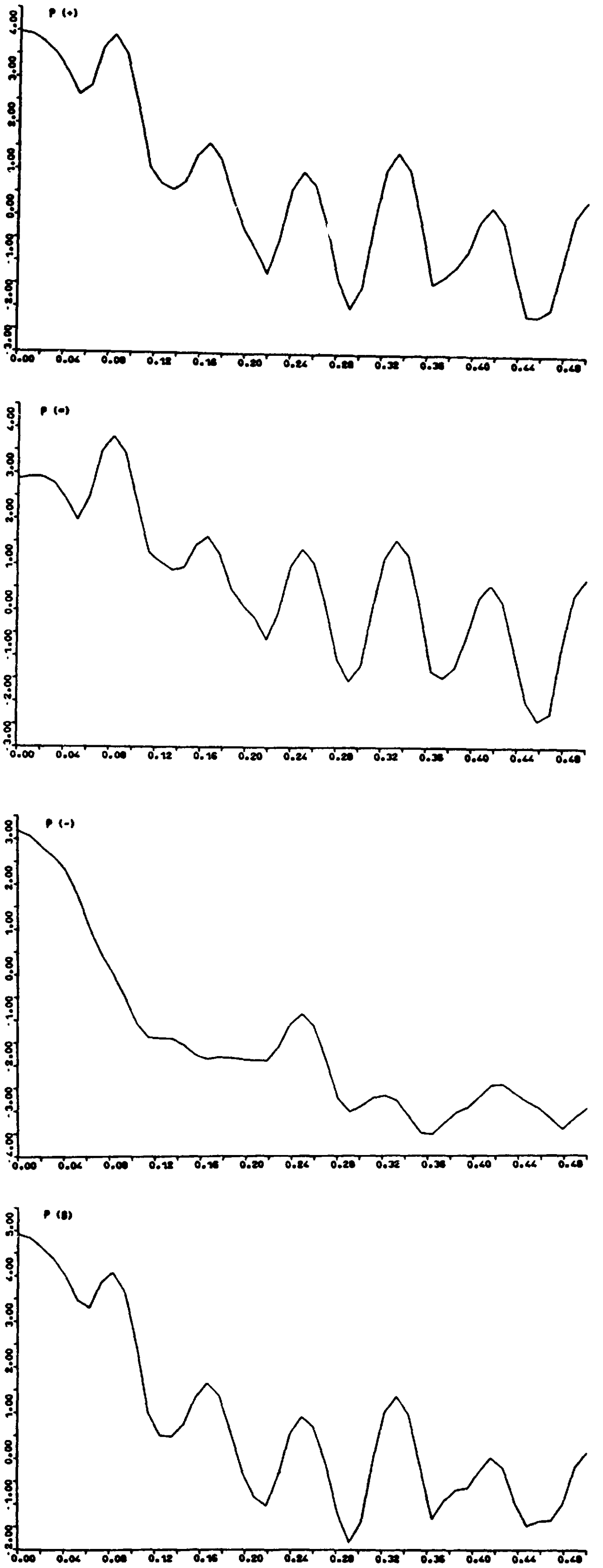

Fig. 13: Log-spectral densities for Price Realizations, German Firms 1975 - 1983

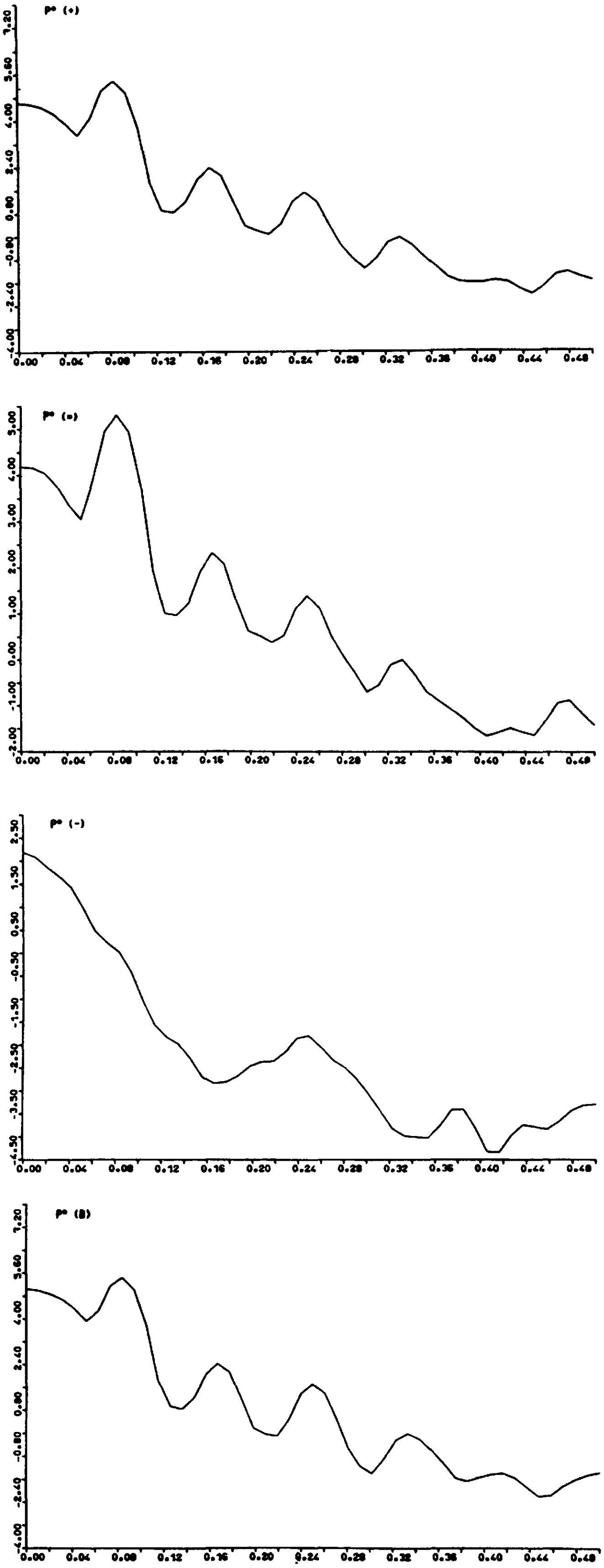

Fig. 14: Log-spectral densities for Price Anticipations, German Firms 1975 - 1983

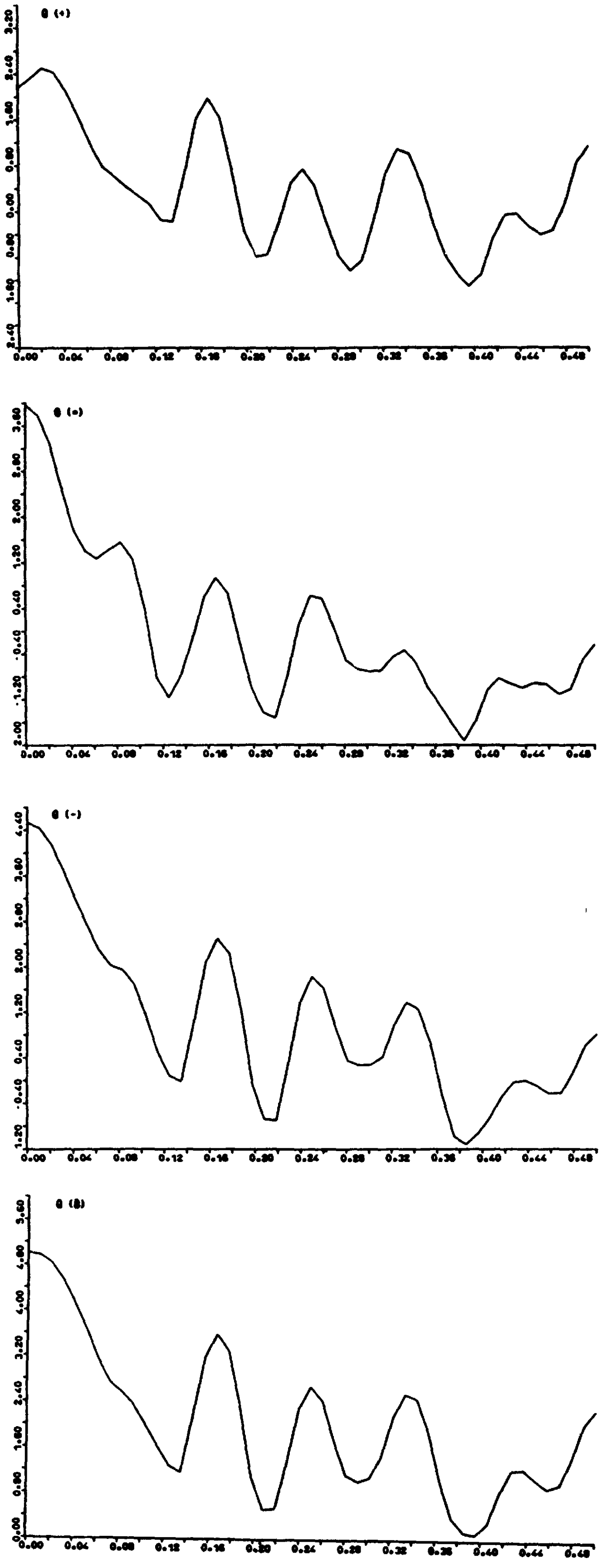

Fig. 15: Log-spectral densities for Production Realizations, German Firms 1975 - 1983

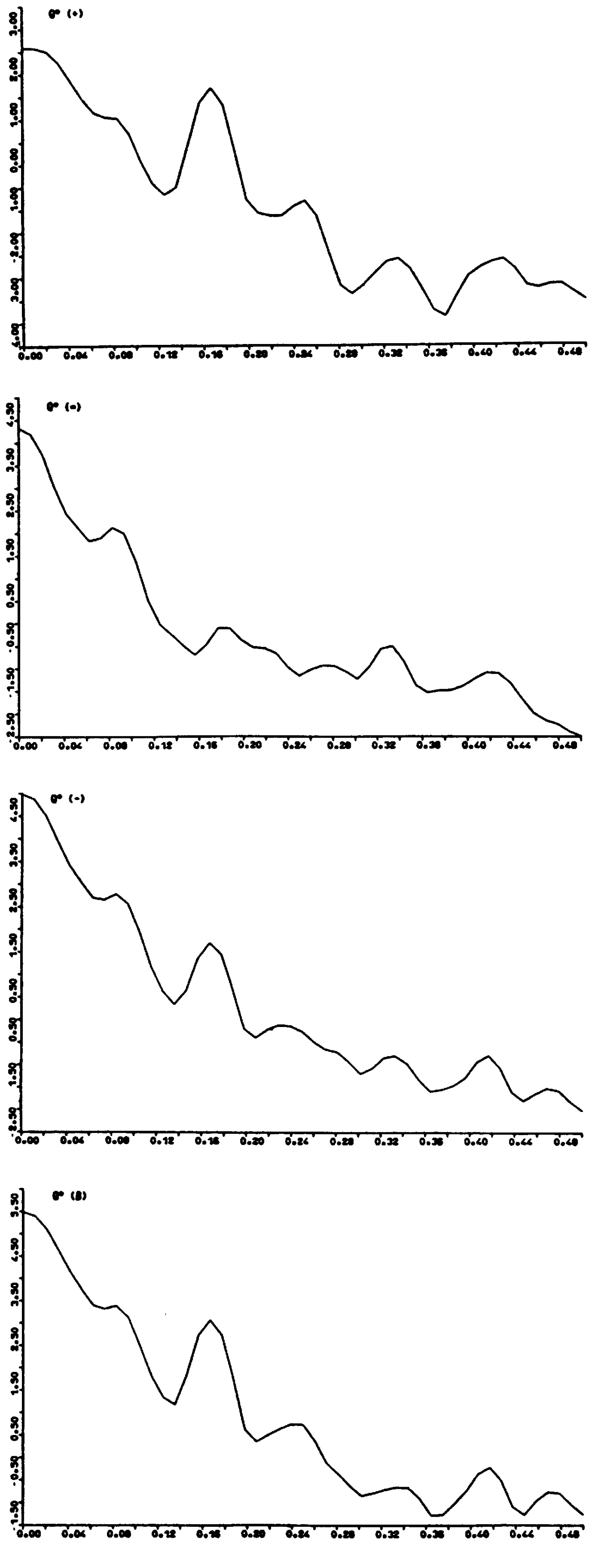

Fig. 16: Log-spectral densities for Production Plans, German Firms 1975 - 1983

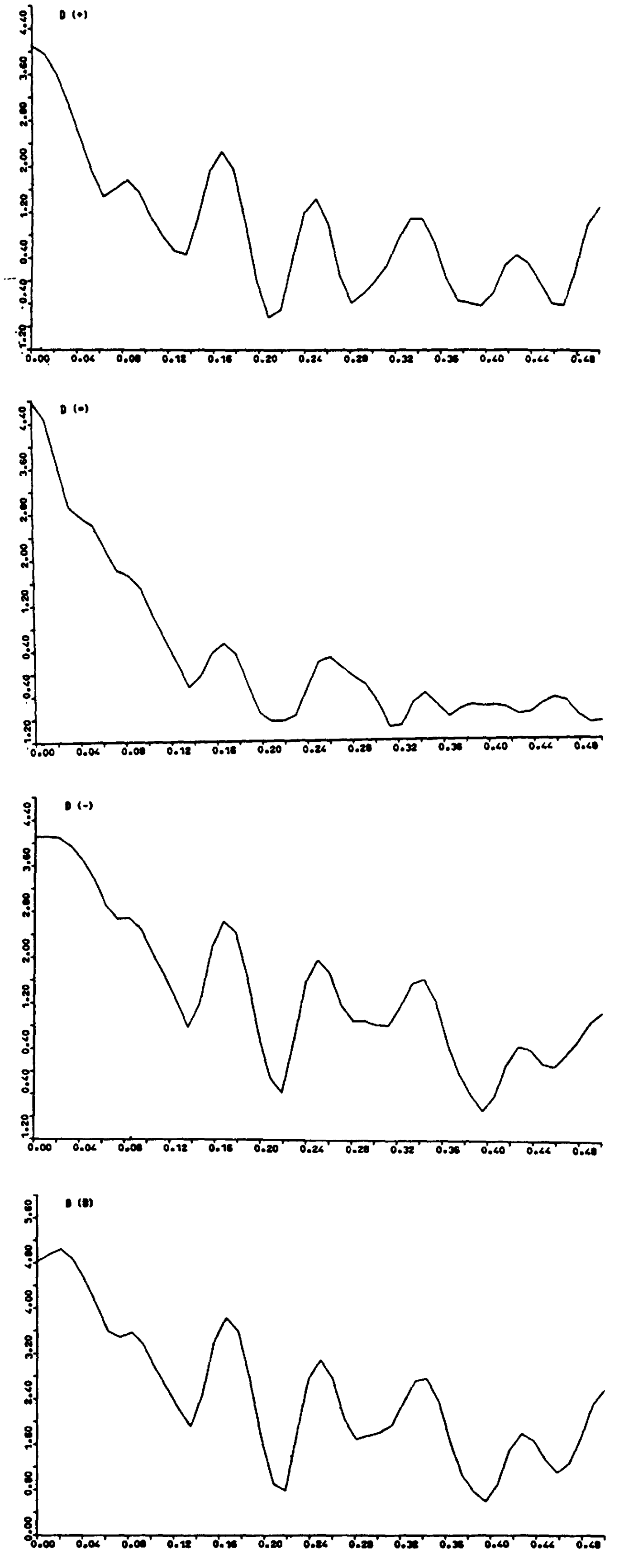

Fig. 17: Log-spectral densities for Demand Realizations, German Firms 1975 - 1983

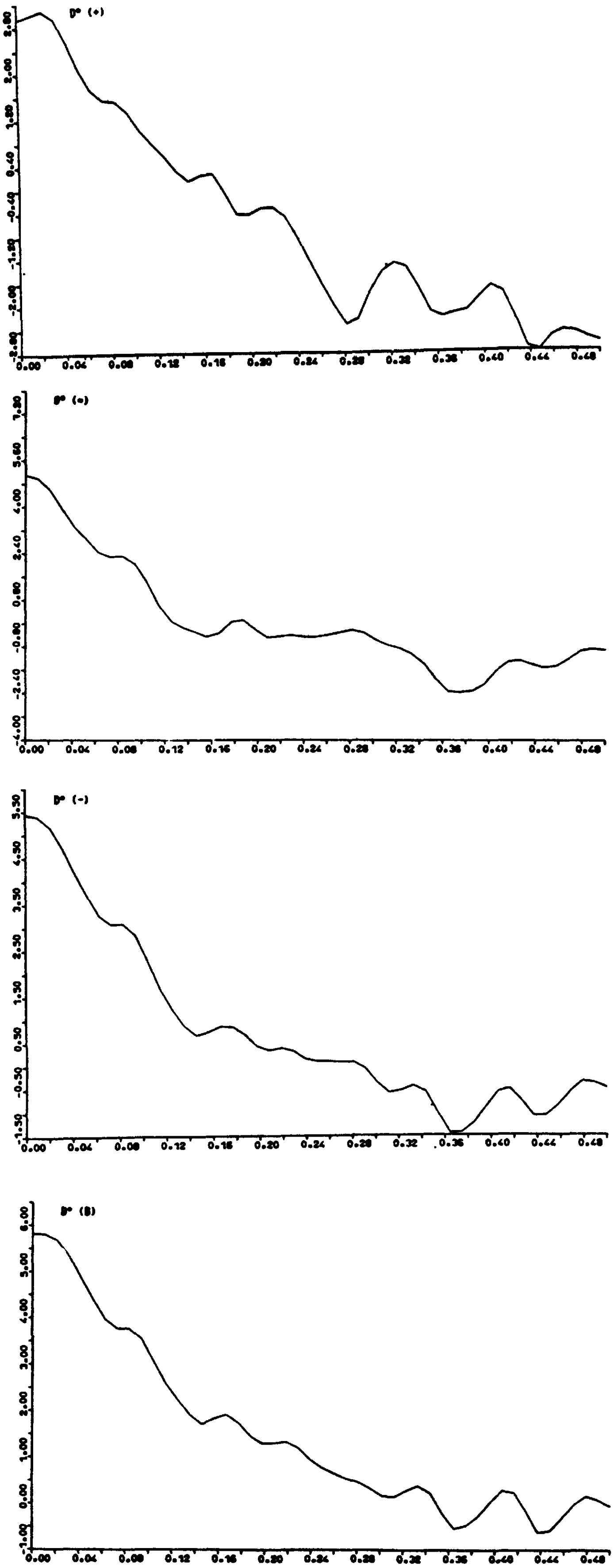

Fig. 18: Log-spectral densities for Demand Expectations, German Firms 1975 - 1983

3. Estimation of Relationships between Ex Post and Ex Ante Variables Taking Account of Season and Cyclical Phase

3.1 Definition of C and S

In order to test the sensitivity of the relationships between ex ante values of price, production and demand variables and the corresponding ex post values to cyclical and seasonal factors, we introduce two new categorical variables, C to indicate cyclical phase, and S, to indicate month or, in the case of France, survey date. A study of the interactions between C or S and the variables reflecting price, production or demand changes shows how seasonal or cyclic factors affect the relation between ex ante and ex post values. We find that, while cyclical and seasonal factors are higly significant in determining the probabilities of response in each category of the price, production , or demand variable, these factors are of much less significance in their effects on the relation between ex ante and ex post.

There do not exist definitive reference cycles for France. We have therefore constructed a cyclical indicator using data on industrial production as follows:

FRANCE: Definition of C

Before	–	June 1975	Recession
July 1975	-	February 1977	Recovery
March 1977	-	January 1978	Recession
February 1978	-	July 1979	Recovery
August 1979	-	July 1982	Recession
Since		August 1982	Recovery

For Germany we have used the dating of boom and recession phases of the Bundesbank. These are as follows

GERMANY: Definition of C

January 1975	- April 1975	Recession
Mai 1975	- January 1977	Recovery
February 1977	- Mai 1978	Recession
June 1978	- January 1980	Recovery
February 1980	- November 1982	Recession
Since	December 1982	Recovery

The definition of S is simple for Germany since the data are monthly throughout the period. S is a categorical value with one category for each month January through December. Since, however, surveys are taken in France at unequal intervals during the year and, moreover, were taken three times per year prior to June 1978 and four times per year thereafter, we need two different categorical variables to describe the season: S_1, which has three categories, applies to the period prior to June 1978 and takes on the values March, June and November; S_2 applies to the period starting in June 1978 and takes on the values January, March, June and October. (Note that S_1 and S_2 may not be used together in an analysis covering both periods. Rather we treat each period separately but denote both S_1 and S_2 by a single symbol S.)

3.2 The Models Estimated

In the notation of our previous Papers on this subject, we have estimated the following log-linear probability models for Germany

$$(P, P^*_{-2}, S, C)$$

$$(Q, Q^*_{-2}, S, C)$$

$$(D, D^*_{-2}, S, C)$$

The *ex post* value corresponding to the *ex ante* variable is taken to be the value two months ahead which we have found to be the best indicator of the realization to which the anticipation refers. All orders of interaction have been included. For France the models are identical except the *ex ante* variable is taken from the immediately preceding survey.

3.3 Bivariate Relationships between Ex Ante and Ex Post Variables

To examine the effect of reason and cycle phase on the relationship between P and P^*_{-2} or P^*_{-1}, Q and Q^*_{-2} or Q^*_{-1}, and D and D^*_{-2} or D^*_{-1}, respectively, we have computed the values of the bivariate component gamma coefficents conditional on S and C The results are presented for the German data in Tables 1-3 and for the French data, for the period before June 1978 and the period after June 1978, in Tables 4-6.

Table 1:
Component Gamma P x P^*_{t-2} Conditional on C and S, German Data

	Recession	Recovery
January	0.9026	0.8941
February	0.8825	0.8111
March	0.8962	0.8617
April	0.8862	0.8893
May	0.8756	0.8514
June	0.8977	0.8584
July	0.9260	0.8918
August	0.9208	0.9300
September	0.8807	0.8869
October	0.8990	0.8811
November	0.8707	0.8686
December	0.8686	0.8850

Unconditional Component Gamma = 0.883
(356,3)

Table 2:
Component Gamma Q x Q^*_{-2} Conditional on C and S, German Data

	Recession	Recovery
January	0.6000	0.5830
February	0.5851	0.5227
March	0.6162	0.5390
April	0.6039	0.6021
May	0.6528	0.6047
June	0.6187	0.6193
July	0.6069	0.5851
August	0.5415	0.5612
September	0.5995	0.5074
October	0.6215	0.5830
November	0.6321	0.5621
December	0.5864	0.6001

Unconditional Component Gamma = 0.6044
(187,1)

Table 3:
Component Gamma D x D^*_{t-2} Conditional on C and S, German Data

	Recession	Recovery
January	0.3545	0.4075
February	0.3652	0.3906
March	0.3852	0.3413
April	0.3847	0.3880
May	0.4339	0.3706
June	0.3992	0.3906
July	0.3805	0.3739
August	0.3793	0.4082
September	0.3687	0.3906
October	0.3863	0.4085
November	0.3521	0.4100
December	0.3647	0.4011

Unconditional Component Gamma = 0.401
(133,4)

Table 4: Component Gamma P x P^*_{-1} Conditional on C and S, French Data

Period before June 1978:

	Recession	Recovery
March	0.781	0.813
June	0.883	0.860
November	0.825	0.809

Unconditional Component Gamma = 0.832

Period since June 1978:

	Recession	Recovery
January	0.878	0.844
March	0.866	0.820
June	0.633	0.824
November	0.661	0.824

Unconditional Component Gamma = 0.810

Table 5: Component Gamma Q x Q^*_{-1} Conditional on C and S
French Data

Period before June 1978:

	Recession	Recovery
March	0.635	0.680
June	0.748	0.699
November	0.638	0.583

Unconditional Component Gamma = 0.667

Period since June 1978:

	Recession	Recovery
January	0.717	0.720
March	0.573	0.605
June	0.670	0.708
November	0.677	0.657

Unconditional Component Gamma: 0.669

Table 6: Component Gamma D x D^*_{-1} Conditional on C and S French Data

Period before June 1978:

	Recession	Recovery
March	0.520	0.653
June	0.630	0.445
November	0.508	0.605

Unconditional Component Gamma = 0.565

Period since June 1978:

	Recession	Recovery
January	0.593	0.614
March	0.471	0.501
June	0.569	0.609
November	0.599	0.572

Unconditional Component Gamma = 0.568

Considering the German data first: The component gamma for the P, P^*_{-2} interaction varys from 0.86 to 0.93 depending on the season and cycle phase, with an unconditional component gamma of 0.88 There appears to be no systematic pattern of variation. For the interaction between Q and Q^*_{-2} the conditional component gamma varies from 0.51 to 0.65, with an unconditional gamma of 0.60. The values seem generally higher for recession than for recovery phases but the differences are slight and the variations unsystematic. For the interaction between D and D^*_{-2} we find a variation between 0.35 and 0.43 with an unconditional gamma of 0.40. However, as is well-known, the component gamma represents only a summary of the bivariate interaction parameters. To test whether S and C jointly significantly affect the *bivariate* relation between an *ex ante* variable, X*, and its corresponding *ex post* value, X, we must examine the effect not of omitting these variables entirely but only of supressing their effects on the bivariate relationship between X and X*. A likelihood ratio test statistic may be computed by comparing the maximum likelihood when the interactions XxX*xSxC, XxX*xS, and XxX*xC are suppressed with the maximum likelihood for the suturated model. The three interactions suppressed depend upon a total of 92 parameters in this case so the -2 log likelihood ratio is distributed as χ^2 with 92 degrees of freedom. We find

Germany: Chi-square Values for the Likelihood Ratio Test of a Significant Effect of S and C on the Bivariate Relation between Ex Ante and Ex Post

Variable	Chi Square	Probability
Prices	890.0	0.000
Production	86.0	0.657
Demand	∿0.0	∿1.0

Thus S and C significantly affect the relation only for prices for the German data.

The French data tell a different story. Here we find much more variation in the conditional component gamma both with respect to cyclical phase and with respect to season. There are also marked differences between the first and second periods. The Chi-square test statistics are presented below:

France: Chi-square Values for the Likelihood Ratio Test of a Significant Effect of S and C on the Bivariate Relation between Ex Ante and Ex Post

Variable	Period	Chi-square	Probability
Prices	1	57.0	0.000
	2	47.8	0.011
Production	1	33.6	0.029
	2	37.9	0.101
Demand	1	67.8	0.000
	2	42.3	0.041

The appropriate value of the degrees of freedom in this case is 20 for the first subperiod and 28 for the second subperiod.

We see that in contract to the results for German firms S and C affect the relationships for all variables.

3.4 The Significance of Cycle and Season on the Overall Relations between Ex Ante and Ex Post

Clearly, if C and S significantly affect the bivariate part of the relationship between an *ex ante* variable and its corresponding *ex post* value, the overall relation is affected, but not the converse. That is, C and S may significantly affect the so-called main effects which represent variations in the marginal probabilities of each variable without at the same time affecting the bivariate parameters which reflect only that part of the joint relationship which remains after aggregate effects have been accounted for. While it is apparent from examination of the detailed computer output that the interactions XxS, X*xS, XxC and X*xC contain large numbers of conventionaly significant parameters, a more dramatic test of the significance of S and C may be obtained by computing the likelihood ratio omitting S and C entirely versus including both, i.e. for the model omitting all interactions containing S and C against the saturated model. The results are as follows:

Chi-square Values for the Likelihood-Ratio Test of the Significance of S and C.

Country and Period	Variable	Chi-square	DF
Germany	Prices	49.50	207
	Production	39.42	207
	Demand	45.14	207
France before June 1978	Prices	2190.3	45
	Production	2712.8	45
	Demand	3054.3	45
France after June 1978	Prices	3442.2	63
	Production	4304.3	63
	Demand	4609.9	63

All of the chi-square values are highly significant, the approciated probability in the upper tail being always negligibly different from zero.

It is thus apparent that while S and C are higher significant in the overall relationship between ex ante and ex post they are much less so when consideration is restricted to the purely bivariate relation. In this case we find that, except for prices in Germany, they are significant but with considerably lower associated chi-squares.

4. Summary

In this report we presented some empirical evidence in which way seasonal and cyclical components may influence the relation between ex ante and corresponding ex post variables.

Firstly, we have shown that seasonality exists in most variables, even in those which are requested to be adjusted for seasonal effects by the individual firm. We have further indicated that the construction of so-called balances may result in artifical cyclical components. As far as applied research is concerned one may consider it as a matter of research strategy (or research philosophy) whether seasonal adjustment should be carried out for the original (plus, minus) responses or for balances. In any case a more elaborated study with respect to the effects of different seasonal adjustment procedures on turning points, especially of leading indicators, would be necessary. A caveat with regard to the empirical significance of our results seems in order: The German data used for the spectral analysis cover roughly two business cycle periods. Needless to stress that a longer period is warranted to improve the significance of these results.

Secondly, we have presented evidence that for German firms with exception of prices, the bivariate interaction between ex ante and ex post responses is not influenced by seasonal and cyclical factors. For French firms, however, both seasonal and cyclical factors are important to "explain" variations in the association of these variables. Variations in component gamma-coefficients in more complicated models, as reported in earlier work (see König/Nerlove, 1982) may be attributed partly to these effects. A more detailed study of these relationships including seasonal and cyclical dummies could give inside if this variability in some relations depends on the specific seasonal and cyclical pattern. This, however, increases the dimension of contingency tables by an order with leads to serious estimation problems.

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APPENDIX A: Questions from the French and German Surveys Used in the Analyses

Ifo Survey

Related to

D — Die Nachfragesituation (In- und Ausland) für XY hat sich bei uns gegenüber dem Vormonat - gebessert, nicht verändert, verschlechtert.

D* — Unsere Geschäftslage für XY wird in den nächsten 6 Monaten in konjunktureller Hinsicht - also unter Ausschaltung rein saisonaler Schwankungen - eher günstiger, etwa gleich bleiben, eher ungünstiger.

P — Unsere Inlandsverkaufspreise (Nettopreise) für XY wurden - unter Berücksichtigung von Konditionsveränderungen - gegenüber dem Vormonat - erhöht, nicht verändert, gesenkt.

P* — Unsere Inlandsverkaufspreise (Nettopreise) für XY werden - unter Berücksichtigung von Konditionsveränderungen - voraussichtlich im Laufe der nächsten 3 Monate - steigen, etwa gleich bleiben, fallen.

Q — Unsere inländische Produktionstätigkeit bezüglich XY war gegenüber dem Vormonat - lebhafter, unverändert, schwächer.

Q* — Unsere inländische Produktionstätigkeit bezüglich XY wird voraussichtlich im Laufe der nächsten 3 Monate in konjunktureller Hinsicht - also unter Ausschaltung rein saisonaler Schwankungen - steigen, etwa gleich bleiben, abnehmen.

INSEE Survey

Related to

D — Évolution de la Demande - tendance au cours des 3 ou 4 derniers mois + = -

D* — Évolution de la Demande - tendance probable au cours des 3 ou 4 prochains mois + = -

P — Veuillez indiquer la variation de vos prix de vente (hors taxes) +___% = - ___ %.

P* — Quelle sera la variation probable de vos prix de vente (hors taxes) + ___ % = - ___ %.

Q — Evolution de votre Production - tendance au cours des 3 ou 4 derniers mois + = -

Q* — Évolution de votre Production - tendance probable au cours des 3 ou 4 prochains mois + = -

APPENDIX B: Cyclic Artifacts in Balances

In this Appendix we show that it is possible to take the difference of two series having smoothly decling spectral densities to produce a third series which has a spectral peak near the origin which might be interpreted as evidence of cyclic variability. The reason the possibility exists is that differencing two series, even those not having identical spectral representations or cyclic peaks, or spectral zeros at the origin, may introduce a zero at the origin. Given the typical spectral shape of an economic time series and the "smudging" effects of all estimation procedures, an apparent peak will than be introduced near the origin. The exact location of the peak will depend on the rate of descent of the time spectral density near but not at the origin and on the width of the spectral estimation window, but it will be near the origin and thus interpretable in terms of a rather long-cycle, such as one of 36, 48 or more months in length.

Consider two time series $\{x_t\}$ and $\{y_t\}$ each of which has an ARMA representation:

$$x_t = \frac{P_1(U)}{Q_1(U)} \varepsilon_{1t} \quad , \quad \varepsilon_{1t} \sim \text{IND}\ (o, \sigma_{11})$$

(i)

$$y_t = \frac{P_2(U)}{Q_2(U)} \varepsilon_{2t} \quad , \quad \varepsilon_{2t} \sim \text{IND}\ (o, \sigma_{22})$$

where U is the backward shift operator and P_1, P_2, Q_1 and Q_2 are polynominals in U, all of which have roots lying outside of the unit circle (i.e., x_t and y_t are generated by stationary, invertible ARMA processes). The assumption of Gaussian white noise inputs, which do not necessarily have to be independent of each other but which will be assumed so here, guarentees that the difference $w_t = x_t - y_t$ will also follow a stationary ARMA process but one which is now not necessarily invertible:

$$(2) \quad w_t = \frac{R(U)}{Q_1(U)Q_2(U)} \quad \varepsilon_t \quad , \quad \varepsilon_t \sim \text{IND } (o, \sigma^2) \quad .$$

This means that R may have a root on the unit circle even if P_1 and P_2 do not. The presence of a root $w_o = 1$ implies a zero at the origin in the spectral representation of w. This, as we have argued, will generally lead to a peak in the estimated spectral densitiy near the origin.

To see why this may occur, we write out the covariance generating transform for the series w:

$$(3) \quad \sigma^2 g_{ww}(z) = \frac{|P_1(z)Q_2(z)|^2\sigma_{11} - |P_2(z)Q_1(z)|^2\sigma_{22}}{|Q_1(z)Q_2(z)|^2}$$

It is thus necessary and sufficient for the spectral density of w to have a zero at the origin that

$$(4) \quad \left| \frac{P_2(1)Q_1(1)}{P_1(1)Q_2(1)} \right|^2 = \frac{\sigma_{11}}{\sigma_{22}} = H \frac{\sigma_{xx}}{\sigma_{yy}}$$

where σ_{xx} and σ_{yy} are the observed variances of x and y respectively and H is a function of the coefficients of the polynominals P_1, P_2, Q_1 and Q_2. (The general result proved by Nerlove, Grether and Carvalho, 1979, Chapter 4, may be applied to find H explicitly.) It is apparent that there are many possibilities for a root $w_o = 1$ to occur. A simple example suffices to show this:

Let x_t and y_t both have ARMA (1,1) representations

$$x_t = \frac{1-\beta_1 U}{1-\alpha_1 U} \quad \varepsilon_{1t} \qquad |\alpha_1| , |\beta_1| < 1 ,$$

(5)

$$y_t = \frac{1-\beta_2 U}{1-\alpha_2 U} \qquad |\alpha_2|, \ |\beta_2| < 1,$$

Then the condition (4) reduces to

$$(6)\quad \frac{(1-\alpha_1^2)}{(1-\alpha_2^2)}\,\frac{(1-\beta_2)^2}{(1-\beta_1)^2}\,\frac{(1-\alpha_2^2)}{(1-\alpha_1^2)}\,\frac{(1+\beta_1^2-2\alpha_1\beta_1)}{(1+\beta_2^2-2\alpha_2\beta_2)} = \frac{\sigma_{xx}}{\sigma_{yy}}$$

For example when α_1 = o.9. and α_2 = o.8, fairly typical values, and for σ_{xx}/σ_{yy} = 0.5, 1, and 5, values close to those formal in our data, the possible combinations of ß, and β_2 leading to a root w_o = 1 are given in the following table. We have chosen only combinations of real roots such that the MA components of both series are invertible.

σ_{xx}/σ_{yy} = 0.5		σ_{xx}/σ_{yy} = 1.0		σ_{xx}/σ_{yy} = 5.0	
β_1	β_2	β_1	β_2	β_1	β_2
0.33	0.81	0.33	0.71	0.57	-0.90
0.40	0.82	0.37	0.72	0.57	-0.80
0.45	0.83	0.40	0.73	0.57	-0.70
0.50	0.84	0.44	0.74	0.57	-0.60
0.54	0.85	0.47	0.75	0.57	-0.50
0.58	0.86	0.50	0.76	0.58	-0.40
0.62	0.87	0.53	0.77	0.58	-0.30
0.65	0.88	0.55	0.78	0.58	-0.20
0.68	0.89	0.58	0.79	0.58	-0.10
0.71	0.90	0.61	0.80	0.59	0.00
0.74	0.91	0.63	0.81	0.59	0.10
0.77	0.92	0.66	0.82	0.60	0.20
0.80	0.93	0.68	0.83	0.62	0.30
0.83	0.94	0.70	0.84	0.64	0.40
0.86	0.95	0.73	0.85	0.67	0.50
0.89	0.96	0.75	0.86	0.71	0.60
0.91	0.97	0.78	0.87	0.77	0.70
0.94	0.98	0.80	0.88	0.86	0.80
0.97	0.99	0.83	0.89		
		0.86	0.90		
		0.89	0.91		
		0.94	0.92		

We observe that given the coefficients α_1 and α_2 there exists a wide range for the value of the MA-processes which will result in an unit root producing a zero in the first frequency band.

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