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A quantitative investigation into the Dutch tomato market: a seasonal analysis

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Summary

In this paper a quantitative analysis of the Dutch tomato market is presented on the basis of time-series data over the period 1950 to 1961. In order to establish the influence of the main

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factors on the demand and prices of Dutch tomatoes, attention will be paid to the significance of exports and the seasonal pattern of the market.
Consequently a substantial part of the paper will be devoted to the phenomenon of interdependency between different outlets for Dutch tomatoes, and to the seasonal analysis of the markets by checking the results derived on the basis of different estimation procedures.

1. Introduction

The purpose of this paper is twofold. Firstly a quantitative analysis is presented of the factors determining price and demand of Dutch tomatoes during the period 1950 to 1961. Secondly the use of alternative estimation procedures will be compared especially with reference to seasonal analysis.
Like many other Dutch agricultural products, exports are a very important outlet for Dutch tomatoes. A proper analysis should also include exports, but this is often hampered by lack of sufficient data on export markets. A more fundamental question is, To what extent is it permissible to assume a function for export demand? Exports vary from year to year in an erratic way because of changes in trade policy of importing countries, by entrance of new competitors or changes in sales methods. It is evident that this is especially true when exports are spread over a great many foreign markets and have a small share in these markets. If exports are large and have a substantial share of the foreign market, then it is logical to assume the existence of an export function. This is more or less true of Dutch tomatoes of which exports are concentrated mainly in Western Germany and the United Kingdom.
Fluctuations in production and prices are so large during the production period from May to August that tomatoes have a quite divergent appeal to consumers according to the season. Consequently, in the Netherlands and the export markets tomatoes are a luxury product in May, but become a rather common food in August. In this paper, therefore, great attention will be paid to seasonal analysis of the demand, and especially in this context alternative estimation procedures will be used and their estimates compared. The plan of the paper is as follows: In section 2, a brief description of the Dutch tomato market is given, which is again limited to those aspects only which have a direct bearing on this analysis. In section 3, a model is formulated and is discussed, especially with regard to estimation procedures. Thereafter, an outline of the data used is presented in section 4. The estimation results will be discussed and conclusions therefrom infered in section 5. Finally, some conclusions will be summarised in section 6.

2. The market situation

2.1. Production of tomatoes

The production of tomatoes is a very important sector of Dutch horticulture. About 35 % (Dfl. 175.000.000) of the total turnover of vegetables (Dfl. 492.731.000) in 1961 originated from the sales of tomatoes. The main production areas are "Westland" (South of The Hague), "de Kring" (between Delft and Rotterdam) and the production centre near Venlo.
Dutch tomatoes are grown predominantly in glasshouses. As is shown in TABLE 1, their production, and especially that in heated glasshouses, increased substantially during the twelve-year period 1950—1961. Not only did the production area increase

by 151 % (from 1110 ha to 2790 ha) in the period 1950/61, but the yield also increased by 19 % (from 67 tons to 80 tons p. ha) in the same period.
But, even more important than an increase in the volume of total production is its shift to earlier months of the year. This is indicated in TABLE 1 by the relative areas and growth rates of heated and cold-house tomatoes.

TABLE 1. Area of Dutch tomato production in glasshouses (ha)

	In the year		
	1950	1956	1962
Unheated glasshouses	754	1154	1421
Heated glasshouses	356	749	1407
Total	1110	1903	2828

Source: L.E.I. landbouwcijfers 1962/63.

Tomatoes are harvested in the Netherlands mainly during the period from May to October, *viz.* May—July in heated and July—October in unheated glasshouses. FIG. 1 shows that, in the period under consideration, the supply shifted to the earlier seasons of the year.

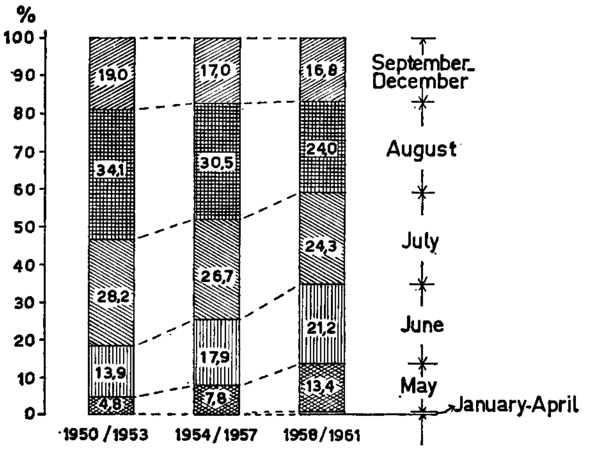


FIG. 1.
The % distribution of total tomato supplies over the year during the periods 1950/53, 1954/57 and 1958/61 (Source: Produktschap voor Groenten en Fruit)

2.2. Some aspects of the marketing system in the Netherlands

One of the main characteristics of the marketing system is that tomatoes are marketed through auctions like all other vegetables for fresh consumption. The wholesalers, who buy the produce supplied by the growers, will pass it to the foreign markets or to domestic retailers; some domestic retailers buy directly at the auctions.
A review of all the activities of auctions, organized at the Central Bureau of Horticultural Auctions, cannot possibly be given within the scope of this paper. But amongst the important functions of auctions is the operation of a minimum-price insurance scheme.
No tomatoes are auctioned below the prescribed minimum prices. In case of a market glut, tomatoes which cannot be sold at the minimum price are removed from the

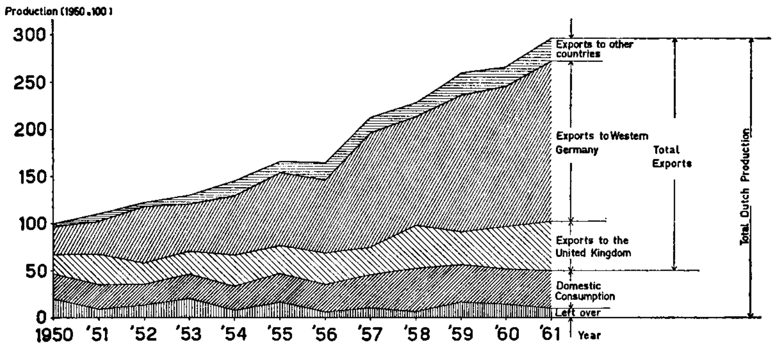
market and the producer receives that minimum price. For this purpose a compensation fund is financed by a levy imposed on all tomatoes sold through the auctions. The object of this system is to protect the home market as well as export markets from over-supply and disastrous price decline when the demand becomes completely inelastic. As it is heavily dependent on export markets, the system cannot be used for artificially realising high prices. In fact, minimum prices are much lower than the production cost of tomatoes.

2.3. Market outlets

2.3.1. *Export markets*

As is shown in FIG. 2, the largest part of the total Dutch tomato production, *i.e.* about 83 % in 1961, is currently exported and export sales have taken a progressively larger share of the total output during the passed twelve years.

FIG. 2. Total yearly supply of Dutch tomatoes and their destination (Source: Produktschap voor Groenten en Fruit)



Western Germany is by far the largest importer. This country bought 57 % of the total Dutch production in 1961. Second in importance is the United Kingdom to which 17 % of Dutch tomatoes were sold in 1961. Sweden, Switzerland, Belgium, France and some other countries import minor quantities.

2.3.1.1. *Western Germany.* Since 1957 the Netherlands have been the largest supplier of the West German tomato market (FIG. 3). Increasing population and per capita income are generally considered to be the two main factors stimulating West German consumption.

Some causes of the absolute as well as relative increase of Dutch export are:

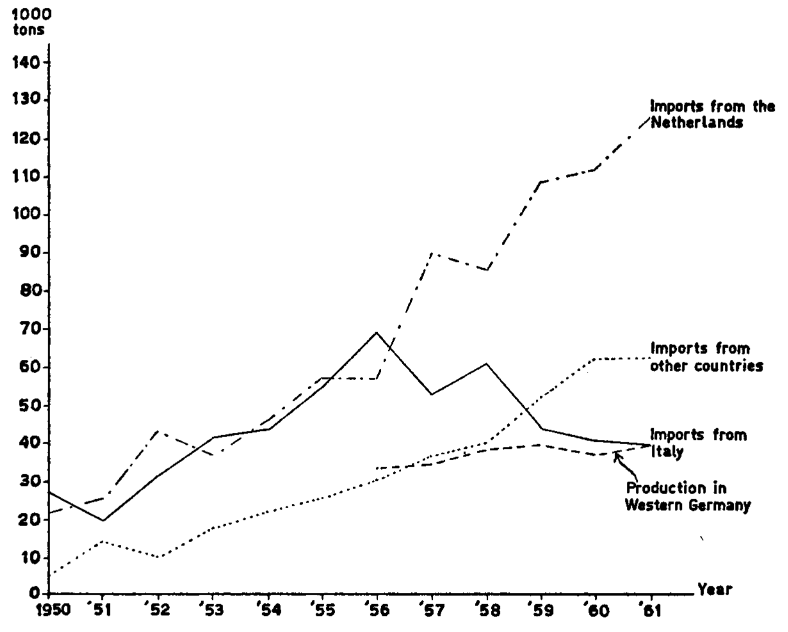
a. the distinctive quality of Dutch tomatoes [1];
b. the close proximity of Dutch production areas to West German consumption centres, especially the Ruhr-area;
c. the expansion of production towards earlier seasons of the year, in which period the increase in demand was relatively higher than in any other period.

In this context the declining importance of Italian exports to Western Germany is a striking feature (see FIG. 3), even though Italian production has increased during recent years from 2.550.300 tons in 1958 to 2.940.500 tons in 1962 [2]. Notwith-

[1] Quality is related to properties of solidity, shape, ripeness, freshness, *etc.*

[2] Bureau voor de Statistiek der Europese Gemeenschappen; *Landbouw Statistiek 1962.* No. 2, p. 58.

FIG. 3. Yearly imports and domestic production of tomatoes in Western Germany (Sources: Produktschap voor Groenten en Fruit and Central Bureau of Horticultural Auctions)



standing an average yearly export decrease of 5973 tons during the period 1957/61, which is a great change in Italian exports, it is a small shift in the outlets of the total Italian production.

Nevertheless the trend of Italian exports since 1957 (FIG. 3) suggests that the decrease in exports is not accidental but is a consequence of systematic influences. One of the influences might as well be a growing domestic demand both for fresh use and processing purposes. Had the yearly increase in domestic demand been of great importance, a yearly decrease of Italian exports during 1956/61 larger than 8,6 % would have been the result. Therefore, the weaker competitive position of Italy vis-à-vis the Dutch exports because of lower quality seems to us a more significant factor in this development. A detailed analysis of decreasing Italian exports to Western Germany is beyond the scope of this article.

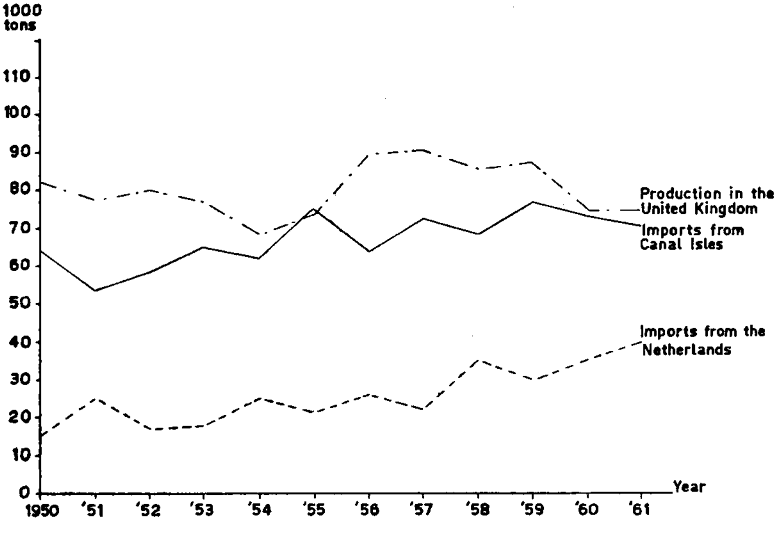
According to EEC sources, Western Germany had an *ad valorem* tariff of 3 % on the import price at the beginning of the 1963 season, rising to 12 % in later periods of the year. Tariffs or other trade-hampering measures varied quite often during 1950—1961, but did not seem to have depressed the volume of exports substantially.

2.3.1.2. *United Kingdom.* Dutch exports of tomatoes to the United Kingdom are smaller in volume than the exports to Western Germany. They are nevertheless of great importance; exports to the United Kingdom amounted to 38.674 tons in 1961 and are to a large extent concentrated in the months of May and June.

In fact exports to the United Kingdom were liberalised in 1953 [1]. Tariffs changed quite often during the period 1954—1961 and are still higher than in Western Germany. At present (1963) tariffs are £ 1.17.4 d per cwt in August and also in May, when the British prices exceed £ 7 per cwt. From mid-June to August, tariffs are £ 2.16.8 d per cwt. If prices are below a given level in May and during the period from November to May, tariffs are 10 % ad valorem.

Dutch produce must not only compete with mainland supplies over these substantial barriers, but also with supplies from the Channel Islands, Guernsey and Jersey, which enter the United Kingdom duty-free. The total as well as per capita yearly consumption of tomatoes in the United Kingdom did not show a clear trend and had a rather erratic character during the period 1950—61 (see FIG. 4). Dutch exports to

FIG. 4. Yearly imports from the Channel Islands and the Netherlands, and domestic production of tomatoes in the United Kingdom (Source: Produktschap voor Groenten en Fruit)



the United Kingdom, however, increased in May and June. The growing demand in the early season, when tomatoes are high-priced, may be attributed to increasing real income in the United Kingdom. It also appears that the Dutch tomato industry took more advantage from the increase of British demand in the early season than the other suppliers, like tomato growers of the Channel Islands.

2.3.2. *Domestic consumption in the Netherlands*

Although the domestic consumption of tomatoes also substantially increased during the period under reference, it has not equalled the export increase. At the beginning of the season consumption is low and rises to a peak in August.

It is apparent from FIG. 5 that consumption has increased in every month. Domestic consumption is still very low in May and June, probably as a consequence of

[1] This liberalisation in the sense of quota went together with an increase in tariffs.

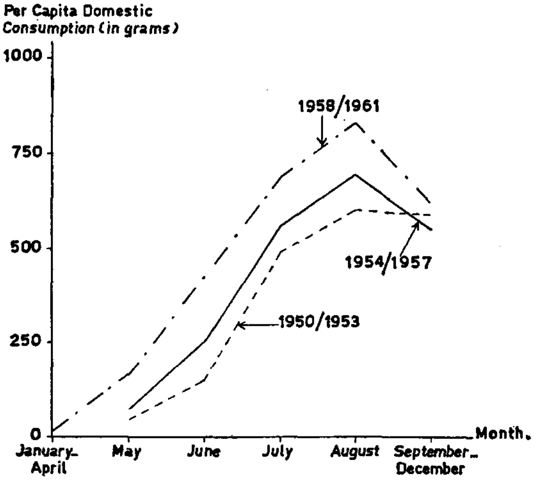


FIG. 5.
Per capita domestic consumption of tomatoes in the Netherlands from May to August (Figures supplied by the Central Bureau of Horticultural Auctions)

high prices, but increasing income induces the Dutch consumers to enter into the market earlier. The fact that these changes in consumption are not uniform over the months makes a detailed seasonal analysis all the more desirable.

3. The model

In the foregoing section, an outline of the market situation of Dutch tomatoes was presented with a view to provide a background against which the primary object of this paper, *i.e.* the quantitative analysis of the economic relationships in the Dutch tomato market must be understood. The next step is to propose a model. We have visualised this model in FIG. 6.

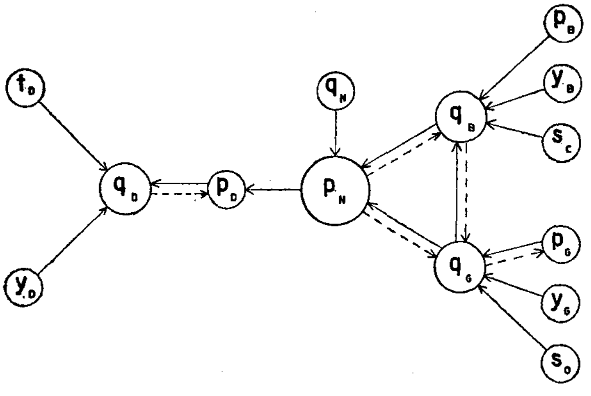


FIG. 6.
Assumed major relationships determining price and demand of Dutch tomatoes (For symbols used, see section 3.3; broken lines indicate minor influences)

3.1. Relevant factors

3.1.1. *Factors influencing prices*

It is evident that, other things being equal, a larger supply of tomatoes will lead to lower market prices. Since such a large part of total tomato output is exported, the level of exports will greatly influence the price at Dutch auctions, so that a detailed analysis of the demand for exports is necessary.

In fact a small part of Dutch production is sold on the home market and this part consists to a great extent of tomatoes which cannot be exported because of quality considerations [1]. Therefore changes in domestic consumption are not considered to have great influence on the price level of tomatoes at Dutch auctions.
One might get the impression, from the foregoing argument, that the domestic market is a separate entity exclusively for non-exportable tomatoes. However, according to export opportunities and total supply, a varying quantity of exportable tomatoes is diverted to the home market. It is, therefore, assumed that prices in the domestic market are largely determined by the export situation.

3.1.2. *Factors influencing demand*

Only a small number of factors are assumed to explain the size of exports and domestic consumption (see FIG. 6). Besides income and prices, it is supposed that exports depend on the supply of competing exporters. In order to explain domestic demand, average daily temperature is also introduced. Mean daily temperature in Western Germany and the United Kingdom is less meaningful as a factor influencing foreign demand because of the deviations from this average in various parts of these countries where Dutch tomatoes are sold. It seems justified to expect that, other factors being equal, a possible influence of higher temperature on foreign consumption will lead to higher prices and thus promote Dutch exports.
Except for the supply of tomatoes from other countries, the supply of substitute products is not included in the model. Undoubtedly there will be some competition between tomatoes and other kinds of vegetables or fruits, but it is not thought that competition with any specific kind is so strong that it should be introduced in the model explicitly. A general price-index of fruits and vegetables was at first introduced to represent the joint effect of a group of weakly-competing products. But, since trials along these lines were found negative, this proposition was eventually abandoned. For this reason only the tomato supplies of competing countries are included in the model.

3.2. Interdependency

With respect to the estimation procedure it is of great importance that some of the variables in our model should be interdependent. One might therefore argue that, other things being equal, low prices in the Dutch market will promote Dutch exports; conversely large exports will stimulate prices.
It is assumed that, during the period under study, a probable stimulus of prices (at Dutch auctions) on exports was of minor importance. This is well substantiated by the fact that while changes in Dutch exports of tomatoes showed a continuously upward trend, the price level had no clearly established trend.
Another group of interdependent variables might have been exports to and prices in importing countries. This possibility will be taken into consideration for the West German market. On the other hand, there exists less need to assume such interdependency in the case of the United Kingdom since the Dutch share of the market is about 20,4 % during the period from May to August 1961. Nevertheless, the assumption of interdependency will be tried for the British market too.
Finally the exports to Western Germany and the United Kingdom may be competitive. However, some preliminary computations based on this hypothesis did not show any significant evidence, hence this assumption was dropped.

[1] Dutch tomatoes have to meet certain quality standards in order to be exported.

3.3. Mathematical formulation

On the basis of FIG. 6 and foregoing discussion we may mathematically formulate the model as follows:

(1) $q_B = f(y_B, s_C, p_B)$

(2) $q_G = f(y_G, s_O, p_G)$

(3) $q_G = f(q_N, p_G/p_N)$

(4) $p_F = \dfrac{q_B p_B + q_G p_G + q_O p_O}{q_B + q_G + q_O}$

(5) $p_N = f(p_F, q_E/q_N)$

(6) $q_E = q_B + q_G + q_O$

(7) $p_D = f(p_N)$

(8) $q_D = f(y_N, p_D, t_D)$

(9) $q_N - q_B - q_G - q_O - q_D = q_W$

q_N = Total Dutch production
q_E = Total Dutch exports
q_G = Dutch exports to Western Germany
q_B = Dutch exports to the United Kingdom
q_O = Dutch exports to other countries
q_D = Domestic consumption
q_W = Production not sold because of the minimum price regulations
s_C = Supply of Channel Islands tomatoes to the British market
s_O = Supply of other exporters to the West German market
y_G = West German real income
y_B = British real income
y_N = Dutch real income
p_G = Price level of Dutch tomatoes in the West German market
p_B = Price level of Dutch tomatoes in the British market
p_N = Price level of tomatoes at Dutch auctions
p_O = Price level of Dutch tomatoes in other export markets
p_F = Average export price of Dutch tomatoes
p_D = Price of Dutch tomatoes entering domestic consumption
t_D = Mean daily temperature in the Netherlands

This system of nine equations contains nine endogenous variables namely q_E, q_B, q_G, q_D, q_W, p_G, p_N, p_F, p_D, so the system is complete.
However, we are able to simplify the model a little. The function expressing the value of q_W is known a priori: $q_N = q_W$, if $p < p_O$ (p_O being the minimum price). Also, since q_W is small (see FIG. 2), no attention will be paid to equation (9). By substitution of (6) in (5), and (4) in (5) one can get rid of (6) and (4).
It is further assumed that the relative, and not the absolute values of the variables are relevant to the model. This can be expressed by an exponential form of the functions, *e.g.* $y = x_1^{\alpha} x_2^{\beta}$.
As is well known, this function is linear in its logarithmic transformation. Such transformation has some consequences for the estimation procedure which will be taken up in section 3.4. The interdependency between q_B and p_B will be tested by introducing an additional supply equation $q_B = f(q_N, p_B/p_N)$. The terms p_B/p_N and p_G/p_N in the export equations may express the relative margin accruing to Dutch exporters. But this margin does not seem to influence exports greatly. Therefore, an alternative specification was estimated by substituting p_B/p_N and p_G/p_N for p_B. and p_G.

3.4. Some aspects of estimation

It is assumed that the endogenous variables are influenced by a stochastic random term which is distributed normally. If the interdependence between p_G and q_G is disregarded, in WOLD's (1960) terminology (p. 443) the system will be of the "conditional causal chain" type and estimation of the functions by the method of least squares is statistically sound.

If, however, interdependence between p_G and q_G is assumed, the least squares estimation of the functions will no longer give unbiased estimates and we may then use one of the simultaneous equation estimation procedures. Since all equations in the present model are overidentified, a feasible estimation procedure will be of the two-stage least squares method as developed by THEIL (1958) on p. 223.

Using logarithmic transformations, the substitution of (4) and (6) does not work since the decomposition of the log of (4) and (6) will not provide a linear combination of the logs of other endogenous variables. However, by the elimination of identities (4) and (6), one is left with an overcomplete system and two endogenous variables have to be removed. The endogenous part of p_F and q_E is brought about by the endogenous variables p_G, q_G and q_B included in the model. Consequently, the expected values of the endogenous part of p_F and q_E are generated by the exogenous variables in equations (1), (2), (3), (5) and (7) of the model. Using the two-stage least squares procedure to estimate the structural functions of the model, q_E and p_F in (5) will be substituted for $\hat{q}_E$ and $\hat{p}_F$, being the least squares estimates of q_E and p_F by linear regression on the exogenous variables. This procedure implies that the influence of q_O and p_O on p_F and q_E is neglected which is acceptable in view of the small size of q_O. Secondly, this approach assumes that the expected values of q_E and p_F are *linear* combinations of the exogenous variables which cannot be proved. However, since the fit of the estimates $\hat{q}_E$ and $\hat{p}_F$ was very good, we felt justified in following this procedure.

Finally, the estimation results by simple least squares estimation will be compared with those of the two-stage least squares method in order to see to what extent our *a priori* hypothesis influenced the results.

3.5. The problem of multicollinearity

A glance at FIG. 2, 3 and 4 makes it clear that many variables in our model have a trend during the period 1950—1961. Consequently, some of the predetermined variables in our system are correlated. The meaning and interpretation of the estimated regression coefficients depend heavily on the presence of correlation between the predetermined variables. A *ceteris paribus* interpretation of estimates of the elasticity coefficients could be given only if the explanatory variables were not correlated. Because we are not only interested in the estimation of the endogenous variables but even more in the partial influence of some specific variables, there will have to be some procedure to handle this problem.

In this study, this problem will be taken care of, if necessary, by orthogonalizing the correlated exogenous variables in the structural equations. It is reasonable that such procedure makes sense only in sofar as an economic interpretation of the orthogonalised variables can be given. For instance, consider the case that x_1 (production) and x_2 (exports), both influencing the price level, are correlated because of a trend. So x'_2 (that part of x_2 which is orthogonal to x_1) may be interpreted as exports in sofar they are not generated by a change in production. Orthogonalising in the reverse provides x'_1, which is production in sofar as it is not correlated with exports. Sometimes x'_1 has no economic meaning, as in the case of agricultural products, of which the supply is given in a particular year.

3.6. Additional remarks

In the export equations we have used total income and total export instead of per capita figures, for the total figures are necessary in equations (5) and (6) of our model.
By using total real income, the regression coefficients of the factor income in equations (1) and (2) of the model express a combined effect of per capita income and population growth on exports.
Therefore, we estimate in functions (1) and (2):

$$\varepsilon_y = \frac{d \ln x.\, p}{d \ln y.\, p} = \frac{d \ln x + d \ln p}{d \ln y + d \ln p}$$

where x = per capita exports and y = per capita income and p = population size. So, for a given value of $p = p_O$, ε_y is the income elasticity in its classical form. However, p is changing too and we do not estimate the income elasticity, *ceteris paribus.*
It can easily be seen that when $d \ln p > o$

$$\varepsilon_y = \frac{d \ln x + d \ln p}{d \ln y + d \ln p} > \frac{d \ln x}{d \ln y} \text{ if } d \ln x < d \ln y$$

$$\varepsilon_y = \frac{d \ln x + d \ln p}{d \ln y + d \ln p} < \frac{d \ln x}{d \ln y} \text{ if } d \ln x > d \ln y.$$

It appears that the estimates of ε_y are higher or lower than $\frac{d \ln x}{d \ln y}$ according to the value of $d \ln x/d \ln y$. Therefore, per capita figures for exports and disposable income will also be used when the export functions are estimated by the method of least squares.

4. Data

4.1. Data used in the analysis of tomato market for the period May to mid-August

q_N = Dutch production of tomatoes in metric tons (Source: C.B.A. [1])
q_E = Total Dutch exports of tomatoes in metric tons (Source: C.B.A.)
q_G = Dutch exports to Western Germany in metric tons (Source: C.B.A.)
q_B = Dutch exports to the United Kingdom in metric tons (Source: C.B.A.)
q_O = Dutch exports to other countries in metric tons (Source: C.B.A.)
q_D = Domestic per capita consumption of tomatoes in grams (Figures supplied by the C.B.A.)
s_C = Supply of Channel Islands and domestic produce in the British market in metric tons (Source: C.B.A.)
s_O = Supply of other exporters in the West German market in metric tons (Source: C.B.A.)
y_G = West German real "Massen Einkommen" [2] in milliard Marks. Deflator: Price-index of cost of living (Source: "Agrarwirtschaft", Wirtschaftszahlen)

1 C.B.A. denotes Central Bureau of the Horticultural Auctions.
2 The term "Massen Einkommen" is defined as net wages plus subsidies.

y_B = British total real "personal" income in milliard Pounds. Deflator: Price-index of cost of living (Source: National Income and Expenditure)

y_N = Dutch real per capita disposable income in guilders. Deflator: Price-index of cost of living. (Source: C.B.S. Nationale Rekeningen and Maandschrift)

p_G = Deflated average export price of Dutch tomatoes, f.o.b. German border in ct/kg. (Source: Produktschap voor Groenten en Fruit) Deflator: Price-index of cost of living.

p_B = Deflated average export price of Dutch tomatoes f.o.b. British border in ct/kg. (Source: Produktschap voor Groenten en Fruit) Deflator: Price-index of cost of living.

p_F = Deflated average export price of Dutch tomatoes in ct/kg. (Source: Produktschap voor Groenten en Fruit) Deflator: Price-index of cost of living.

p_N = Deflated average price of tomatoes at Dutch auctions in ct/kg (Source: C.B.A.) Deflator: Price-index of cost of living.

p_D = Deflated average domestic price of tomatoes at Dutch auctions in ct/kg. (From sources of Produktschap voor Groenten en Fruit) Deflator: Price-index of cost of living.

t_D = Mean daily temperature in the Netherlands in Centigrades (Source: Landbouwcijfers)

4.2. Data used in the analysis of tomato market on the basis of monthly data

The monthly data are expressed in the same units as indicated in section 4.1. Data on production, prices and exports are derived from sources of the Produktschap voor Groenten en Fruit.

Data on prices and quantities refer to wholesale level. Prices are weighted averages as derived after dividing total sales by total quantities.
All data are in time series of the period 1950—1961, and are used as logarithmic transformations of the original observations unless otherwise stated. No monthly price quotations of Dutch tomatoes were available in West German and British markets. Average export prices of Dutch tomatoes f.o.b. were used as a substitute representing the price level of Dutch exports to foreign markets.

5. Results

5.1. Results based on the analysis of data covering the period May to mid-August

5.1.1. *Estimation results*

Estimation on the basis of data over the years 1950—1961, gave the following results by using the least squares method:

(10) $q_B = 1{,}93969\ y_B - 1{,}92376\ s_C + 0{,}67843\ p_B + 10{,}29277 \qquad R^2 = 0{,}88$
$\quad (\pm\ 0{,}36380) \quad (\pm\ 0{,}81763) \quad (\pm\ 0{,}55777)$

(11) $q_G = 1{,}58950\ y_G + 0{,}21595\ s_O + 0{,}19165\ p_G + 1{,}14196 \qquad R^2 = 0{,}94$
$\quad (\pm\ 0{,}31923) \quad (\pm\ 0{,}30354) \quad (\pm\ 0{,}53912)$

(12) $p_N = 0{,}99862\ p_F + 0{,}60515\ q_E/q_N - 1{,}21093 \qquad R^2 = 0{,}84$
$\quad (\pm\ 0{,}16301) \quad (\pm\ 0{,}35279)$

(13) $p_D = 0{,}83752\ p_N + 0{,}42754 \qquad R^2 = 0{,}76$
$\quad (\pm\ 0{,}0704)$

(14)[1] $q_D = +\ 1{,}57276\ y_D - 0{,}51977\ p_D^* + 2{,}74309\ t_D^* \qquad R^2 = 0{,}91$
$\quad (\pm\ 0{,}19537) \quad (\pm\ 0{,}19232) \quad (\pm\ 0{,}71873)$

[1] In contradistinction to other equations, the variables are expressed as deviations from their mean in this equation. Variables shown with an asterisk are orthogonalized.

The fit (R^2) is high. However, one should keep in mind that the interpretation of these correlations as causal relationships depends on our a priori hypothesis. One might as well argue that the value of the coefficient of income, being by far the most significant explanatory variable, is indicating also the influence of a trend in some other non-mensurable factors such as summarised under the term "consumption habits". We feel, however, that most of these factors are in one way or another related to the growth of income, and therefore it is preferable to include these trend effects in the income variable instead of introducing a separate trend variable.

5.1.2. *Discussion of the estimates*

5.1.2.1. *Demand for exports.* The income elasticities of the British and the West German demand for Dutch tomatoes are 1,94 (± 0,36) and 1,59 (± 0,32) respectively.

Such high values can be well understood if one takes into consideration the fact that the increasing incomes in these two countries are spent on the consumption of high-quality food, for which the demand has not yet reached a saturation point. The shift in Dutch production to earlier parts of the year also corresponds to these developments. That these two aspects are very important for the export to the United Kingdom is in accordance with the evidence that the income elasticity of tomatoes has a figure (0,43 in 1960 as estimated on total yearly data) much lower than the one for Dutch tomatoes during the period from May to August (Min. Agric. Fish. and Food, 1960, p. 84). In addition, export-demand relationships were also estimated by using per capita figures both for exports and income. On that basis income elasticities for the British and West German demand of 2,12 (± 0,53) and 1,67 (± 0,34) were found. Following the argument in section 3.6, the income elasticities in equation (10) and (11) are a little lower, namely 1,94 (± 0,36) and 1,59 (± 0,32). The under-estimation by using total exports and income, however, is so small that it may safely be ignored. The influence of other predetermined variables in the export equations also needs some discussion. It appears that the supply of British domestic mainland producers and of the Channel Islands has an important impact on Dutch exports. An increase in prices in the British market seems to have a positive influence on Dutch exports, but this influence is too small to be established statistically different from zero.

In the West German market the supply from other countries had even a more negligible influence on the expansion of Dutch exports to that country. A impact of West German prices on Dutch exports could not be observed either. Of course, these conclusions do not exclude the possibility that, from day to day or week to week, changes of prices in the export markets may have influenced Dutch exports.

5.1.2.2. *Price formation.* It may be concluded from equation (12) that the price level at the Dutch auctions is mainly determined by the price level in export markets. The ratio of exports to total supply seems to have only a negligible positive influence on prices at Dutch auctions. Its influence could not be verified to be statistically different from zero which, however, seems hard to believe. This conclusion might be interpreted in the way that trends in the autonomous expansion of foreign demand and the increasing production in the Netherlands equilibrated so well that no trend in Dutch prices was brought about. And, in fact, average prices at Dutch auctions during this season had no trend from 1956 to 1961, notwithstanding the clearly increasing trends in production and exports simultaneously.

5.1.2.3. *Domestic demand.* The income elasticity of Dutch consumers, *i.e.* 1,57 (± 0,19), is a bit lower than that of foreign demand. Dutch domestic demand also increased (FIG. 5), but at a lower rate than exports. The rather low price elasticity, *i.e.* — 0,52, suggests that consumers do not greatly respond to changes in prices. If, however, the pattern of consumption and prices between each month from May to August is compared, it appears that the foregoing conclusion is not valid. An increase in temperature has a positive influence on consumption.

5.1.2.4. *Estimation results under the assumption of interdependence of* p_G *and* q_G *by the two-stage least squares procedure.* Using the two-stage least squares procedure under the assumption of interdependence between p_G and q_G, the estimated relationships were:

$$(15)\quad q_B = \underset{(\pm\ 0{,}36380)}{1{,}93969\ y_B} - \underset{(\pm\ 0{,}81763)}{1{,}92376\ s_C} + \underset{(\pm\ 0{,}55777)}{0{,}67843\ p_B} + 10{,}29277 \qquad R^2 = 0{,}88$$

$$(16)\quad q_G = \underset{(\pm\ 0{,}40557)}{1{,}41931\ y_G} + \underset{(\pm\ 0{,}3716)}{0{,}08428\ s_O} + \underset{(\pm\ 1{,}1373)}{0{,}78347\ p_G} + 0{,}88400 \qquad R^2 = 0{,}94$$

$$(17)\quad q_G = \underset{(\pm\ 0{,}22313)}{1{,}08028\ q_N} + \underset{(\pm\ 0{,}74604)}{0{,}68501\ p_G/p_N} - 0{,}70010 \qquad R^2 = 0{,}97$$

$$(18)\quad p_N = \underset{(\pm\ 0{,}28509)}{0{,}9485\ p_F} + \underset{(\pm\ 0{,}34877)}{0{,}05076\ q_E/q_N} - 0{,}05276 \qquad R^2 = 0{,}56$$

In so far as the results obtained by this method are statistically reliable, they are similar to those obtained by least squares procedure. The income elasticity in Western Germany was of the same size. No significant influence of competitive supplies or of West German price level on Dutch exports could be determined. Also the equation explaining changes in tomato price at the Dutch auctions showed about the same results.

Undoubtedly, the increase in Dutch exports could not have been realised solely by passive adaptation to the increased demand brought about by the growth of income and population. The sales activities of middlemen and the entrepreneurial skill of producers must also be taken into account. Because of this autonomous stimulus to exports, a supply equation for the West German market is introduced. However, the estimation of this function did not give much information, as the non-mensurable export-stimulating factors mentioned above, could not be introduced. The estimates tell us that export changes can be fairly completely explained by changes in production, and that the price ratio p_G/p_N has a positive influence of minor importance.

The assumption of the interdependency between p_B and q_B required an additional supply function for Dutch tomatoes to the British market: $q_B = f(q_N, p_B/p_N)$.

One may observe that the estimated function:

$$q_B = \underset{(\pm\ 0{,}17094)}{0{,}61593\ q_N} - \underset{(\pm\ 0{,}52598)}{0{,}23519\ p_B/p_G} \qquad R^2 = 0{,}89$$

leads to the analogous conclusion as in the West German case, namely the price ratio p_B/p_G does not seem of great importance. Since the other estimates of the other functions under this assumption of interdependency between p_B and q_B are just slightly different from equation (10)—(18), they will not be discussed further more.

Taking into consideration the foregoing arguments, the results of the supply equation must be considered to be of a descriptive nature only. Substituting p_G/p_N by p_G and p_B/p_N by p_B, no statistically reliable influence of West German price, p_G, and British prices on Dutch exports could be established.

5.2. Results based on monthly data

In section 2.3 it became clear that seasonal aspects within this short period, *i.e.* May to August, were very important for a correct interpretation of the market situation. One would therefore get a better understanding if an analysis were given for a number of months separately. Since monthly data of many variables are available, the model will be analysed as far as possible on a monthly basis.

5.2.1. *Some approaches to seasonal analysis*

Before starting a detailed seasonal analysis, some hypotheses on the origin of a seasonal pattern of demand and prices will be given. The following points of view might be taken:

5.2.1.1. *The seasonal pattern in the dependent variable y* is brought about by the seasonal pattern of an independent variable x. Thus there is no need to make special arrangements for seasonal adjustments, for one may assume that the monthly data of y are generated by one function of x, f (x). This does not imply that the elasticity is the same in every season, since x/y and consequently $\varepsilon_{y.x} = \frac{dy \cdot x}{dx \cdot y}$ may change systematically without any change in $\frac{dy}{dx}$.

A special case might be when the seasonal pattern is generated by specific variables only in certain parts of the year. In cases where those variables are measurable, *e.g.* temperature, an introduction of the variable in the function is sufficient to explain seasonal changes. If they are not measurable, *e.g.* vacation periods, their influence may be represented by dummy variables (1,0-variables).

5.2.1.2. *The seasonal pattern of demand* is the consequence of differences in the parameters of the demand function. Here, different methods might be adopted:

a. For every season a demand function will be assumed and estimated separately.
b. One assumes that the actual consumption is made up of yearly and seasonal components, which leads to the use of covariance techniques as developed for that purpose by BROWN (1959) on p. 228 and GOLLNICK (1961) on p. 1.
c. One might assume that some parameters of consumer behaviour, like $\frac{\delta q}{\delta y}$ and $\frac{\delta q}{\delta p}$ where q = consumption, y = income and p = price, are functions of independent variables, having a seasonal pattern.

5.2.2. *Application of the proposed hypotheses to the tomato market*

One may hold the view that seasonal pattern of exports and prices depends to a great extent on the seasonal pattern of production in importing countries and in other exporting countries. The seasonal analysis of the model consisting of equations (1)—(7) was therefore started by estimating without any special arrangement for seasonal influences. It might as well be that additional variables are responsible for the seasonal pattern of exports which could not otherwise be specified. For that reason, additional dummy-variables were introduced. Both seasonal analyses gave results which completely differed from the results obtained in section 5.1 and were not either in accordance with our a priori hypotheses. We were therefore forced to abandon a rather ambitious trial to estimate the whole model of section 3 on the basis of monthly data, and instead limited our seasonal analysis to exports and domestic demand.

5.2.3. *Seasonal analysis of Dutch exports*

Export functions were analysed on the assumption that the parameters of these functions differ in every month. Estimation of these functions for every month gave the results separately as follows:

May:

(19) $q_B = 4{,}28663\, y_B + 0{,}48806\, s_C + 3{,}8580\, p_B/p_G - 11{,}65922 \quad R^2 = 0{,}93$
$(\pm 1{,}33712) \quad (\pm 0{,}30147) \quad (\pm 1{,}82856)$

(20) $q_G = 3{,}98974\, y_G - 0{,}12354\, s_O - 1{,}44665\, p_G + 4{,}89406 \quad R^2 = 0{,}99$
$(\pm 0{,}30139) \quad (\pm 0{,}09930) \quad (\pm 0{,}31593)$

June:

(21) $q_B = 2{,}83763\, y_B - 0{,}87063\, s_C - 0{,}54199\, p_B/p_G + 4{,}93236 \quad R^2 = 0{,}73$
$(\pm 0{,}65089) \quad (\pm 0{,}53734) \quad (\pm 1{,}06354)$

(22) $q_G = 2{,}19204\, y_G + 0{,}32158\, s_O + 0{,}51533\, p_G + 9{,}39039 \quad R^2 = 0{,}94$
$(\pm 0{,}41043) \quad (\pm 0{,}12435) \quad (\pm 0{,}60549)$

July:

(23) $q_B = 0{,}86961\, y_B - 0{,}59276\, s_C + 0{,}16394\, p_B/p_G + 4{,}77168 \quad R^2 = 0{,}33$
$(\pm 0{,}77419) \quad (\pm 0{,}43841) \quad (\pm 0{,}57522)$

(24) $q_G = 1{,}86759\, y_G - 0{,}45670\, s_O + 0{,}10290\, p_G + 5{,}03623 \quad R^2 = 0{,}98$
$(\pm 0{,}10418) \quad (\pm 0{,}06968) \quad (\pm 0{,}14647)$

August:

(25) $q_B = -1{,}20600\, y_B - 0{,}81653\, s_C - 1{,}83315\, p_B/p_G + 12{,}29389 \quad R^2 = 0{,}49$
$(\pm 1{,}15577) \quad (\pm 0{,}65148) \quad (\pm 0{,}94599)$

(26) $q_G = 1{,}61800\, y_G + 0{,}02262\, s_O + 0{,}52414\, p_G + 7{,}39169 \quad R^2 = 0{,}93$
$(\pm 0{,}19624) \quad (\pm 0{,}08379) \quad (\pm 0{,}26898)$

Before discussing these results, some comments should be made on the income data. Since no monthly data were available, quarterly figures were used in the West German case and yearly data for the United Kingdom. The absence of monthly data does not, however, prevent the seasonal analysis. In our opinion monthly changes in disposable income are of minor importance for consumers' decisions on tomatoes. The disposable income over a longer period as it is expressed in yearly or quarterly figures, seems more appropriate for quantifying relationships between consumption of tomatoes and income.

The low fit of British exports equations for July and August implies that other factors than those included in the function, were mainly responsible for changes in Dutch exports to the United Kingdom. It may be that relative higher tariffs in July and August as compared to May and June have hampered Dutch exports. A yet more important reason for the low fit may have been the exclusion of monthly British home-grown supply; data on this factor were available only after 1955. The exclusion of this factor in May and June did not seem to have great impact on our estimation results since the British mainland supplies were not yet large in these two months.

5.2.3.1. *Income.* Striking differences can be observed between the estimated functions for the separate months. Income elasticities in the United Kingdom were 4,29 in May and 2,84 in June, but not statistically different from zero in later months. That there is a lower British demand for Dutch tomatoes in July and August, as noted earlier, may be explained by a larger share of home-produced tomatoes coupled with relatively higher tariffs on Dutch imports. On the other hand, it is interesting to note that income elasticities in Western Germany are very high in May and June and remain at a relatively high level in July and August. Trade barriers in Western Germany are not as prohibitive as in the United Kingdom and also the German domestic production is of no real importance until the second part of August [1] (TABLE 2).

TABLE 2. Estimated income elasticities for Dutch tomatoes

	May—August	May	June	July	August
Export U. Kingdom .	1,94 (± 0,36)	4,29 (± 1,34)	2,84 (± 0,65)	0,87 (± 0,77)	–1,20 (± 1,15)
Export W. Germany .	1,59 (± 0,32)	3,99 (± 0,30)	2,19 (± 0,41)	1,87 (± 0,10)	1,62 (± 0,20)
Domestic demand . .	1,57 (± 0,19)	2,22 (± 0,82)	2,00 (± 0,25)	0,77 (± 0,18)	0,39 (± 0,51)

5.2.3.2. *Competitive supply.* Seasonal analyses gave also a more differentiated picture with regard to competitive supplies. Thus, in the British market competitive influence of imports from Channel Islands could be observed in June, July and August, but not in May. These influences, however, were not statistically different from zero, and therefore could account for changes in Dutch exports only to a limited extent. The probable competitive influence of British home-produced supplies in July and August could not be verified because of the inadequacy of data. In the West German market no competitive influence from other imports could be established, except for the month of July. This result is in accordance with expectations, since exports to Western Germany from other countries (mainly Italy and Bulgaria) are higher in July than in any other month of the year.

5.2.3.3. *Prices.* Changes of prices in export markets had not a great influence on Dutch exports, except in the British market during May. Had the influence of p_B / p_G been substantial, the reverse effects should have been present in Dutch exports to Western Germany because of a switch from Western Germany to the United Kingdom. However, this could not be observed.

5.2.3.4. *Concluding remarks.* The seasonal analyses of exports confirm and amplify our conclusions of section 5.1 that increasing income has stimulated demand in export markets, especially in the early season. It looks as though Dutch tomatoes, because of their distinctive quality, are such a differentiated product in the West German market, that they suffer very little from competition with other suppliers in May and June. This special position of Dutch tomatoes in the West German market is, however, weaker in July and August. Exports to the United Kingdom increased not so much as a consequence of better quality per se, but the Dutch tomato industry seized the initiative to supply the increasing demand in the early income-elastic season more than its prospective competitors. Cost advantages to the Dutch producers may have been of importance for this development too.

1 Monthly income elasticities of foreign demand were also estimated on the basis of per capita figures. The differences between these estimates and those summarised in *Table* 2 were in keeping with our arguments posited in section 3.6. However, they were so small that the already substantial collection of data on income elasticities need not be expanded any more.

5.2.4. *Seasonal analysis of domestic demand*

An analysis of domestic demand on the basis of monthly data was also carried out by different methods. The simplest assumption namely, that seasonal consumption pattern finds its origin in seasonal pattern of prices and temperature, leads to the estimation of $q_D = f(y_D, p_D, t_D)$ on the basis of monthly data. Since the purpose is to check differences in elasticity coefficients for separate months, it was necessary to estimate the function on the basis of original data with the result:

$$(27) \quad q_D = \underset{(\pm\ 0{,}12347)}{0{,}02300\ y_D} - \underset{(\pm\ 0{,}08402)}{0{,}56758\ p_D} + \underset{(\pm\ 0{,}13410)}{0{,}09163\ t_D} + 508{,}0 \qquad R^2 = 0{,}79$$

The elasticity coefficients of price, ε_p, derived from equation (27) are given in TABLE 3.

TABLE 3. Price elasticities of domestic demand for Dutch tomatoes derived from equation (27)

	May	June	July	August
ε_y	—0,7076	—0,1494	—0,0353	—0,0220

Compared with the values for the period May—August, as computed in section 5.1, these estimates are low. Another questionable point is that the coefficient of the factor income is not statistically different from zero, while in section 5.1 changes in income were found to be the most important determinants of domestic consumption. Actually monthly changes in consumption will find their origin more in changes of prices than in changes of income, since the latter factor will have a long-run influence. In this analysis this is still truer of domestic demand, as we are using annual data for the income variable, which do not show any variation during different months of the same year.

The use of dummy variables for measuring seasonal changes of demand, gave very unsatisfactory results, as was also the case when analyzing export demand.

Assuming seasonal parameters, demand functions were estimated for every month separately, and the following results were obtained [1]:

May:

$$(28) \quad q_D = \underset{(\pm\ 0{,}82499)}{2{,}22439\ y_D} - \underset{(\pm\ 0{,}59813)}{1{,}74946\ p_D} + \underset{(\pm\ 0{,}93137)}{1{,}19688\ t_D} - 0{,}56887 \qquad R^2 = 0{,}88$$

June:

$$(29) \quad q_D = \underset{(\pm\ 0{,}24934)}{2{,}00576\ y_D} - \underset{(\pm\ 0{,}13015)}{0{,}97813\ p_D} + \underset{(\pm\ 0{,}39823)}{1{,}11541\ t_D} - 1{,}42432 \qquad R^2 = 0{,}97$$

July:

$$(30) \quad q_D = \underset{(\pm\ 0{,}18382)}{0{,}76955\ y_D} - \underset{(\pm\ 0{,}17856)}{0{,}68174\ p_D} + \underset{(\pm\ 0{,}35603)}{1{,}06690\ t_D} + 0{,}84644 \qquad R^2 = 0{,}88$$

August:

$$(31) \quad q_D = \underset{(\pm\ 0{,}51219)}{0{,}38897\ y_D} - \underset{(\pm\ 0{,}21321)}{0{,}50630\ p_D} + \underset{(\pm\ 1{,}01078)}{1{,}07057\ t_D} + 1{,}40450 \qquad R^2 = 0{,}59$$

The estimates show that the demand of tomatoes is income-elastic in May and June.

[1] The reader should note that equations (28)—(31) are based again on logarithmic transformations of the variables.

Consumption of tomatoes in July and especially in August is less sensitive to changes in income. The price elasticity of demand for tomatoes was high only in May (—1,75). In other months it varied from —0,50 to —0,99.
Here again, as also was observed in section 5.1, the temperature had a positive influence on demand. This influence was statisticaly different from zero only for the months of June and July. In August the influence of temperature was found to be negligible.

One might object that the assumption of different demand functions for every month separately is rather arbitrary. Another assumption might be to consider some parameters of the demand function as a function of price. This is based on the fact that the parameters of the macro-demand function are changing during the period from May to August, since with a decrease in prices more consumers enter into the market. However, in using this approach information is lacking on two crucial points. Firstly, one does not know according to what pattern consumers enter into market. Secondly, the difference of the parameters in the micro-functions are unknown.

Domestic prices of tomatoes are very high in May and remain rather high in June and decrease very suddenly in July (see FIG. 7); the total consumption has the reverse pattern (see FIG. 5). The way consumers enter the market might therefore be described by a lognormal distribution function of the price. However, we cannot propose any hypothesis about differences in the micro-parameters. Hence a very rough simplification was tried by assuming that: for the function,

$$q_D = f(p_D, y_D, t_D), \quad \frac{\delta q_D}{\delta p_D} = \alpha + \beta p_D + \gamma y_D \text{ and } \frac{\delta q_D}{\delta y_D} = \zeta + \Theta p_D$$

This assumption implies a macro-demand function of the form:

$$(32) \quad q_D = \alpha_0 + \alpha_1 p_D + \alpha_2 p^2_D + \alpha_3 y_D + \alpha_4 p_D y_D + \alpha_5 t_D$$

It is interesting to notice that the price elasticity is dependent on the level of personal income.
Estimation of this function, on the basis of monthly non-logarithmic data for May, June, July and August during the years 1951—1960, gave the following result:

$$(33) \quad q_D = \underset{(\pm\ 0{,}32994)}{-1{,}60023\ p_D} + \underset{(\pm\ 0{,}14913)}{0{,}65567\ p^2_D} + \underset{(\pm\ 0{,}08669)}{0{,}12173\ y_D} - \underset{(\pm\ 0{,}09316)}{0{,}00328\ p_D y_D} + \underset{(\pm\ 0{,}17660)}{0{,}17191\ t_D} - 4333{,}0 \qquad R^2 = 0{,}90$$

The income and price elasticities derived from this equation, however, differ very much from the foregoing results.
Using logarithmic transformations of the variables under this hypothesis, leads to the equation:

$$(34) \quad q_D = \underset{(\pm\ 0{,}79464)}{3{,}77108\ p} - \underset{(\pm\ 0{,}22539)}{1{,}48506\ p^2} + \underset{(\pm\ 0{,}11309)}{0{,}17707\ y} + 0{,}14819 \qquad R^2 = 0{,}94$$

Price elasticities derived from this equation are:

ε_p = —1,46 at $p = \bar{p}$ and —2,45 in May, —1,82 in June, —0,94 in July and in August —0,56 respectively.

Since data for all months were used collectively, these price elasticities express primarily the reaction of demand to price changes throughout the year; therefore they

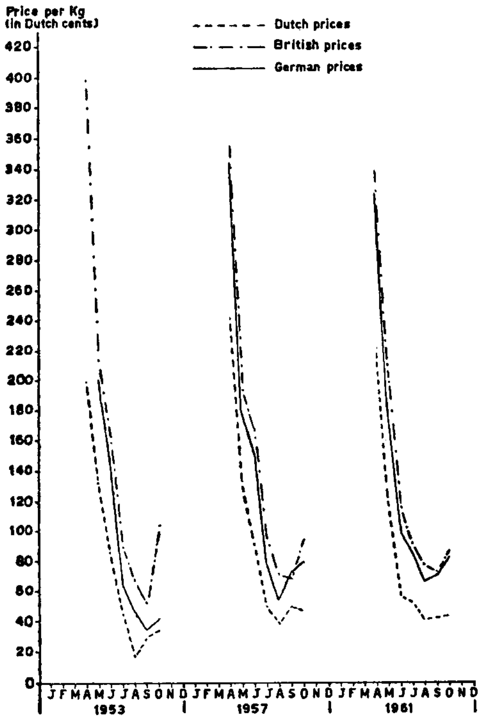


FIG. 7.
Dutch tomato prices, *i.e.* prices obtained at auctions of tomatoes consumed in the Netherlands; British and German prices are f.o.b. prices of Dutch tomatoes exported to these countries (Source: Produktschap voor Groenten en Fruit)

are substantially larger than those determined from equations (28)—(31) which express reactions of demand on prices for different months separately.

Since the parameters of our monthly-demand functions differed greatly and monthly figures on income were not available, the covariance technique developed by GOLLNICK (1961, p. 1) is not applicable here. It is therefore felt that the estimation of separate demand functions for every month, equations (28) to (31), provides the best information.

Where one has data for only a few years, the method of estimating demand functions for every season separately will not work because of insufficient degrees of freedom. A covariance analysis will then be the only one possible. It must be stressed that the use of any one method depends on the origin of seasonality, the available data and the purpose of the analysis.

6. Conclusions

a. The observed trends in exports of Dutch tomatoes to Western Germany and the United Kingdom are mainly brought about by the increase of income in the two countries which stimulates demand for tomatoes of high quality. This can also be seen from the fact that exports to these countries increase most during May and June when tomatoes are high-priced.

b. It looks as though Dutch tomatoes, by reason of their distinctive quality *inter alia,* are such a differentiated product that they suffer little from competition of other suppliers in May and June. However, in July and August they meet more competition, especially in the United Kingdom.

c. Given the conclusions in a. and b., it may be expected that the increase of Dutch tomato production will be largest in May and June. In the later months increase of production will find better outlets in Western Germany than in the United Kingdom.
d. The fact that there is no evidence of a trend in the average price suggests a harmonious expansion in Dutch tomato production and exports during the period under study. It looks as though Dutch exporters made good use of the opportunities available.
e. The estimates by least squares and by two-stage least squares differed little in this study. This may be the consequence of the predominating influence of just a few exogenous variables like income, on the endogenous variables.
f. Alternative assumptions on the origin of seasonality, especially in the analysis of domestic demand, led to quite different estimates. The present analysis shows that no uniformly best method of seasonal analysis can be given.

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