A short term econometric model
for the consumer demand of
roasted coffee in the Netherlands

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1. Introduction

In recent years, the world coffee market, after that for petroleum the most important commodity market, has been in the center of interest because of the heavy price movements. One of the most important events in the recent history of the coffee market is the price explosion in 1976-'77, which was due to the frost in Brazil in July 1975 causing the destruction of almost the entire crop of 1976.

An interesting question to be asked is what are the reactions of the consumers to the price movements. There were news-reports on a consumer boycot in the U.S.A., and large inventories of roasted coffee in households. To what extent are these reactions different from reactions to small price increases or can they be explained in a generally valid model.
In this paper we shall specify and estimate a model for the consumer demand of roasted coffee in the Netherlands for the period from January 1970 to February 1979, wherein the stability of the model over this period will receive special attention. The model must reflect short term reactions of consumers. Therefore it is desirable to use data on the shortest possible time interval. For the Netherlands monthly data are available.

In most of the studies concerning the coffee market, consumption equations are estimated using annual figures. Bucholz (1964) was perhaps the first who estimated a consumption equation for coffee, using annual and quarterly data for Germany for the period 1952-1961. He found a good fit when explaining the consumption (approximated by net imports) by the coffee price and the income per capita, both deflated by the general price index. Seasonal dummy variables were included in the quarterly equation. Bucholz already noted that economic theory supplies little information useful for specifying a consumption equation. Empirical verification is the most important aspect of the model specification.

In other publications, mostly dissertations or reports of international organizations, the consumption of coffee is explained by the same type of variables used by Bucholz. See e.g. Bacha (1968), Ford (1977), Lovasy (1967) and Shamsher Singh (1977).

In modelling the consumption of coffee in the Netherlands we follow a similar strategy. Some variables are indicated by economic theory, while the use of other variables and the form of the equation result from the empirical analysis. The following section contains a description of the variables and the data. The results of a statistical analysis of some of the variables are given in section 3. The specification, estimation and verification of the model is out-lined in section 4. In section 5 the results are summarized.

2. The model

An econometric model with the variables indicated by the economic theory
concerning the demand of a commodity, will generally contain the following
variables:

$$c_t = f(p_t, y_t, p_{ti}^c, p_{tj}^s) + u_t$$

with : c_t = consumption of some commodity

p_t = price of that commodity

y_t = personal income

p_{ti}^c = price of a complementary commodity i

p_{tj}^s = price of a substitutive commodity j

u_t = disturbance term; it is assumed that the disturbances
are independently and normally distributed with zero
means and constant variances, and that the disturbances
are independent of the explanatory variables.

The variables to be included in a coffee consumption equation for the
Netherlands will now be described.

Coffee consumption

Data on coffee consumption by Dutch households are not available. Therefore,
we shall use the deliveries of coffee by wholesale dealers to the retail trade
as a proxy for the consumer demand. The original series measures deliveries
on a four week basis.[1] They are converted into monthly data by allocation
proportional to the number of days in a month[2], and then divided by the
population size. The latter series is shown in figure 1. It concerns only
data on roasted coffee. It is not possible to obtain the same type of data
on instant coffee.

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1) This series was obtained from Douwe Egberts B.V.
2) E.g. If the delivery of the first period is x ton and those of the
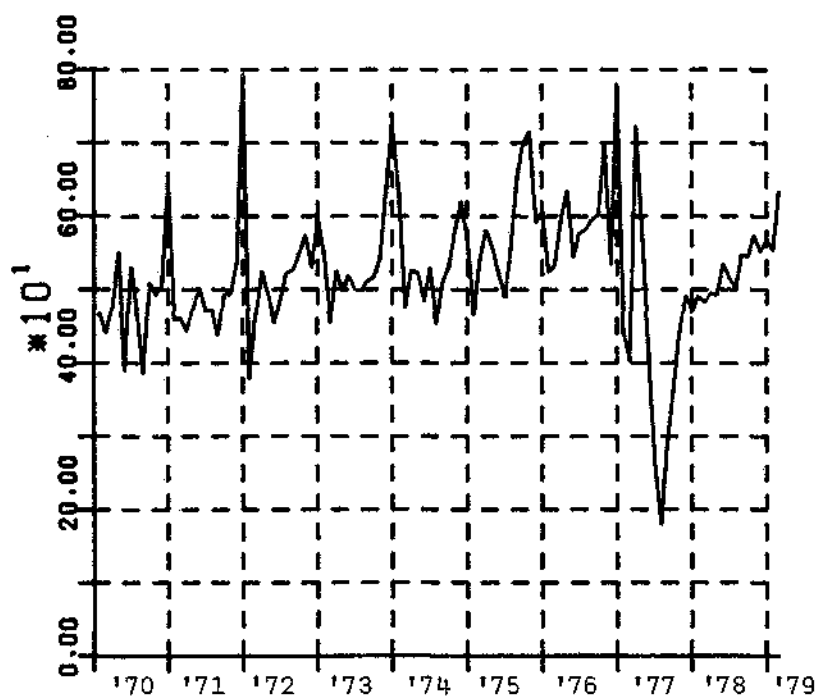second y ton, we take for January: $\frac{28}{28} x + \frac{3}{28} y$ ton.

Fig. 1: The deliveries of roasted coffee by whole-
sale dealers to the retail trade, in gram
per capita in the Netherlands from
1-1-70 to 1-3-79

Prices[3]

The prices[4] we use are expressed as index numbers with base = 100 in 1969.
The retail price index for coffee is plotted in figure 2. We have collected
the retail price index for instant coffee, tea, and soft drinks as prices
of substitutes for roasted coffee. Prices of complementary goods, such as
sugar and coffee-cream, are not collected, because it is not expected that
these prices influence the demand of coffee.

Another price variable that might be a useful explanatory variable is the
world market price for coffee. The retail price will react with some delay
to the movement of the world market price. This aspect will be investigated
later on.

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3) All price index numbers have been collected by the Central Bureau for
   Statistics of the Netherlands.

4) All prices, in the text and figures, are deflated by the consumption
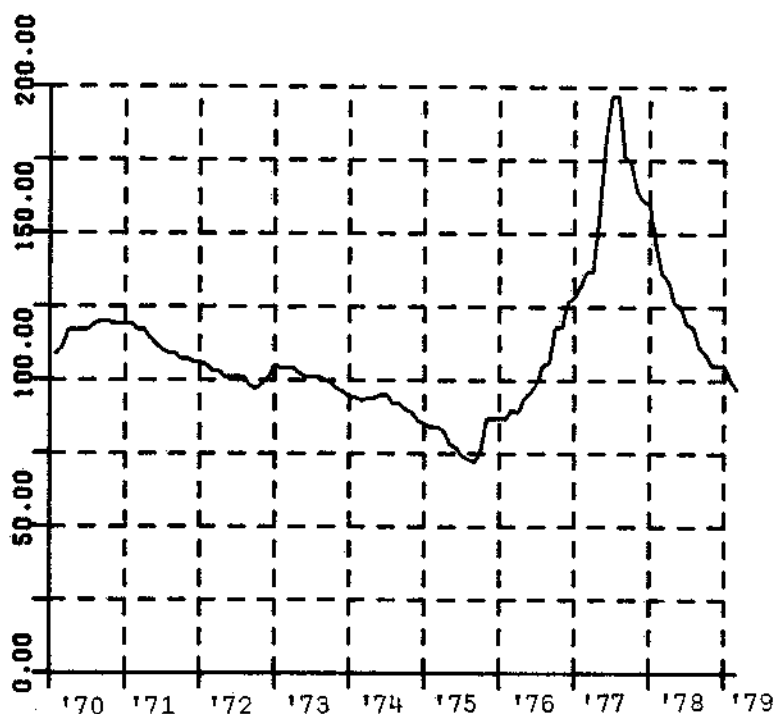   price index.

Fig. 2: The coffee price index for the retail
trade in the Netherlands from
1-1-70 to 1-3-79

Since important events on the world market are reported in the newspapers,
one might expect that consumer behaviour is influenced by these news items.
We use the Composite Daily Indicator Price[5], with basis the 1968 International
Coffee Agreement, as the world market price. This indicator price is an
average price of the four most important types of coffee, traded on the New
York spot market. The indicator price is originally measured in dollar cents
per pound but we have converted it into Dutch cents per gram by using average
monthly exchange rates. This series is also divided by the consumption price
index. This world market price with respect tot the Netherlands is plotted in
figure 3.

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5) Source: Quarterly Statistical Bulletin on Coffee from the International
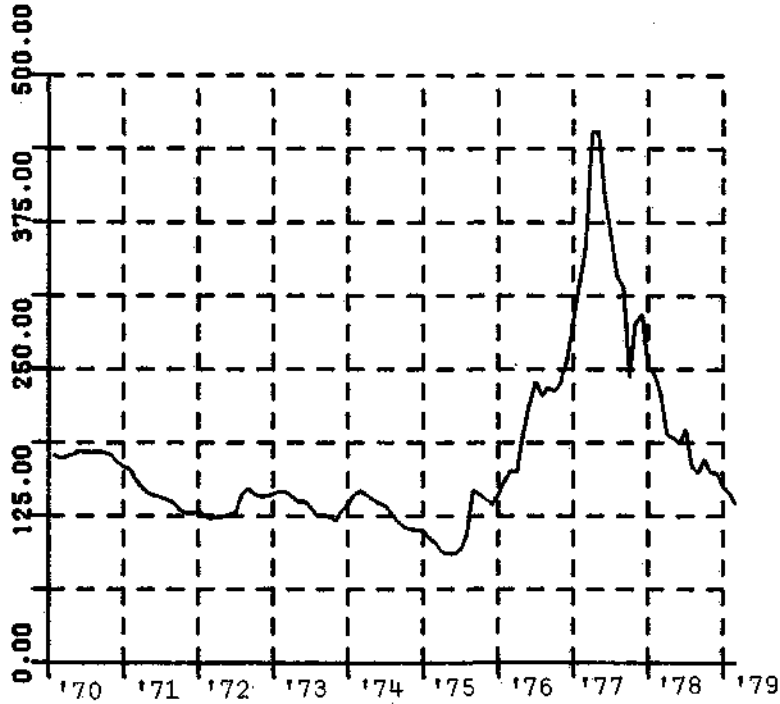   Coffee Organization.

Fig. 3: The Composite Daily Indicator Price in
Dutch cents per gram from 1-1-70 to 1-3-79

For investigating to what extent the retail price follows the fluctuations
in world market price, we have calculated the cross correlation function
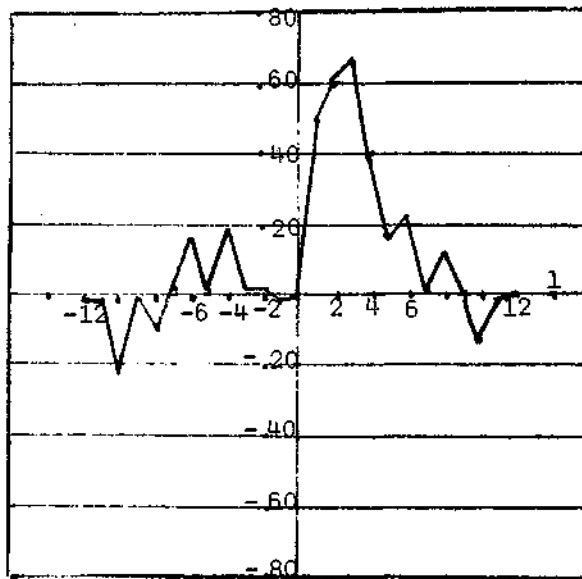(ccf) between the changes in these prices. This ccf is illustrated in
figure 4.

Fig. 4: The ccf between $\nabla CPRI_t$ and
∇CDP_t, lags of $\nabla CPRI_t$ have
positive 1

Figure 4 shows that price changes on the worldmarket are followed by price changes in the retail trade with a time interval up to six months.
The maximum correlation is at an interval of three months (.65).
So we may assume that consumer behaviour is influenced by news reports concerning the worldmarket. For the consumption equation it is not unreasonable to use the worldmarket price as an indication for the development of the retailprice in the near future.

Income

Data on net personal income are not available on a monthly basis. As a proxy for the income series, we use the index of total consumption in constant prices divided by the population size (the base pariod is July 1975).
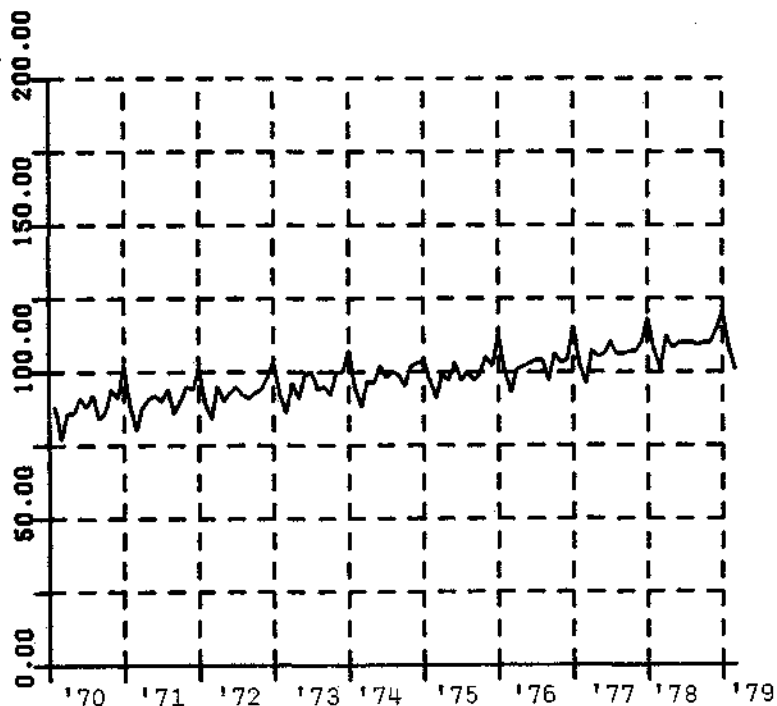This series is plotted in figure 5.

Fig. 5: The index of the total consumption for the Netherlands from 1-1-70 to 1-3-79.

3. Analysis of the data on the variables of the model

Before specifying and estimating a model, we want to have more insight in the data on the variables.
At first we look at the plots of the variables. There are some striking features.

- The demand for coffee shows a peak in December, except for the last two years. The peak is possibly caused by the December festivities and by the prospects of a price increase on January 1st due to e.g. a tax increase or related to the price regulations by the ministry of economic affairs. In 1977 and 1978 when the coffeemarket was recovering from a period of heavy pricefluctuations, the December peak was not observed, because there were large consumer inventories of coffee. From the picture it is not clear whether there are periodical movements in the series.
- The figure shows that the coffee price series is dominated by a trend-movement.
- A seasonal pattern seems to be present in the consumption index.

From the picture it is not clear whether there are other periodical movements in the series. In order to investigate the presence of any seasonal variation in the data, we computed on additive, a multiplicative and a mixed additive - multiplicative seasonal pattern, by means of a simple statistical analysis. This analysis of the coffee consumption, price and the index of total consumption suggest the presence of an additive seasonal pattern in the consumption index.
No indication of either an additive or a multiplicative seasonal pattern was found in the other variables. Because the consumption index is the only variable with a seasonal pattern we do not expect a seasonal bias in the parameter estimates as is indicated, by Wallis (1974) if the consumption index is adjusted for its additive seasonal pattern. Some fluctuations around a increasing linear trend remain after this adjustment.
In order to get more insight whether there are any cyclical patterns other than the seasonal ones , the sample autocorrelation function (acf) and the sample autospectrum of the coffee deliveries are computed and illustrated in figure 6 and 7. The acf is plotted with twice the standard errors. The large sample standard errors are approximately $\sqrt{\frac{1}{T}}$ under the null hypothesis that the series is random (T is the sample size). See e.g. Granger and Newbold (1977).
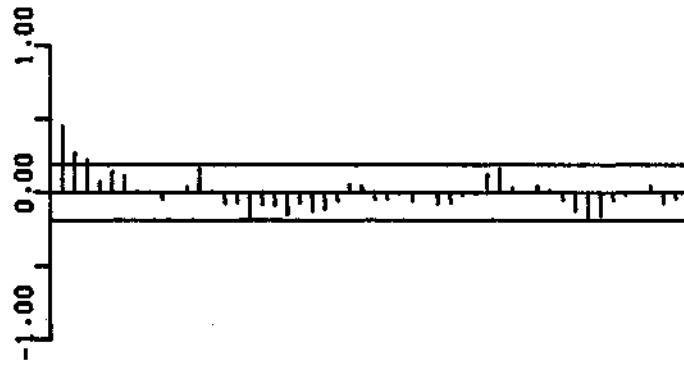
Fig. 6: The acf of the coffee consumption
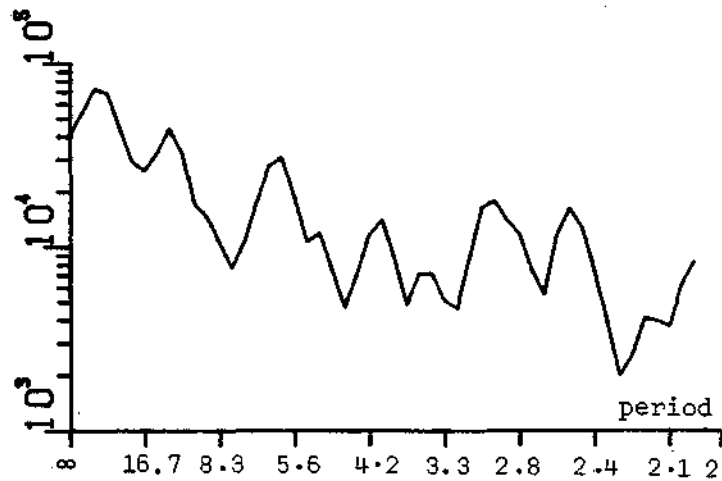
Fig. 7: The spectrum of the coffee consumption

For the consumption series we find some significant positive autocorrelation.
The spectrum clearly exhibits a twelve months cycle and its harmonics.
Since the series is not stationary, the spectrum of the first differences of
the series is also calculated and plotted in figure 8. The twelve months cycle
has not been affected by first differencing. But the low frequency components
have been eliminated, just as is done by the seasonal-eliminating-filters
described in Sims (1974).

Fig.8 : The spectrum of the 1st difference of the coffee consumption

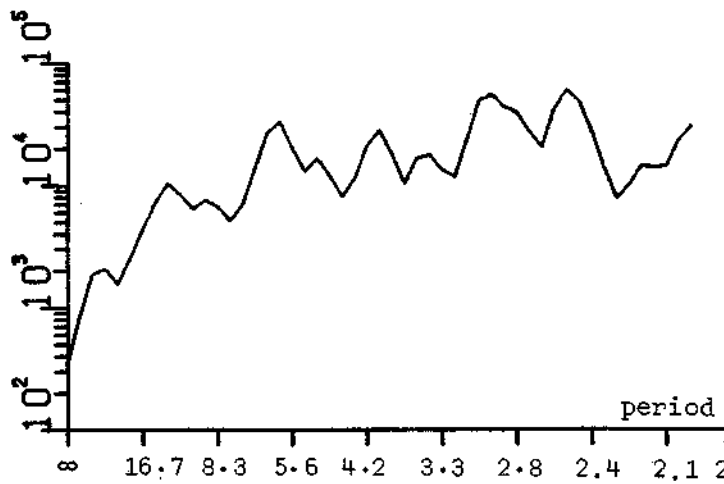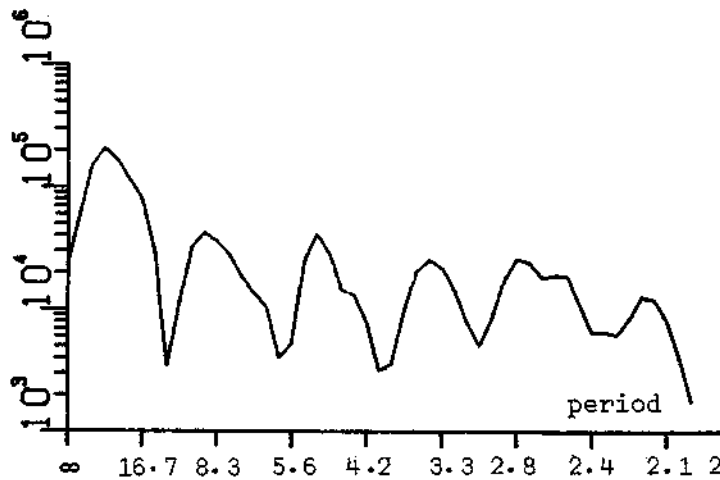Fig. 9 : The spectrum of the twelve months difference of the coffee consumption

The twelve months cycle in the consumer demand has a simple interpretation. Coffee consumption is subject to habit formation and therefore a significant correlation between corresponding months is not unexpected. So when specifying the model the presence of this cycle has to be taken into account. This might be done by using the twelve months lag of the consumption as an explanatory variable in a modelspecification for the present level of the consumption or by specifying the twelve months difference in the consumption as the dependent variable. For that reason the spectrum of the twelve months difference of the coffee deliveries is also computed. As is seen in figure 9, the twelve-months-difference-filter eliminates the twelve months cycle and its harmonics, but it leaves low frequency components in the series as opposed to what happens when we take first differences.

In the next section we shall specify and estimate a consumer demand equation for roasted coffee.

4. <u>Specification, estimation and evaluation of the model</u>

In this section we shall first describe the specification of the variables which will be used for estimating a model for the coffee consumption. After that, different specifications will be estimated and their validity will be tested.

The following notation for the variables will be used:

$CONS_t$: The coffee deliveries to the retail trade per capita in month t

$CPRI_t$: The coffee price index for the retail trade in month t

TCI_t : The total consumption index (quantity per capita) in month t

$TCIA_t$: TCI_t adjusted for the additive seasonal pattern

CDP_t : The composite daily indicator price for coffee in month t (1968 agreement), in Dutch cents per gram

D_t : A dummy variable for the month December,

$D_t = 1$ in December,

$D_t = 0$ in the other months

P_t^T, P_t^I, P_t^S : The price index for the retail trade of tea, instant coffee and soft drinks in months t .

The following operator symbols will be used:

∇ : The first difference operator, $\nabla X_t = X_t - X_{t-1}$

$(1 - B^{12})$: The twelve-months-differcence operator,

$$(1 - B^{12}) X_t = X_t - X_{t-12}$$

The twelve months difference of a variable can also be split up into two variables representing the increases and decreases respectively of the original variable. We define:

$$(1 - B^{12})^+ X_t = (1 - B^{12}) X_t \quad \text{if} \quad X_t > X_{t-12}$$
$$= 0 \quad \text{if} \quad X_t \le X_{t-12}$$

$$(1 - B^{12})^- X_t = (1 - B^{12}) X_t \quad \text{if} \quad X_t < X_{t-12}$$
$$= 0 \quad \text{if} \quad X_t \ge X_{t-12}$$

This splitting up is particularly relevant for the coffee price.
A criterium for the habit formation in the consumption is the irreversibility
of the demandfunction (see e.g. Bucholz (1964) p. 176).
A consumption equation is called reversible if the reactions of the consumers
are identical for price increases and price decreases.
Positive irreversibility occurs if price decreases result in greater changes
in demand than for price increases and negative irreversibility if the opposite
is true. Irreversibility is tested by checking whether the difference between
the coefficient of $(1 - b^{12})^{+} CPRI_t$ and $(1 - B^{12})^{-} CPRI_t$ in the model is

significantly different from zero.

A general specification of the consumption equation is:

$$CONS_t = f \left(CONS_{t-12} , CPRI_t , (1 - B^{12})^{+} CPRI_t , (1 - B^{12})^{-} CPRI_t , \right.$$

$$\left. CDP_t , P_t^{T} , P_t^{I} , P_t^{S} , TCIA_t \text{ or } TCI_t , D_t \right) + u_t$$

with f being linear in its arguments.

The following alternative specifications are reasonable and will be tested.

- The use of $(1 - B^{12})P_t^{T}$, $(1 - B^{12})P_t^{I}$, $(1 - B^{12})P_t^{S}$ instead of
  the present level of these variables.

- The use of $(1 - B^{12})CPRI_t$ instead of the distinction between
  price increases and decreases.

- The use of $(1 - B^{12})CONS_t$ as dependent variable. In that case
  $CONS_{t-12}$ and the dummy variable will not be included as explanatory
  variables.

- The inclusion of TCI_t instead of $TCIA_t$ and D_t. TCI_t has just
  as $CONS_t$ a peak in December, so it might be possible that specifying
  TCI_t makes the dummy variable a superfluous explanatory variable.
  Also it is possible that both TCI_t and D_t give the best fit.

- The inclusion of one or more lags of CDP_t or its first difference.

- Combinations of the previously mentioned specifications.

Some of the estimation results will be tabulated, while other ones will only
be described, because the number of analyses is too large for tabulating all
of them.
There is one problem concerning the sample period. For most of the variables
the sample period is January 1970 - February 1979, only the price indices

of tea and instant coffee are available (at this stage of our research) for the period January 1970 - August 1978.

So we first estimate the consumption equation using the data for the latter period.

Estimating the general specification results in:

$$\hat{CONS}_t = 671.61 + .23 \, CONS_{t-12} - 2.99 \, CPRI_t - 2.50 \, (1-B^{12})^+ CPRI_t$$
$$\qquad (214.27) \quad (.10) \qquad (1.81) \qquad (.90)$$

$$-.67(1-B^{12})^- CPRI_t + 1.16 \, CDP_t - .56P_t^T - .04P_t^I - .61P_t^S$$
$$\quad (.70) \qquad\qquad (.24) \qquad (2.02) \quad (3.36) \quad (2.00)$$

$$-.26 \, TCIA_t + 100.04 D_t \qquad\qquad R^2 = .65 \qquad DW = 1.74$$
$$\quad (.37) \qquad\qquad (27.73) \qquad\qquad \text{sample period: Jan. '70 - Aug. '78}$$
$$\text{(standard errors in parentheses)}$$

The coefficients of the substitutes and the consumption index have the wrong sign and very low t-values. Also the t-value of the present level of the coffeeprice is rather low. The use of twelve months differences [6] of these four variables has the following result:

$$\hat{CONS}_t = 543.64 + .26 CONS_{t-12} - 3.15 CPRI_t - 3.09 (1-B^{12})^+ CPRI_t$$
$$\quad (92.42) \quad (.10) \qquad (.63) \qquad (1.54)$$

$$-1.64 \, (1-B^{12})^- CPRI_t + 1.15 CDP_t - 1.01 \, (1-B^{12})P_t^T + 1.68 \, (1-B^{12})P_t^I$$
$$\quad (1.25) \qquad\qquad (.21) \qquad (1.08) \qquad\qquad (2.62)$$

$$+ 1.23 \, (1-B^{12})P_t^S + .56(1-B^{12})TCI_t + 95.84 \, D_t \qquad R^2 = .65$$
$$\quad (2.38) \qquad\qquad (2.80) \qquad\qquad (27.74) \qquad DW = 1.81$$

Only the estimated coefficient of price index of tea has the wrong sign, but the t-values of instant coffee, soft drinks and consumption index are still very low. However the estimates of the remaining parameters have larger t-values.

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6) Notice that $(1-B^{12}) \, TCI_t = (1-B^{12}) \, TCIA_t$

The estimation results of other specifications like those without inclusion of all the prices of substitutes or with $(1-B^{12})CONS_t$ as the dependent variable are similar with respect to the coefficients of P_t^T, P_t^I and P_t^S. Some conclusions can be drawn from this analysis:

- The restriction that the coefficient of $CONS_{t-12}$ equals 1 has to be rejected. Testing this restriction with the likelihood ratio test results in a value of about 50 for the test statistic when different specifications are compared. The $\chi^2_{.95}(1)$ value equals 3.84, so the restriction is clearly rejected.

- The coefficient of $TCIA_t$ differs not significantly from zero and has the wrong sign, while specifying TCI_t has the consequence that its coefficient has a positive significant value and also that P_t^S has a positive significant influence.

- Applying the likelihood ratio test confirms that P_t^I and P_t^T might be omitted, while this is not the case with P_t^S.

- Lags of CDP_t give a worse fit, lower R^2 and t-values. The specification of ∇CDP_t results in a bad estimate of the coefficient for $CPRI_t$.

As a consequence of these preliminary results we go on with investigating the model that contains now the following variables.

$$CONS_t = f \left(\text{constant}, CONS_{t-12}, CPRI_t, (1-B^{12})^+ CPRI_t, (1-B^{12})^- CPRI_t \text{ or} \right.$$
$$\left. (1-B^{12})CPRI_t, CDP_t, P_t^S, TCI_t, D_t \right) + u_t$$

Just as before we will test the specification of the model. Some of the estimation results are presented in table 1. In this table ln L is the value of the log likelihood function and the standard errors are given in parentheses.

eq	constant	$CONS_{t-12}$	$CPRI_t$	$(1-B^{12})CPRI_t$	$(1-B^{12})^+CPRI_t$	$(1-B^{12})^-CPRI_t$	CDP_t	P_t^S	TCI_t	D_t	ln L	R^2	DW
1	67.82 (283.17)	.22 (.10)	-3.86 (.42)	-1.14 (.43)			1.09 (.19)	2.96 (1.85)	3.11 (1.50)	72.46 (29.43)	-500.28	.66	1.70
2	124.79 (282.37)	.17 (.10)	-3.54 (.46)		-2.06 (.70)	-.34 (.65)	1.15 (.19)	1.92 (1.93)	3.40 (1.49)	72.63 (29.13)	-498.78	.67	1.67
3	490.25 (103.71)	.21 (.10)	-3.72 (.41)	-1.09 (.44)			.98 (.17)		1.58 (1.16)	87.95 (28.05)	-501.66	.65	1.71
4	382.00 (114.13)	.16 (.10)	-3.40 (.43)		-2.21 (.69)	-.15 (.62)	1.11 (.18)		2.57 (1.23)	81.69 (27.68)	-499.33	.67	1.66
5		.22 (.09)	-3.88 (.41)	-1.16 (.43)			1.10 (.18)	3.37 (.67)	3.40 (.88)	69.17 (25.88)	-500.31	.66	1.70
6		.18 (.10)	-3.57 (.50)		-2.05 (.70)	-.39 (.63)	1.18 (.18)	2.70 (.78)	3.92 (.93)	66.66 (25.69)	-498.89	.67	1.66
7		.35 (.10)	-3.22 (.44)	-1.36 (.48)			.73 (.19)		5.73 (.85)	25.79 (27.68)	-512.36	.56	1.44
8		.21 (.10)	-2.85 (.42)		-3.20 (.66)	-.35 (.63)	1.05 (.19)		5.85 (.79)	38.68 (25.94)	-505.07	.62	1.45
9	-257.70 (257.75)	.31 (.09)	-3.88 (.43)	-1.30 (.44)			1.10 (.19)	4.45 (1.79)	4.64 (1.40)		-503.48	.64	1.72
10	-201.79 (257.80)	.26 (.10)	-3.56 (.47)		-2.21 (.72)	-.50 (.66)	1.17 (.20)	3.43 (1.89)	4.93 (1.40)		-502.02	.65	1.70
11		.31 (.09)	-3.83 (.43)	-1.27 (.44)			1.05 (.19)	2.78 (.65)	3.57 (.91)		-504.02	.63	1.75
12		.26 (.10)	-3.50 (.46)		-2.25 (.72)	-.42 (.65)	1.14 (.19)	2.07 (.76)	4.13 (.96)		-502.44	.64	1.72
13	542.18 (170.85)	.26 (.10)	-3.66 (.41)	-1.38 (.43)			1.12 (.19)	.50 (1.45)		97.79 (27.31)	-502.58	.64	1.79
14	627.24 (181.09)	.23 (.10)	-3.37 (.46)		-2.17 (.72)	-.73 (.64)	1.18 (.19)	-.55 (1.64)		99.93 (27.22)	-501.58	.65	1.76
15	596.70 (68.36)	.25 (.09)	-3.65 (.41)	-1.33 (.40)			1.09 (.15)			98.67 (27.06)	-502.65	.64	1.78
16	570.93 (70.55)	.24 (.09)	-3.41 (.44)		-2.12 (.70)	-.58 (.53)	1.21 (.18)			98.94 (26.92)	-501.64	.65	1.77

Table 1 : Summary of some estimation results using $CONS_t$ as dependent variable

It is obvious from table 1 that some of the parameter estimates are rather stable, while others are sensitive for changes in the modelspecification. The coefficients of $CONS_{t-12}$, $CPRI_t$, $(1-B^{12})CPRI_t$ or the splitting up, and the CDP_t are of the same magnitude in the different equations.
But those of the constant term and the dummy, P_t^S and TCI_t are rather different. The coefficient of P_t^S is significant and has the correct sign only if TCI_t is included, which might be caused by the relationship between t-values and partial correlations coefficients (see Theil (1971) p. 174 and for another empirical example Davidson et al. (1978)).
The coefficient of $(1-B^{12})^-CPRI_t$ is not significant but when the estimates of the coefficients of $(1-B^{12})CPRI_t$, $(1-B^{12})^+CPRI_t$ and $(1-B^{12})^-CPRI_t$ are compared, substantial differences in their values are noticed that make a further analysis of the irreversibility an interesting question.

The likelihood ratio test will be applied for testing the inclusion of some of the explanatory variables. The results of these tests are presented in table 2.

Test	Models compared	$-2 \ln \Lambda$ [7]	number of restrictions
1	1 and 2	3.00	1
2	1 and 3	2.76	1
3	2 and 4	1.10	1
4	1 and 5	.06	1
5	2 and 6	.22	1
6	5 and 6	2.84	1
7	5 and 7	24.10	1
8	6 and 8	12.36	1
9	1 and 9	6.40	1
10	2 and 10	9.40	1
11	5 and 11	7.42	1
12	6 and 12	7.10	1
13	1 and 13	4.60	1
14	2 and 14	5.60	1
15	1 and 15	4.74	2
16	2 and 16	5.72	2

Table 2: Results of the likelihood ratio test applied to the models in table 1.

7) Λ is the likelihood ratio

The conclusions from this specification analysis and from the likelihood
ratio tests are as follows:

- The constant term might be omitted, since its insignificant value
  and the results of the tests 4 and 5. Also the large range of the
  estimates in the different experiments is reason to delete this term.

- The constant represents the slope coefficient of a trend term in
  the level of consumption, since the coffee consumption is specified
  as a twelve months difference. From figure 1 it is clear that over
  the whole sample period a trend is not present. Only the first years
  1970-1976 show a small positive trend.

- Deleting the constant term results in highly significant values
  of the parameters of the other variables.

- Specially, the price of soft drinks has a high t-value when the
  constant term is not specified. This might be caused by the fact that
  P_t^S fluctuates within a small range, which might result in multi-
  collinearity problems with the constant term.
  See also the result of test 7 in favour of P_t^S .

So we conclude that the specifications 5 and 6 have to be prefered. Until
now nothing is said about splitting up the variable $(1-B^{12})CPRI_t$.
Testing the hypothesis, that the influence of price increases and decreases
on the coffee consumption is equal, by means of the likelihood ratio test
resultes in the value 2.84 for the test statistic (test 6).
This is significant at a level of 9.19 %.
Together with the already mentioned differences in the parameter estimates make
it worthwhile to analyse it further.
However another aspect is the insignificant value of $(1-B^{12})^-CPRI_t$.
Because the months September 1978 to February 1979 show still a large price
decrease, it might be possible to obtain better results for these variable
by estimating the model over the sample period January 1970 to February 1979.

As mentioned before, data on the variables which are now inserted in the model
are available for this sample period. So we re-estimate model 1, 2, 5 and 6
for the sample period January 1970 to February 1979. The results are:

(17) $\quad \hat{CONS}_t = 169.75 + .24CONS_{t-12} - 3.85CPRI_6 - 1.08 (1-B^{12})CPRI_t$

$\qquad\qquad (274.24) \quad (.09) \qquad\qquad (.41) \qquad\quad (.40)$

$\qquad\qquad + 1.07CDP_t + 2.49P_t^S + 2.41 TCI_t + 64.09D_t$

$\qquad\qquad\quad (.19) \qquad\quad (1.77) \quad (1.46) \qquad (27.65)$

$\qquad\qquad R^2 = .64 \qquad DW = 1.70 \qquad \ln L = -533.10$

(18) $\quad \hat{CONS}_t = 231.05 + .20CONS_{t-12} - 3.50CPRI_t - 2.11 (1-B^{12})^+CPRI_t$

$\qquad\qquad (273.04) \quad (.10) \qquad\qquad (.45) \qquad\quad (.70)$

$\qquad\qquad -.31 (1-B^{12})^-CPRI_t + 1.15CDP_t + 1.29P_t^S + 2.77TCI_t + 63.79 D_t$

$\qquad\qquad (.58) \qquad\qquad\qquad (.19) \qquad\quad (1.87) \quad (1.45) \qquad (27.32)$

$\qquad\qquad R^2 = .66 \qquad DW = 1.67 \qquad \ln L = -531.36$

(19) $\quad \hat{CONS}_t = .25CONS_{t-12} - 3.88CPRI_t - 1.12 (1-B^{12})CPRI_t$

$\qquad\qquad (.09) \qquad\quad (.41) \qquad\quad (.39)$

$\qquad\qquad + 1.10CDP_t + 3.52P_t^S + 3.14 TCI_t + 55.88D_t$

$\qquad\qquad\quad (.18) \qquad\quad (.61) \qquad (.87) \qquad (24.18)$

$\qquad\qquad R^2 = .64 \qquad DW = 1.69 \qquad \ln L = -533.31$

(20) $\quad \hat{CONS}_t = .21CONS_{t-12} - 3.55CPRI_t - 2.10 (1-B^{12})^+CPRI_t - .41 (1-B^{12})^-CPRI_t$

$\qquad\qquad (.09) \qquad\quad (.45) \qquad\quad (.70) \qquad\qquad\qquad (.57)$

$\qquad\qquad + 1.18CDP_t + 2.74 P_t^S + 3.72TCI_t + 52.80D_t$

$\qquad\qquad\quad (.18) \qquad\quad (.76) \qquad (.92) \qquad (24.00)$

$\qquad\qquad R^2 = .65 \qquad DW = 1.66 \qquad \ln L = -531.75$

Comparing these results with the equations 1, 2, 5 and 6 show that the conclusions previously drawn from table 1 are still valid. The estimates of the constant term and the dummy variable are rather unstable in contrast to the other parameters. The t-value of $(1-B^{12})^-CPRI_t$ is hardly larger: equations 2 and 18 show a difference of +.01 and equations 6 and 20 give an increase of +.10 . So just as before we prefer the models 19 and 20 as the most acceptable model specifications.

Now we shall investigate the irreversibility of the demand equation.

The restriction that price increases and decreases have the same influence (model 19) can be tested with the likelihood ratio test.

The χ^2-value of the test statistic is 3.12, that is significant at a level of 7,79 %. Testing whether the difference of the coefficients of $(1-B^{12})^+CPRI_t$ and $(1-B^{12})^-CPRI_t$ is significantly different form zero (in model 20), results in a t-value of 1.71, that is significant at a level of 9.04 % (two tail).

The estimation results and the above mentioned test statistics suggest that the consumption equation of coffee is a negative irreversible relationship. Bucholz (1964) also concluded that his estimated consumption equation for Germany was negative irreversible.

So from our analysis we like to propose equation 20 as an acceptable model for the coffee consumption in the Netherlands.

A final check on the specification of equation 20 is done by analysing the residuals. The acf and the spectrum of these residuals are computed and illustrated in figure 10 and 11. The acf refers to random series.

The spectrum fluctuates around a fixed level, which is also in agreement with the properties of random series.

In figure 12 we show a decomposition of the least squares computed values of $CONS_t$. This picture shows clearly an unsatisfactory feature of the model: the peaks in December. We have not been able to explain the variability in the peaks of the demand for coffee in the month December.

This is caused by the large year to year variation of the peaks and by the absence of the peaks at the end of the sample period.

However we have been able to formulate a single model which explains rather well the influence of samll and heavy price movements on the consumption of coffee. Apparently, the exceptional circumstances in the coffeemarket during the years 1976/1977 did not lead to a structural change in a model for the coffee consumption in the Netherlands.

At last we compute some elasticities at the sample means, see table 3.

variable	elasticity
$CPRI_t$	-1.03
CDP_t	.39
TCI_t	.70
P^S_t	.46

Table 3: Some elasticities of $CONS_t$
with respect to prices
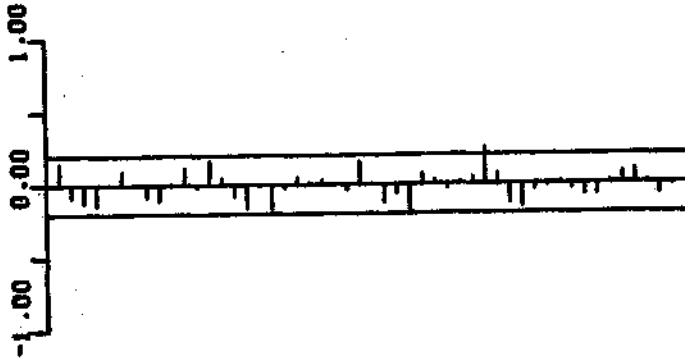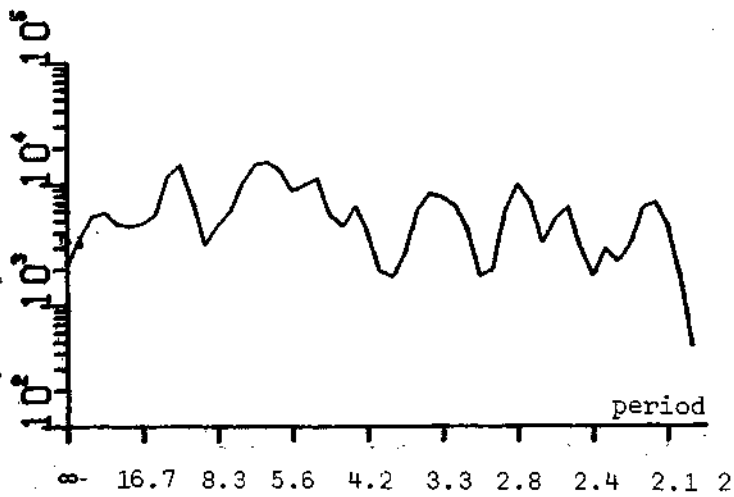
Fig. 10: The acf of the residuals
of equation 20
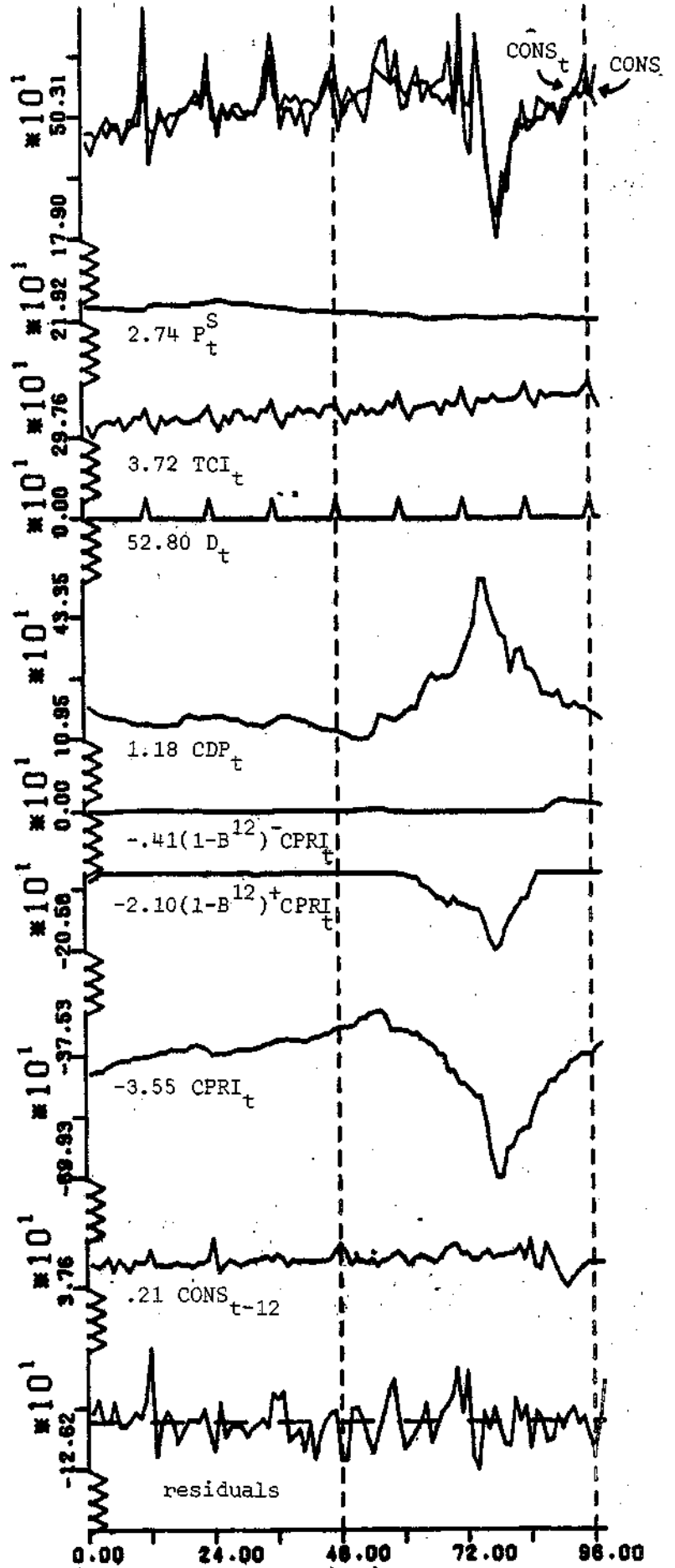
Fig. 11 : The spectrum of the residuals
of equation 20

period

∞- 16.7 8.3 5.6 4.2 3.3 2.8 2.4 2.1 2

$CONS_t$

CONS

50.31

$*10^1$

17.90

$2.74 \ P_t^S$

$*10^1 \ *10^1 \ 21.92$

29.76

$3.72 \ TCI_t$

$*10^1 \ *10^1$

0.00

$52.80 \ D_t$

$*10^1$

43.95

10.95

$1.18 \ CDP_t$

$*10^1 \ 10.95 \ *10^1$

0.00

$-.41(1-B^{12})^- CPRI_t$

$*10^1$

-20.50

$-2.10(1-B^{12})^+ CPRI_t$

$*10^1$

-27.53

$-3.55 \ CPRI_t$

$*10^1 \ -69.93$

3.76

$.21 \ CONS_{t-12}$

$*10^1$

-12.62

residuals

$0.00 \quad 24.00 \quad 48.00 \quad 72.00 \quad 96.00$

Fig. 12: The decomposition of $CONS_t$
using o.l.s. estimates of
equation 20

5. Summary and conclusions

In this paper, a model for the consumption of roasted coffee in the Netherlands has been specified and estimated, using monthly data for the period January 1970 to February 1979.

A statistical analysis of the data showed the importance of the corresponding months in the different years for the consumer demand of coffee.

By estimating several specifications of the model it became clear that only soft drinks is a relevant substitute for coffee. The relationship appeared to be negative irreversible: price increases have a larger effect on consumer demand than price decreases.

The world market price, assumed to influence the future retail price, influences also the demand.

The specification of the model that has been found acceptable, is:

$$\tilde{\text{CONS}}_t = .21\ \text{CONS}_{t-12}\ -3.55\text{CPRI}_t\ -2.10\ (1\text{-}B^{12})^+\text{CPRI}_t\ -.41\ (1\text{-}B^{12})^-\text{CPRI}_t$$
$$\phantom{\tilde{\text{CONS}}_t = .21\ } (.09) \phantom{\text{CONS}_{t-12}\ } (.45) (.70) \phantom{-2.10\ (1\text{-}B^{12})^+\text{CPRI}_t\ -.4} (.57)$$

$$+ 1.18\text{CDP}_t + 2.74\text{P}_t^S + 3.72\text{TCI}_t + 52.80\text{D}_t$$
$$ (.18) \phantom{\text{CDP}_t + 2.} (.76) \phantom{\text{P}_t^S + 3.} (.92) \phantom{\text{TCI}_t + 5} (24.00)$$

The peaks at the turning of the year are still a problem. The heavy price movements in 1976/'77 did not result in a structural change in the coffee consumption.

Figure 12 shows that the whole sample period is explained rather well by the model. If data on instant coffee and inventories of roasted coffee were available, it seems plausible that the model could still be improved.

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