Problems

A Quantitative Study of Food Consumption in the Low Countries during the Sixteenth Century *

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Introduction

The literature on consumption demand in the Ancien Régime is abundant. We now have a fairly good knowledge of the general reactions of consumers in the Ancien Régime to drastically changing grain prices, or of their reactions to increases in the standard of living. Yet the contribution of modern microeconomics to these studies has been limited. There seem to be two main reasons for this situation. The mathematical orientation and the formalisation of microeconomic theory probably do not hold much attraction for economic historians. Many of them feel that the theory of consumption is a piece of sophisticated, ivory-tower economics without relevance to the real world of the past. The method of making some assumptions when constructing a theoretical model seems dangerous and irresponsible to the historian, who wants to include all aspects of reality in his explanatory effort. But making the assumptions explicit at the onset, and accepting the fact that the historian can try only to explain a part of the historical reality, should eliminate those fears and inhibitions. In the second place, it might seem that the data needed to apply an econometric demand system are not available for the Ancien Régime. Detailed and representative quantitative data on consumption in the remote past, indeed, are not easy to find. After all, it is sometimes difficult to find a consistent data base even for the period after World War II. We were

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fortunate, however, to find an excellent data-set on consumption in the Low Countries during the sixteenth century. Before presenting this data-set and commenting on it in section II, we shall try in section I to highlight the main features of the so-called complete demand systems. In so doing we will also introduce the "Rotterdam model," the functional form of the demand system that we have estimated. The presentation of our empirical results in section III will give concrete form to the argument in section I and, we hope, convince some readers of the potential usefulness of this kind of quantitative exercise.

1. The Economics of complete demand systems

Everybody will agree that data do not speak by themselves: we need some theory to make them understandable. In fact, information is useful only when it can be integrated into a consistent framework. In our opinion, this is the best angle from which to consider the economic theory of consumption. It is a method (probably the most powerful one) to structure the data.

The starting point is self-evident: consumption decisions are determined by (subjective) preferences on the one hand and by (objective) possibilities on the other hand.[1] The main determinants of the latter are the available budget and the prices of the different commodities. We summarise this by saying that the consumer is constrained by his budget m, because by definition

$$p_1q_1 + p_2q_2 + \ldots + p_nq_n = m \tag{1}$$

where $q_1, \ldots q_n$ are the quantities of the n commodities, $p_1, \ldots p_n$ are the corresponding prices, and m is total expenditure. Using the summation sign, we can also write (1) as

$$\sum_i p_iq_i = m \tag{2}$$

Equations (1) and (2) express the simple idea that the sum of all expenditures on individual commodities has to equal total expenditure. It is obvious that the possibilities of the consumer change if either the total budget m or any of the prices $p_1, \ldots p_n$ change. If the consumer tries to do the best he can with the available means, changes in m or $p_1, \ldots p_n$ will therefore change his consumption pattern.

Let us now consider all other determinants of consumption and denote them by the variables $z_1, \ldots z_h$. These variables thus capture all influences on demand, either from changes in tastes or from changes in the environment (apart from the budget). We therefore can state, almost as a tautology, that consumption of the different commodities is determined by (or "a function

[1] Our summary overview of the economic theory of consumption contains nothing new. Interesting monographs are PHILIPS (1983), THEIL (1975, 1976), and DEATON and MUELLBAUER (1980). A more difficult review is BARTEN (1977).

of") the variables $z_1, \ldots z_h$, the prices $p_1, \ldots p_n$, and the total means available (m), or

$$q_i = f_i (m, p_1, \ldots p_n, z_1, \ldots z_h) \; i = 1, \ldots n \tag{3}$$

where the subscript i in f_i expresses the need for a different function for each commodity i.

Of course, further specification of (3) is necessary if we want to use it for empirical purposes. Yet, even this general form already reveals an important feature of the framework: for the determination of qi, i.e., the consumption of commodity i, the prices of all other commodities do matter in principle. This is obvious if we return to equation (2): any change in one price will change the consumption possibilities of the consumer and therefore his consumption of all the other commodities. To give an example from the Ancien Régime: an increase in the price of rye during a grain crisis will not only affect the consumption of rye itself. Obviously such an increase also has an effect on all other commodities. Although some of the price effects may be so small as to be negligible in empirical work, none can be neglected a priori. *The main purpose of the estimation of so-called complete demand systems is to structure all these price effects* and to make them theoretically interpretable. It is no small task if the number of commodities considered is large.

The concentration on the structure of price effects and the difficulty of identifying and measuring the "other variables" $z_1, \ldots z_h$ have led the microeconomic tradition to a relative neglect of "taste change" variables. We will sustain the tradition and assume that the variables $z_1, \ldots z_h$ are empirically unimportant for our analysis. The reasonableness of this assumption will be discussed in section II. It is perhaps good to note that most of the more qualitative historical research also focuses on the effects of income and price changes.

Let us now concentrate on the interpretation of the price effects. Basic microeconomic theory argues that the effect of any price change can be broken down to two effects: a pure (or compensated) price effect and an income effect (of the price change). In terms of elasticity, we therefore write

$$\epsilon_{ij} = \epsilon^*_{ij} - \beta_i w_j \tag{4a}$$

which gives as a special case for the own price effect

$$\epsilon_{ii} = \epsilon^*_{ii} - \beta_i w_i \tag{4b}$$

In (4), ϵ_{ij} and β_i refer to the (global) price and income elasticity respectively. The compensated-price elasticity (by definition) is given by ϵ^*_{ij} and w_j refers to the share of commodity j in the total budget, or (by definition)

$$w_j = (p_j q_j)/m \tag{5}$$

An example from the Ancien Régime can help to clarify the presumptions behind (4a) and (4b). An increase in the price of rye will lead immediately to

a loss of purchasing power for the individual consumer: the real worth of his total means declines and he therefore will adjust his consumption pattern. This effect obviously is analogous to a change in income and is captured by the term $\beta_i w_j$ in (4a). But it is not the only effect of the price change. To make this clear, assume that the consumer is "compensated" for the price increase: let us say that he gets an increase in nominal income, as the price of rye increases, and that the increase is sufficient to keep real income constant. This does not mean, however, that the consumer will buy exactly the same quantities of the different commodities as he did before. Indeed, because of the increase in the price of rye, his previous choice is no longer optimal: the consumer now will be better off if he buys less of the more expensive commodity (rye) and more of its substitutes (e.g., the other grains). Because the "income effect" of the price change is compensated for, it can be interpreted as a "pure" (in fact "utility") effect. Such pure effects are especially relevant to analysis of the preference structure of the consumer. We will return to the interpretation of the "compensated" effects in section III.

One difficulty with (3) is the dimensionality of the estimation problem. As we noted above, the basic idea of a complete demand system is that all prices enter into each equation. If we have n commodities, we must estimate n^2 price effects. In our case with ten commodities (described in section II), we would get one hundred compensated-price elasticities. This creates interpretational and (possibly) statistical problems. We know that the imposition of theoretical restrictions on the coefficients may help to overcome these problems. Economic theory suggests such restrictions, following either from the budget constraint (2) or from the hypothesis that consumers try to maximise their welfare and therefore adapt optimally to price and/or income changes. It is not our purpose to go deeply into the derivation of these theoretical restrictions[2]. We will comment on some of them in section III, where they are needed for the exact interpretation of our results.

At this stage it is sufficient to note that we estimated a specification, which allows us to impose easily all theoretical restrictions. This specification is the so-called *Rotterdam model* (for its derivation see appendix). It can be written as

$$w_{it} \ln q_{it} = b_i (\Delta \ln m_t - \sum_j w_{jt} \Delta \ln p_{jt}) + \sum_j s_{ij} \Delta \ln p_{jt} \qquad i = 1, \ldots, n \qquad (6)$$

$$\text{where } \Pi \ln q_{it} = \ln q_{i,t} - \ln q_{i,t-1} \qquad i = 1, \ldots, n \qquad (7a)$$

$$\Pi \ln p_{jt} = \ln p_{j,t} - \ln p_{j,t-1} \qquad j = 1, \ldots, n \qquad (7b)$$

$$\Pi w_{it} = (w_{it} + w_{it-1})/2 \qquad i = 1, \ldots, n \qquad (8)$$

The coefficients are to be interpreted as (see appendix)

[2] For more details, see any of the works cited in note 1 above.

$$b_i = w_i\beta_i \qquad i = 1, \ldots n \qquad (9)$$

$$s_{ij} = w_i \epsilon^*_{ij} \qquad i = 1, \ldots, n;\ j = 1, \ldots, n \qquad (10)$$

We will return in section III to the interpretation of these coefficients. Some features of the model, however, can be noted here. The Rotterdam model is an easy linear specification of n equations, one for each commodity. The explanatory variables are the same in each of the equations. Yet the estimation problem is not at all trivial because the use of the theoretical restrictions leads to the simultaneous estimation of the whole system. These restrictions are imposed immediately on the constant parameters in (6): the b_i 's, $i = 1, \ldots, n$, and the s_{ij} 's, $i = 1, \ldots, n$; $j = 1, \ldots, n$. The constancy of the estimated coefficients implies (see (9) and (10)) that both the income and price elasticities vary from year to year (since they involve the variable budget shares). For the interpretation of our results, we carefully have to take this fact into account. It is clear, however, that there is not one fundamental reason why the elasticities should be constant.

II. The data: the yearly budget of the infirmary of the Beguinage of Lier for foodstuffs (1526-1575)

A. General Remarks

The estimation of a system such as (6) requires an extensive list of data. We need a (sufficiently long) time series of the total expenditures of the consumption unit, the share of each commodity in the total budget, and the prices of all commodities. It might seem that such a complete data base cannot be constructed for the Ancien Régime but such is not the case; in fact, a complete budget was found in one source of the sixteenth century: the accounts of the Infirmary of the Béguinage at Lier.[3] For the same period it was possible also to construct complete series for all relevant prices.

The Infirmary was a kind of home for the sick and elderly members of the community of nuns at the Lier Béguinage. Lier was a small town in Brabant of circa 4.000 inhabitants in the sixteenth century, only 12 miles away

[3] The accounts of the Infirmary of the Béguinage are preserved in the archives of the Commission of Poor Relief, (now called Openbaar Centrum voor Maatschappelijk Welzijn) (O.C.M.W.) of the town of Lier, near Antwerp in Belgium: n. 681-4 (years 1526-1621). All the information given in this study with respect to the Infirmary has been gathered from this source. The information with respect to the population of the town of Lier, and with respect to the number of nuns in the Béguinage and in the Infirmary, was found in CUVELIER (1912-1913), vol II, pp. 462-63. A statistical overview of the food budget for the period 1526-1602 has been published in VAN DER WEE (1963), vol. I, pp. 533-7.

from then booming Antwerp. The Béguinage, founded in the thirteenth century and originally located outside the city walls, but later integrated into the town when the new city walls were built, was in 1526 a flourishing religious community of 69 béguines. The number of béguines at the Infirmary was 7 in the same year. Until the Revolt period at the end of the sixteenth century, the community remained a flourishing one. The number of nuns might have increased slightly during the second quarter of the century: the rise in the total population of Brabant during that period normally should have increased the number of béguines, but the spread of the Reformation probably kept the increase in check.

The same holds true for the number of béguines at the Infirmary. The accomodation of the sick and elderly béguines in a new home, especially built for that purpose, had just started in 1526. No extensions were built during the following decades, so that we can assume that the number of nuns living and consuming in the Infirmary was more or less constant during the second and third quarters of the century.[4]

The Infirmary accounts studied cover, in fact, the period 1526-1602. They run from Candlemas (2 February) to Candlemas for the period 1526-1543, and after 1543 from 1 May to 30 April. From 1526 to 1575 the accounts are mostly made on a yearly basis. After 1575 the accounts generally cover two or more years. We decided at once to exclude from our empirical test the data from the latter period. As the seasonal movements of prices and quantities of goods consumed follow a yearly cycle, the homogeneity of the cycle would be destroyed if we had included the data from the accounts after 1575. Moreover, consumption after 1575 was influenced heavily by the political unrest and by the military ravages of the war. As shown below, it is also difficult to construct adequate price series for the period after 1575.

There are also some minor lacunae in the data-set of the first fifty years (1526-1575): there are no observations available for the year 1560; for the years 1542 and 1543 only one account covering the two years was made. These two lacunae were filled in by methods of interpolation, on which we comment at the end of this section.

To complete our data base we need a price series for each commodity. The original data distinguish twelve commodities, of which the last is a "various" category (mostly containing peat). We do not have a price for "various", of course. Moreover, peat is not a foodstuff. It therefore makes sense to neglect this last category, so that we confine ourselves to the food budget.

[4] This information is important for theoretical reasons. Indeed, the economic theory of consumption essentially starts from an individual consumer (or consumption unit), so that real total expenditure can be considered as an indicator of "average real income." If the number of consumers in the Infirmary would have changed during the period under consideration, it would have been necessary to correct for this change. In our case, however, such corrections are not necessary.

The fact that this is not a "complete" budget does not create a problem, because it can be shown that under reasonable assumptions a group of goods can be taken together and analysed separately, i.e., neglecting the prices of the other goods. We then can apply the philosophy of "complete" demand systems to this group.[5]

Note also that the food budget of a skilled wage earner in Lier, such as a mason or a carpenter, covered on average about 70 percent of his total budget during the second and third quarter of the sixteenth century. In other words, the margin available for consumption of goods other than essential foodstuffs for a typical family of five persons (father, mother, and three children, with the father as the only income earner), calculated on the basis of market prices and nominal daily wages with adjustment for employment per year, was on the average about 30 percent.[6]

A more basic problem arises from the very heterogeneous category "milk, vegetables, eggs and fruit", for which there are no data before 1555. Most of these goods must have been produced on the farm owned by the Béguinage. The farmer not only had to pay his yearly rent, but on top of it he had to provide the Infirmary with milk, vegetables, eggs and fruit. This kind of autoconsumption is not easily captured in the framework of section I. We decided, therefore, to omit this category altogether, admitting that it is a serious gap in our data set. The kind of separability assumptions described above, when referring to housing, heating, clothing, and lighting, make much less sense here. The set of basic foodstuffs mentioned here must have been autoconsumed in many households of the villages and small towns of Brabant during the sixteenth century: even in the larger towns a number of middle-income people must have been able to get such foodstuffs or a part of them through auto consumption. On the other hand, the fact that the category appears in the budget of the Infirmary from 1555 onwards proves the diversification of food consumption in sixteenth century Brabant. Indeed, in 1555 the Infirmary started to buy on the market some vegetables and fruit that the farmer did not grow himself. The share of these purchases in the total food budget, spent at the market, is still very small (only 1.4 percent on average during the period 1555-1575), but the purchases are, in any case, a good indicator of some degree of diversification of food consumption.

We then still have ten commodities. The total food budget is defined as the sum of the expenditures for these different commodities. To find the relevant prices, we assume that the economic integration in Brabant during the sixteenth century was intense enough to prevent large price differences among the towns of western Brabant. This assumption allows us to use information about prices in Antwerp, Lier, and Malines.

Research on the matter of market integration in Brabant revealed that

[5] For more details, see the works cited in note 1 above.

[6] Van der Wee (1963a), vol. III, p. 93, graph 40.

already in the fifteenth century market prices in the towns of Antwerp, Malines, Lier, and Herentals, all located in the northwestern part of the duchy, were moving closely together. During the sixteenth century the market integration became still more pronounced. Only at the end of the century, during the Revolt period, as a result of the military campaigns, did markets disintegrate again, but only temporarily. The latter period was excluded from the test, so that market integration can be assumed.[7]

It is perhaps interesting to note that the rather primitive consumption structure of the Ancien Régime simplified the task of computing the price series: for a very diversified consumption pattern (such as can be found in the twentieth century), there always is a more serious problem of aggregation with respect to different commodities.

It is also easier to accept the assumption of stable tastes for the Ancien Régime, i.e., a period during which the range of commodities available to the consumers was not very diversified. It could be argued that at that time the main purpose of consumption for very large segments of the population was to have at their disposal the necessities of life, i.e., food, clothing, housing, lighting, and heating. It is certainly true that many of these people had them in sufficient quantities during the first half of the sixteenth century, but, nevertheless, these were the commodities they mainly consumed.

Flanders and Brabant might have been an exception, as the standard of living of the upper – and middle – income groups during the early sixteenth century was more favourable than everywhere else in Europe, except Northern Italy. We have already suggested that there is evidence that food consumption in Flanders and Brabant during that period became much more diversified among large segments of the population. It could be incorrect, therefore, to say that consumption of most people in that area during that particular period was on the subsistence level. But it could be taken for granted that the diversification of consumption as mentioned above was too limited to invalidate an assumption of fundamental stability of tastes and of consumption patterns.

We can also ask the question whether our data are representative for consumption in Brabant during the sixteenth century. Our source relates to a religious institution, the Béguinage, and the accounts studied refer to the budget of a group of sick and elderly nuns. A religious institution usually has a material and nonmaterial consumption pattern, which deviates from the normal one. The food budget of sick and elderly people also differs from the normal one. These systematic biases, however, did were not significant as far as our case-study is concerned. The order of the béguines constituted a very loose form of religious community: the béguines lived in small groups or alone in separate houses, each earned her own income, the few rich nuns by living on their own means, the majority by doing all kinds of work against

[7] *Ibid.*, vol. I, pp. 23-4, pp. 31-2.

payment. The béguines could also leave the Béguinage if they wanted so. Of course, they had to follow some rules, in particular with respect to the common prayers in the church of the Béguinage at regular intervals of the day. But as a whole the consumption habits of the béguines must have been closer to the normal consumption habits of the urban middle-income groups than to those of the stricter religious orders. The bias caused by the fact that the food budget refers to the sick and elderly nuns is a real one: the expenditures for spices, for example, will be greater than normal, as spices were used also as drugs. The bias, however, is consistent over time and is not very large, as medicine during that period was still practised on a very limited scale and in a primitive way, and as the food of elderly people did not differ very much from the food consumed in general.

B. Categories of foodstuffs used in the test

The following brief description of the ten commodities and prices series used is based on information available from the Infirmary accounts and from other sources discussed in Van der Wee (1963). vol. I.

1. *White bread.* White bread was a luxury in sixteenth-century Brabant. The Infirmary consumed it in normal years only on Sundays and on other special occasions. In years of high grain prices, consumption was reduced. Over the whole period 1526-1575, the average share of white bread in the total budget of the Infirmary is 7.5 percent. In years of high grain prices the share is much lower: in 1554, for example, it is only 3.8 percent of the total budget.

From the point of view of our demand system estimation, as presented in this study, bread prices have a peculiar feature: they remain constant for very long periods of time, while the weight of the bread changes continually, according to the fluctuations of the prices of wheat on the market.[8] Because of primitive transport technology, frequent political disorder, and weather variations, market prices of grain fluctuated heavily. The urban governments, wanting to secure the supply of basic food for their inhabitants, introduced an easy system of control: bread got a fixed price per unit, but its weight was allowed to fluctuate, the bakers having to follow the instructions of the municipal officers, who adjusted the weight to the fluctuating market prices of grain. As the fluctuating weight of bread could be controlled more easily than a fluctuating price of bread, fraud could be eliminated more efficiently, and the population seemed to be better protected against abuse.

With respect to our analysis, we assume that the consumers are mainly interested in the "wheat" content of their white bread and that they adjust their consumption of units of white bread, when the weight per unit changes, fol-

[8] *Ibid.*, pp. 6-7.

lowing the municipal officers instructions to the bakers. We then can use the market prices of wheat. Wheat prices on the Lier market are available: they refer to monthly sales of wheat at the market by the Poor Relief of Lier, which received it as payment in kind for the use of its mill.[9]

2. *Rye bread.* Rye bread was the predominant foodstuff in the budget of the Infirmary: the average share of rye bread in the total budget over the period 1526-1575 is 37 percent. The price of rye must have been, therefore, an important determinant of the consumption pattern.

Rye bread prices followed the same system as white bread prices: they remained constant for very long periods of time while the weight of the bread changed continually according to the fluctuations of the prices of rye on the market. Following the same reasoning as for the white bread category, we use the market prices for rye.

Rye prices on the Lier market are not available in a continuous series, but they are available for the nearby Antwerp market. As already indicated, full market integration in northwestern Brabant in the sixteenth century entirely justifies the substitution of Antwerp market prices for Lier market prices. The price series is based mainly on official yearly estimations of market prices at Antwerp (the estimates are made by the municipal authorities for the conversion of rents, to be paid in kind, into payments in money on the territory of Antwerp).[10]

3. *Beer.* Beer was by far the predominant beverage in sixteenth-century Brabant. Its average share in the budget of the Infirmary over the period 1526-1575 was 19 percent. Many other sources from the late Middle Ages and Early Modern Times confirm the very high consumption of beer in urban and rural lower – and middle – income groups.[11] The importance of beer in the popular budget was due not only to its character of an alcoholic drink but also to its potential of varying the diet during an era that diets were still very simple, monotonous, and heavily dependent on the consumption of grain.

Before the fourteenth century, gruit, a mixture of myrtle berries, herbs, and spices, was the main ingredient used in Brabant for activating the fermentation during the process of brewing the local beer and for adding taste to it. In the fourteenth century a new product, i.e., beer prepared with hops and brewed in Baltic, North German and Dutch towns, made its appearance on the Brabant market: it was imported in rapidly increasing quantities. As a result, the production of local *gruit* beer declined dramatically. The local breweries in Brabant reacted by introducing a strategy of import substitution.

[9] *Ibid.*, pp. 183-8.
[10] *Ibid.*, pp. 173-8.
[11] Van der Wee (1966) pp. 94-101.

The efforts met with success. During the fifteenth and sixteenth centuries, the urban brewing industry in Brabant, now based on the production of indigenous hopbeer, revived everywhere. Gradually the towns closest to the great grain-producing area of Hesbaye in South Brabant took the lead: from the end of the sixteenth century onwards the hopbeers of Louvain, Hoegaarden, and Diest became famous and were exported to Flanders and to other areas in the neighbourhood.[12]

From the point of view of our demand systems estimation, as presented in this study, the beer price has the same feature as the bread prices. The prices of a barrel of beer (and of pints of beer) remained constant for very long periods of time, but the grain-content of the barrels (and pints) was allowed to fluctuate according to the fluctuations of the market prices of grain (mainly barley, wheat and rye). Following the reasoning applied to the two bread categories, we use here the prices of barley, as barley was the main grain ingredient in the hopbeer of Lier. We thus assume, once again, that the consumers adjusted their consumption of units of beer, when the grain content per unit changed, following the instructions of the municipal officers to the brewers of the town.

Good market prices of barley are available for Antwerp. Every year in the fall, the Hospital of Sint-Elizabeth in Antwerp bought on the market large quantities of barley for brewing purposes.[13]

4. *Wine*. Wine was a luxury beverage in Brabant during the late Middle Ages. It had been a more common drink during the twelfth and thirteenth centuries, when beer (*gruit*beer) was of low quality and wine was still produced on a relatively large scale in Brabant itself, in the region of Louvain, Aarschot, and Diest. During the fourteenth and fifteenth centuries, however, consumption of the local wine declined as the competition of higher-quality beer (hopbeer) and of higher-quality wine (Rhine wine) grew stronger. When import substitution during the fifteenth and sixteenth centuries resulted in the local production of hopbeer, consumption of beer increased still more, at the expense of wine.

By the early sixteenth century Brabant wine had disappeared almost entirely from the market in Lier. Imported Rhine wine had taken its place, but seen in the context of the long-term development of drinks in Brabant, wine had become a greater luxury than before, its quality being enhanced at the same time.[14]

The consumption of wine in the budget of the Infirmary confirms the changes mentioned above. The average share of Rhine wine in the budget is only 1.5 percent. Good data on the prices of Rhine wine on the market of

[12] Van der Wee (1963a) vol. I., pp. 228-9.
[13] *Ibid.*, pp. 189-93.
[14] *Ibid.*, pp. 294-5.

Lier are available. The Infirmary and other institutions bought wine each year at Easter.[15]

5. *Fish*. The Catholic Church banned the consumption of meat during the periods of Advent (December) and Lent (six and a half weeks before Easter). The Infirmary of the Béguinage strictly followed the Church's regulations in this matter, and during the two above-mentioned periods replaced meat with fish. In this way fish was not an unimportant source of protein in the budget of the Infirmary of the Béguinage: its average share in the yearly budget during the period 1526-1575 was 3.7 percent.

River fish was commonly consumed in Brabant during the sixteenth century, but sea fish, in particular herring, was consumed more. The Infirmary of the Béguinage yearly bought large quantities of wet, salted herring in barrels on the Antwerp or Malines market.

During the fourteenth century most of the herring sold in the Low Countries came from Scania. In the course of the fifteenth century, several Brabant and Flemish towns took over the Scania technique of processing herring. Some of them gradually became leading export centres of wet, salted herring and of dry, smoked herring. Antwerp and Malines specialized in processing wet, salted herring, and their brands became famous all over Europe.[16]

Prices of wet, salted herrings in barrels at the Antwerp and Malines markets are available in a continuous series for the period 1526-1575.[17]

6. *Sugar and Spices*. Spices were an important element in the food budgets of the sixteenth century. Sugar, only available in the form of cane sugar, had always been considered in the same category as spices. Spices, including sugar, were used as drugs, also as flavourings, and as preservatives at a time when the possibilities of keeping foodstuffs fresh were still limited.

Spices were still rare goods in the late Middle Ages. They had to be imported from overseas over long distances. Until the end of the fifteenth century, spices, except sugar, came mainly from the Middle and Far East and were imported via Italy. At that time sugar was increasingly imported from the Atlantic Islands (the Canaries in particular). In the sixteenth century, spices were imported by Portugal directly from the East Indies and sold at its staple market at Antwerp. Venice, however, soon recaptured part of the spice trade by restoring the Middle East and Mediteranean supply channel. From the second quarter of the sixteenth century spices from Venice were sold again at the market of Antwerp, as well as were spices from Lisbon.

Because of the increasing supply of spices, sensu stricto, and of sugar as

[15] *Ibid.*, pp. 296-9.
[16] *Ibid.*, pp. 277-8.
[17] *Ibid.*, pp. 279-82.

well, the general price trend of spices was declining during the sixteenth century. With prices declining relative to the prices of other commodities, the consumption of spices tended to increase between 1526 and 1575. The average share of spices in the budget of the Infirmary of the Béguinage was 4.5 percent, but in 1575 it reached a high of 8.8 percent.

At the October fair of Antwerp, the Infirmary yearly bought increasing quantities of pepper, ginger, cinnamon, cloves, saffron, sugar, and other spices. It would be possible, on the basis of these purchases and on the basis of purchases made by other hospitals, to calculate a weighted average of spice prices. Such a calculation would have been too time consuming. Pepper being the predominant commodity of the spice category, we decided to use only the price of pepper at the October fair of Antwerp. The error caused by neglecting the other spices, including sugar, cannot be significant, as the correlation of the prices of pepper with the price movements of the different spices is high.[18]

7. *Vinegar and oil.* Vinegar and oil were used in the kitchen of the Infirmary in small quantities only: vinegar for flavouring the courses, oil mainly for frying purposes. The share of both commodities in the total food budget was 0.9 percent. Although not an important budget category as such, it required, in our opinion, separate treatment. In the preference structure, indeed, it could be complementary to many of the other commodities.

Excellent data on the prices of rape seed oil at the market of Lier during the period of Lent were available.[19]

8. *Salt.* The average share of salt in the total food budget of the Infirmary of the Béguinage was 1.2 percent. This is a high figure for modern standards, but reasonable for the period under study, as salt was an important ingredient in the kitchen of the late Middle Ages and Early Modern Times. Salting perishable foodstuffs such as meat, fish, and butter was the most common way at that time to preserve them.

In the fifteenth century salt was still produced in Zeeland by burning salted peat, but increasingly salt was imported from the Bay of Bourgneuf in France and sold at the salt-staple market of Malines. In the sixteenth century salt came also from Aunis and Saintonge, via the port of Brouage in France, later also from Aveiro, Lisbon, and Setubal in Portugal and from the Bay of Cadiz in Spain. Refining took place in small coastal centres in Flanders, Holland, Brabant, and, particularly, Zeeland (originally these centres had been producing salt themselves or had been involved in the herring-industry). The

[18] *Ibid.*, pp. 306-10.
[19] *Ibid.*, pp. 246-8.

refined salt then went to the still great staple market of Malines or, during the sixteenth century, increasingly to the rising salt market of Antwerp.[20]

The Infirmary bought its salt yearly in the autumn at the markets of Antwerp and Malines. Both markets were closely integrated. The price series of French Bay salt available for these markets are excellent.[21]

9. *Meat.* Meat, providing most of the protein, was an important part of the diet in the Infirmary of the Béguinage. The average share of meat in the total budget for the period 1526-1575 was 23.7 percent. Even during periods of sharply rising grain prices, the Infirmary did not drastically cut its expenses on meat, thus revealing the high standard of living of the middle classes in the Low Countries during that period.

A large part of the meat consumed at the Infirmary was salt beef, bought at the market. A good series of market prices of such meat is available for Malines: there, every year after the slaughtering period of October, the Hospital of Our Lady bought large quantities of salt beef for consumption in the hospital during the winter.[22]

10. *Cheese and butter.* The average share of cheese and butter in the total budget of the Infirmary is 1.4 percent for the period 1545-1575.

Two problems arise with respect to this last category. First, the data are lacking for the years 1526 and 1544 and for the period 1528-1542. Second, we may assume that the farmer of the Béguinage had to provide the Infirmary regularly with butter and cheese. It means that in normal circumstances no expenses for these are mentioned, although both commodities are part of the normal diet. From 1542 however, butter and cheese were included in the yearly expenses for food: most probably from that moment cheese and butter traditionally provided by the farmer was supplemented by purchases of Flemish or Dutch cheese and Dutch and Frisian butter on the market, a sign of diversification of food consumption during the sixteenth century.[23]

Cheese and butter are important and interesting examples of semi-luxury consumption. We decided therefore not to exclude them from our study, but to extrapolate the missing data. By extrapolating on the basis of the available data on cheese and butter, we would underestimate the importance of the expenses for cheese and butter during the year of the missing data, as there was an underestimation during the years when the data were available. But for the years for which data are available, we had at our disposal the expenses for diversifying the consumption of cheese and butter, i.e., the luxury aspect of that consumption. This was still worth analyzing, in our view.

[20] *Ibid.*, pp. 287-8.
[21] *Ibid.*, pp. 291-3.
[22] *Ibid.*, pp. 225-7.
[23] *Ibid.*, pp. 120, 217.

Moreover, a splendid series of prices of Flemish cheese at the October fair of Antwerp is available, making possible the examination of the luxury aspect of the consumption of butter and cheese.

C. *Extrapolating the missing data*

Combining the problem for cheese and butter with the minor data problems mentioned above (the lack of data for the years 1542, 1543 and 1560), we may conclude that we have complete budgetary observations for 1527, 1545-1559, and 1561-1575. For the whole of the period 1526-1575, we have a complete set of price observations.[24] The extrapolation method therefore readily suggested itself. We specified a regression equation, linking the consumption of the different commodities with all prices (without further structuring):

$$q_{it} = \alpha_{io} + \sum_{j=1}^{n} \beta_{ij}\, p_{jt} + u_{it} \qquad i = 1, \ldots, n \tag{11}$$

We then used the 31 complete observations to estimate the coefficients α_{io}, β_{ij}, $i = 1, \ldots, n$, and $j = 1, \ldots, n$ in (11). Given these estimates, the observations of the prices and equation (11), we could immediately compute the "data" for 1542, 1543, and 1560 and extrapolate the series for cheese and butter before 1545. The sums of the calculated data for 1542 and 1543 were not equal to the observed sums, of course. We used these observed sums to adjust proportionally the extrapolated data.

After these extrapolations, we have a completely consistent data-set for ten commodities over a period of fifty years: 1526-1575. For each commodity we have a representative price series. Let us now turn to the results obtained by applying the Rotterdam model (6) to these data. In section III we will discuss only the estimation over the whole period 1526-1575. To check the consequences of the extrapolation we also computed the results for 1545-1575. These are similar but, because of the loss of relevant observations, statistically less significant. The choice of the Rotterdam model as our functional form was also based on the (almost) "pure" period 1545-1575 and therefore cannot be conditioned by our extrapolation method.

III. Interpretation of the results

A. *Restrictions imposed by the assumptions made*

By applying the Rotterdam model (6) to the large data set, we estimate ten demand equations, one for each commodity, and in each equation we

[24] Some individual observations were lacking for prices also, but these gaps were filled in with simple interpolation methods.

have one coefficient b_i (see (9), giving the effect of changes in total expenditure, and ten price coefficients s_{i1}, ..., s_{i10} (see (10)). The estimates for all these coefficients over the period 1526-1575 are shown in table 1. Before turning to the interpretation, it is worth noting some characteristics of the table, which follow immediately from the theoretical restrictions imposed.

The most striking one is the symmetry of the matrix S, i.e., $s_{ij} = s_{ji}$ V i,j. Because of this property it is sufficient to give the upper triangular part of the matrix. This symmetry restriction follows from the assumption that the consumer tries to choose the best consumption bundle that he can afford (or, in the jargon, "maximises a utility function under a budget constraint"). It is a strong restriction,[25] which greatly helps in the interpretation of the price effects.

The assumption of maximisation of the utility function under a budget constraint is in our view a realistic one for the consumers studied here. In a primitive economy, as the sixteenth-century economy of the Low Countries was, the consumers from the middle-income groups always tended to choose an optimal consumption basket.

A second restriction follows from the budget constraint (2): the sum of the expenditures on the ten commodities has to equal total expenditure. This leads (automatically) to the result that

$$\Sigma b_i = 1 \tag{12}$$

i.e., the sum of all coefficients in the column b equals one. We also get automatically that

$$\Sigma s_{ij} = 0 \tag{13}$$

i.e., the sum of all price effects in one column equals zero. The interpretation is obvious: if a price decrease leads to an increase in expenditure somewhere, this increase necessarily has to be compensated by a decrease elsewhere, because the consumer is constrained by his total budget. This assumption is true by definition.

In this respect, however, another problem must be mentioned. For the application of our methodology, this total budget must be exogenously given, i.e., must be independent of the prices.

This assumption at first glance seems to be less realistic as far as the budget of the Infirmary of the Béguinage is concerned. The revenues of the Infirmary consisted mainly in income from agricultural or urban rents and from annuities and the like (in kind or in money). In periods of sharply rising prices and of famine, rents and annuities came in more slowly: as a matter of

[25] In fact, the usual test statistics point to the rejection of symmetry for our data. However, these statistics are heavily biased towards rejection if the number of goods is rather large. See MEISNER (1979). Applying the small-sample correction, proposed by ITALIANER (1985), solves the problem.

Table 1
ESTIMATION RESULTS ROTTERDAM-MODEL (1526-1575)

	b (marginal budget shares)	S Wheat	Rye	Beer	Wine	Fish	Spices	Oil	Salt	Meat	Cheese	R^2
Wheat	0.0911**	−0.0726**	0.0166*	0.0191*	0.0021	0.0002	−0.0018	0.0076	0.0012	0.0162	0.0114	0.796
	(0.0327)	(0.0157)	(0.0148)	(0.0136)	(0.0066)	(0.0066)	(0.0119)	(0.0038)	(0.0043)	(0.0183)	(0.0071)	
Rye	0.2801**	+*	−0.1059**	0.0416*	0.0067*	0.0034	−0.0026	−0.0083**	0.0037	0.0569*	−0.0122*	0.546
	(0.0684)		(0.0399)	(0.0245)	(0.0062)	(0.0081)	(0.0129)	(0.0036)	(0.0044)	(0.0299)	(0.0067)	
Beer	0.1821**	+*	+*	−0.1631**	0.0040	0.0123*	0.0218*	0.0057*	−0.0039	0.0512*	0.0114*	0.667
	(0.0423)			(0.0303)	(0.0067)	(0.0084)	(0.0139)	(0.0038)	(0.0048)	(0.0287)	(0.0073)	
Wine	0.0315**		+*		−0.0151*	0.0073*	−0.0014	0.0020	−0.0040*	−0.0114	0.0098*	0.423
	(0.0139)				(0.0083)	(0.0038)	(0.0074)	(0.0033)	(0.0029)	(0.0123)	(0.0054)	
Fish	0.0537**			+*	+*	−0.0312**	0.0058	−0.0020	−0.0004	0.0224*	−0.0178*	0.545
	(0.0164)					(0.0055)	(0.0072)	(0.0021)	(0.0025)	(0.0115)	(0.0038)	
Spices	0.0368*			+*			−0.0445**	−0.0047*	0.0096*	0.0242*	−0.0064	0.217
	(0.271)						(0.0180)	(0.0043)	(0.0049)	(0.0230)	(0.0076)	
Oil	0.0102*	+**	−**	+*			−*	−0.0073**	0.0054**	0.0113*	−0.0097**	0.421
	(0.0080)							(0.0025)	(0.0017)	(0.0062)	(0.0030)	
Salt	0.0099*				−*		+*	+**	−0.0063**	−0.0128*	0.0074**	0.206
	(0.0096)								(0.0025)	(0.0075)	(0.0029)	
Meat	0.286**		+*	+*		+*	+*	+*	−*	−0.1864**	0.0285**	0.433
	(0.061)									(0.0479)	(0.0112)	
Cheese	0.0184	+*	−*	+*	+*	−**		−**	+**	+**	−0.0223**	0.495
	(0.0192)										(0.0071)	

Note: Figures in parentheses are standard errors of the coefficient. The superscripts * and ** denote that the coefficient is larger than or larger than twice its standard error, respectively.

fact, in such circumstances the Infirmary conceded postponement of payment to its own debtors.[26] Faced with smaller revenues during periods of crisis, the Infirmary tried to restore equilibrium in its budget in two ways: first, the expenditures on nonfoodstuffs, such as for maintenance of the buildings and for clothing and the like, were postponed until the crisis was over. Second, the Infirmary bought more goods on credit. Indeed, the habit of buying foodstuffs at the market on credit became increasingly general during the course of the sixteenth century, even in as small a town as Lier.[27] Credit facilities made it possible in times of rising prices to buy with postponement of paying: in times of high grain prices, one could exceed the immediately available budget. Taking into account these movements to restore the equilibrium of the food budget, one can nonetheless consider as realistic the assumption of an exogenous amount of total food expenditure.

The third assumption states that there was no money illusion during the period under study, which means that the consumer took into account relative prices only. It leads to the restriction that

$$\sum_i s_{ij} = 0 \tag{14}$$

i.e., the sum of all price coefficients per equation is equal to zero. This seems at first view an unrealistic assumption, as the period 1526-1575 was part of the Price Revolution of the sixteenth century, and it could be assumed that consumers during that period certainly would be subject to money illusion.

Looking more carefully to the trend of prices in sixteenth-century Brabant, we realize that the main increases of the price level occurred between 1510 and the early 1520's and during the 1570's and 1580's. One cannot deny a rising price trend between 1526 and 1575, but during that very period the rise in Brabant was remarkably slow, compared with the rises during the years preceding and following it.[28] Seen on the whole, and taking into account that prices of many foodstuffs were fluctuating heavily from one year to another, the assumption that money illusion was more or less absent during the period 1526-1575 in Brabant seems historically acceptable.[29]

Note finally that all our price effects s_{ii}, i.e., the diagonal elements of S, are negative. This conforms to the theoretical idea that a (compensated) increase in the own price leads to a decrease in the consumption of the commodity.

[26] Van der Wee (1963a), vol. I, pp. 14-5.

[27] Van der Wee (1977), pp. 300-3.

[28] Van der Wee (1963a), vol. III, p. 119, graph 52.

[29] The statistical test results also point to the acceptance of the assumption. Note also that symmetry together with (13), make restriction (14) superfluous.

B. *The interpretation*

1. *The income elasticities.* Let us now turn to the interpretation of all these numbers and start with column b in table 1. As can be seen from (9), these coefficients have to be interpreted as "marginal budget shares": they show how a marginal change in the budget is allocated over the different goods. The income elasticity can then be computed as

$$\beta_i = b_i/w_i \qquad \forall i \qquad (15)$$

As mentioned above, this elasticity varies over the period because it is dependent on the variable share w_i. If $b_i > w_i$, i.e., the marginal share is larger than the actual share, then $\beta_i > 1$: the share of the commodity in the total budget is growing with welfare increases, and we say that the commodity is a luxury. If $b_i < w_i$, then $\beta_i < 1$, and the reverse interpretation holds: the good is a necessity. The income elasticities have been computed for 1550 (which is a representative year, in the middle of our period) and shown in the second column of table 2.

Table 2
ELASTICITIES IN 1550

Commodities of the budget	Budget share in 1550-1551	Income elasticity	Price elasticity	
		(expenditure elasticity)	Compensated own price elasticity	Total own price elasticity
Wheat	0.061	1.50	−1.19	−1.28
Rye	0.413	0.68	−0.26	−0.54
Beer	0.165	1.10	−0.99	−1.17
Wine	0.015	2.11	−1.01	−1.04
Fish	0.038	1.41	−0.82	−0.87
Spices	0.026	1.42	−1.72	−1.76
Oil	0.007	1.51	−1.07	−1.09
Salt	0.009	1.16	−0.74	−0.75
Meat	0.252	1.14	−0.74	−1.03
Cheese	0.015	1.21	−1.47	−1.49

The pattern of expenditure elasticities is a nice quantitative corroboration of the usual theories. Rye is the absolutely predominant commodity and, in fact, the *only necessity* in the budget of the Infirmary of the Lier Béguinage. An increase in income, i.e., in welfare, will lead to a decrease in the budget share of rye and to an increase in the share of all other commodities. If we make a "luxury ranking" on the basis of the expenditure elasticities, this ranking obviously makes sense: first is "rye" as a necessity, then the group

"beer", "salt," and "meat" with elasticities of about one and finally the luxuries "cheese," "fish," "spices," "oil," "wheat," and "wine."

Thus an increase in income will provoke a decrease in the budget share of rye, keep the budget share of beer, salt, and meat more or less constant, enlarge slightly the budget share of cheese, and enlarge considerably the budget shares of fish, spices, wheat, oil, and particularly wine. One would have expected larger income elasticities for Flemish or Dutch cheese and for spices: their luxury character will show itself more clearly when we analyze the price elasticities.

It is interesting that we get the reverse interpretation if there is a welfare *decrease*, i.e., a decline in real income. This gives us a first idea about the effect of crises on consumption. Our results show that a decrease in real welfare (keeping relative prices constant) would lead to an *increase* in the budget share of rye. The expenditure for rye, however, would not increase in such circumstances. The correct interpretation here is that only the *relative* importance of rye in the budget would be growing. The results also indicate that in case of declining income there would be a large drop in the budget share of the luxuries mentioned above, while the commodities beer, salt, and meat more or less would retain their relative importance in the total budget.

The conclusions are obvious. Rye remains the predominant commodity in the food budget of the middle-income groups, of which the budget of the Infirmary of the Béguinage is a representative example. Such a middle-income food budget, however, is well above the subsistence level. When income falls, the share of beer, salt, and meat in the total budget will not decrease, but it will remain more or less constant.

Another interesting feature is the high income elasticity of wine. To explain it, we have to emphasize the impact of the past. Wine had become a luxury in Brabant during the sixteenth century, based on imports of wine from the Rhine-area. Wine, however, had been less of a luxury in the fourteenth-fifteenth centuries, when the Brabant country wine was still available in relatively large quantities. Consumer behaviour in the sixteenth century seemed to reflect still the larger consumption of wine in the past. When income rose, the budget share of wine in the total food budget increased much more than the share of other luxuries: a clear indicator of the great preference of the Brabant consumers for wine, as a consequence of remote consumption habits.

2. *The price elasticities.* The picture becomes richer if we add the information about the our price effect. The usual presumption indeed suggests that a luxury should have a high price elasticity, while the consumption of necessities should react less strongly to price changes. Using (10) we see that the own price elasticities can be derived from the coefficients s_{ij} by the formula

$$\epsilon^{*}_{ii} = s_{ii}/w_i \qquad (16)$$

These are *compensated* price elasticities, indicating the effect of a price change under the assumption that real income is kept constant. They are shown in the third column of table 2 for 1550. We noted already that they are all negative: an increase in the our price of a given commodity will always generate a decrease in its consumption. Using equation (4b) we can now also compute the *total* price elasticities: these are shown in the fourth column. As we add the effect of the change in real income to the compensated effect, the absolute value of these total effects will be larger,[30] and the difference between the two will increase with the budget share of the commodity. It is therefore not surprising that the total price elasticity of rye is more than twice the compensated price elasticity.

Again our presumption is corroborated by the quantitative results. We see a very low compensated price elasticity for rye. We also get small compensated price elasticities for salt, meat, and fish and a compensated price elasticity of about one for beer, wine, and oil. Note that the absolute value of the compensated price elasticity is high for Flemish or Dutch cheese and for spices: their (intuitively expected) luxury character reveals itself strongly in the price effect.

The total price elasticities give additional insights into the conclusions reached from the compensated price elasticities. Because total price elasticities are all negative, we can derive immediately that the *quantity consumed* of the commodities always will decrease if their price increases. On the other hand, the *expenditures* for the commodity will increase with a price increase, if the elasticity is smaller than one in absolute value. This is the case here (and very strongly so) for rye, and remarkably also for salt and fish. Expenditures would remain almost the same for meat and wine and would decrease for the other commodities in the case of rising prices.

It is important to distinguish carefully the price effects from the income effects, on which we commented earlier. An increase in the price of rye (with real income remaining constant, in other words, with price elasticity being a compensated one, and with the price increase affecting only the price of rye, not the prices of the other commodities) will lead to an increase in the expenditures for rye. On the contrary, an increase in the price of rye leading to a decrease in real income, with relative prices remaining constant, will lead to a decrease in the expenditure for rye (but to an increase in the *share* of rye in the total budget).

The distinction between price and income effects allows us to understand better the patterns of consumer behaviour in times of famine. Some historians have suggested that consumers in times of famine would concentrate their expenditures on the buying of food, rye in particular. Rye, indeed, was the

[30] It would only be smaller for inferior goods (for which $b_i < 0$ and $\beta_i < 0$), but these do not occur in our data.

foodstuff that contained, per unit of money spent, the highest amount of calories. For that reason the share of rye in the total budget would increase, and at the same time the consumption of rye would increase.[31]

The separate analysis of the price and income elasticities shows that in times of famine during the sixteenth century the share of rye in the total budget was growing, but total consumption of rye decreased. Thus consummers were not concentrating their expenditures entirely on the purchases of rye; they continued buying other foodstuffs too: another proof that the middle-income groups in Brabant, even during the second and third quarters of the sixteenth century, were not living on a subsistence level, but on a relatively favourable welfare level.

In summary, we can distinguish four groups of commodities in the budget of the Infirmary of the Béguinage: (1) Commodities with low income elasticities and with low price elasticity: in the first place rye, and also meat and salt. These commodities may be called the *pure necessities.* (2 Commodities with low income elasticity and with high price elasticity: beer. This commodity may be called a good of common use, although not really necessary. (3) Commodities with high income elasticity and with high price elasticity: wheat, spices, and cheese. These commodities may be called the *pure luxuries.* (4) Commodities with high income elasticity and with low price elasticity: wine, fish, and oil.

3. *The cross-price elasticities.* Until now, we have said nothing about the cross-price effects in the equations: the coefficients s_{ij} if if $i \neq j$. Using (10) we could also transform them into elasticities: these are mostly small in absolute value, however, and our interpretation will concentrate exclusively on the *sign* of the effect. We therefore do not give a complete table with all elasticities.

We mentioned in section I that the compensated price elasticities can be interpreted in a certain sense as "pure utility" effects and are therefore relevant to analysis of the preference structure of the consumer. Indeed, *the coefficient s_{ij} gives the effect of a change in the price of commodity j on the consumption of commodity i, under the assumption that the consumer is compensated for the change in real income, brought about by the price change.* It therefore makes sense to define goods i and j as *substitutes* if $s_{ij} > 0$. This would imply that an increase in the price of j leads to an increase in the consumption of good i: the consumer substitutes good i for the now more expensive good j. If $s_{ij} < 0$, the reverse interpretation holds: an increase in the price of j now leads to a decrease in the consumption of good i (together with the decrease in the consumption of good j itself). We then define the goods i

[31] See, e.g., Scholliers (1960). On the same problem see also Van der Wee (1963b).

and j as *complements*. In this way we can derive information about the (unobservable) preference structure of the consumer on the basis of observable consumption behaviour.

Application of these ideas to our estimation results reveals some interesting patterns. The different grain products (wheat, rye, and beer) are substitutes for one another, which obviously stands to reason. The other basic necessity (meat) is a substitute for beer and rye; but has no significant relationship to wheat. Fish and meat are substitutes for one another (perhaps as a source of protein), cheese and meat also. We also recover some intuitively reasonable relationships of complementarity (to which we alluded in section II): between salt and meat in the first place, but also between oil and rye and between oil and cheese. Salt is a substitute for oil and spices. There are some other cross effects, which are more difficult to interpret. Econometricians have proposed more sophisticated techniques to analyse the structure of preferences on the basis of observable behaviour. but application of those techniques would lead us far beyond the scope of this study.

Let us emphasise again that the interpretations made in this subsection are based on the *compensated* price elasticities. One should be aware that these are theoretical constructs, because in reality consumers never are compensated perfectly for the income effect of a price change. We can illustrate the relevance of this distinction by considering the effects of a change in the price of rye on the consumption of the other commodities of the budget. The first column of table 3 shows the compensated price elasticities for 1550, calculated with equation (16). The second column shows the total price elasticities, calculated with equations (4a) and (4b). The differences are striking.

In the first column we see that if the price of rye increases and there is compensation for the income effect, only the consumption of rye and its complements (spices, oil, and cheese) decreases. The other goods can then be substituted for rye. This gives us some information about the preference structure. The second column, however, shows that the income effect of an increase in the price of rye is absolutely dominant: because of the loss of real purchasing power the consumption of all goods declines. This is of course what would be observed in reality and gives us a first insight into the consequences of a grain crisis.

We can deepen this insight by combining the total price elasticities of rye in table 3 with the total price elasticities of wheat. We then can compute the effect on consumption of, e.g., a doubling of the prices of both rye and wheat: this happened more or less during the great grain crises of 1556 and 1565. Our estimates then suggest the percentage changes in consumption, shown in table 4. Note that these results are only suggestive: they follow from an easy summation of two effects and are dependent on the budget shares in 1550. Moreover, we did not give any consideration to the differences in statistical quality of the respective estimates. It is obvious, however, that the pattern makes sense: the negative effect of the rise of grain prices on

Table 3
EFFECTS OF A CHANGE IN THE PRICE OF RYE ON THE CONSUMPTION OF THE OTHER COMMODITIES OF THE BUDGET (1550)

	Compensated price elasticity	Total price elasticity
Wheat	0.27	−0.34
Rye	−0.26	−0.54
Beer	0.25	−0.20
Wine	0.45	−0.42
Fish	0.09	−0.49
Spices	−0.10	−0.69
Oil	−1.22	−1.84
Salt	0.44	−0.04
Meat	0.23	−0.24
Cheese	−0.80	−1.30

Table 4
EFFECTS OF A GRAIN CRISIS (A DOUBLING OF THE PRICES OF RYE AND WHEAT) ON THE CONSUMPTION OF ALL COMMODITIES DURING THE THIRD QUARTER OF THE SIX TEENTH CENTURY

Wheat	−59%
Rye	−33%
Beer	− 7%
Wine	−22%
Fish	−32%
Spices	−28%
Oil	−34%
Salt	+ 3%
Meat	−15%
Cheese	−36%

the consumption of wheat is much more dramatic than the negative effect of the rise of grain prices on the consumption of rye. Except for salt (the consumption of which remains almost the same), all other commodities also experience a loss of consumption. The negative effect is the least pronounced for beer and meat: again, this is a quantitative corroboration of the usual qualitative hypotheses.

Conclusion

The application of the Rotterdam model on food consumption in the

Ancien Régime, as was carried out in this study, has shown its merits. Of course, one should always be aware of the restrictions imposed by the use of an abstract construct. Nevertheless, new insights into the complexities of consumer behaviour during the Ancien Régime and a better understanding of the relative importance of different commodities in a given budget could be obtained.

The study confirmed the common wisdom that rye was the dominant commodity of the budget of the middle-income groups in Brabant during the sixteenth century. But the study went far beyond this common wisdom when it extended the analysis by distinguishing between the income elasticity and the price elasticity of rye and of the other commodities of the budget. Not only rye but also meat and salt have to be considered as belonging to the category of necessities. Beer comes close to the same qualification too. Here we have a very clear indicator of the relatively high standard of living of the middle-income groups in sixteenth-century Brabant, even in as small a town as Lier, and even during the second and third quarters of the sixteenth century (a period when in other regions the standard of living was declining steeply). Another important conclusion concerns the effect of famines on consumer behaviour. Previous research intuitively suggested that famines reinforced the heavy bias of expenditures in the budget towards the predominant commodity "rye," pushing up the prices of rye more than proportionately to the prices of the other commodities, even wheat and barley. The analysis in this study gives more details about the behaviour of the consumer during periods of crisis: expenditures for rye would indeed increase during times of famine, as would the share of expenditures for rye in the total budget, but the quantity of rye consumed would be smaller. Although rye was a dominant necessity, and although the effect of a harvest failure in sixteenth-century Brabant was dramatic, the effect of the failure was not so dramatic that consumption of the other commodities would be reduced to such an extent that the quantity of rye consumed could be maintained: again, a clear indicator of the favourable conditions of living in sixteenth-century Brabant.

Appendix

For purposes of estimation, we must choose a specific mathematical form for the function (3), where the demand relationship can be fully described in terms of observable variables and (constant) coefficients to be estimated by regression analysis. For our analysis, we compared the results for a few functional forms and finally chose the so-called Rotterdam model, mainly for interpretational reasons.[32] This does not imply that we are convinced that the

[32] We compared the results for three systems: Rotterdam, AIDS (in differential

Rotterdam specification is the best for all purposes. The choice of functional form is a difficult problem: the decision depends on the data set to be analysed and will always be somewhat arbitrary, at least in the present state of the art.

To derive the Rotterdam model, we start from a linear logarithmic form of (3):

$$\ln q_i = \alpha_i + \beta_i \ln m + \sum_j \epsilon_{ij} \ln p_j \qquad i = 1, ..., n \tag{17}$$

We now rewrite (17) in differential form as

$$d \ln q_i = \beta_i \, d \ln m + \sum_j \epsilon_{ij} \, d \ln p_j \qquad i = 1, ..., n \tag{18}$$

In (18) $d \ln q_i$ is the change in the logarithm of the consumption of commodity i, $d \ln m$ is the change in the logarithm of total expenditure, and $d \ln p_j$, $j = 1, ..., n$ are the changes in the logarithms of the prices. All of these are observable. The other parameters must be estimated. Given the specification (18), we know that β_i can be interpreted as the income elasticity[33] of commodity i. The own price elasticity of commodity i is given by ϵ_{ii} and the elasticities w.r.t. the other prices by ϵ_{ij}, $i = 1, ..., n$, $j \neq i$.

Inserting the theoretical specifications (4a) and (4b) into (18) yields

$$d \ln q_i = \beta_i \, d \ln m + \sum_j (\epsilon^*_{ij} - \beta_i w_j) \, d \ln p_j \qquad i = 1, ..., n \tag{19}$$

or, after some manipulations,

$$d \ln q_i = \beta_i (d \ln m - \sum_j w_j \, d \ln p_j) + \sum_j \epsilon^*_{ij} \, d \ln p_j \qquad i = 1, ..., n \tag{20}$$

The first observable variable on the right-hand side in (20) is now $(d \ln m - \sum w_j \, d \ln p_j)$; this can be interpreted as the *change in real income*, since we deflate the nominal change $d \ln m$ with a price index, in which the changes in (the logarithms of) the different individual prices are weighted by the share of the respective commodities in the total budget. In fact, we could estimate (20) as such. We would then have to estimate n equations (one for each commodity i) and the dependent variables would be $d \ln q_i$, $i = 1, ..., n$. The explanatory variables would be the same in each equation: the change in the logarithm of real total expenditure and the changes in the logarithms of all prices.

form), and CBS. All estimations were run with the DEMMOD program, constructed by Barten. The estimation procedure of DEMMOD was introduced by BARTEN and GEYSKENS (1975). More information on the specifications and especially on the Rotterdam model can be found in the works cited in note 1 above.

[33] This is not quite correct. Given our definition of m, β_i is an expenditure elasticity, but we use the more common term "income elasticity" in the text.

The estimated parameters could then be interpreted as the income elasticities and the compensated price elasticities. This specification therefore would imply that these elasticities are constant over the estimated period.

A problem with (20) is that the restrictions, following from the theory of consumer behaviour are not formulated in terms of the elasticities only. They therefore cannot be imposed if we would estimate (20) as such. The *Rotterdam model is a transformation of (20) that allows us to impose easily all theoretical restrictions.* Multiplying both sides of (20) through by w_i (the share of commodity i in the budget) we get

$$w_i \, d \ln q_i = w_i \beta_i (d \ln m - \sum_j w_j \, d \ln p_j) + w_i \sum_j \epsilon^*_{ij} \, d \ln p_j \qquad i = 1, \ldots, n \qquad (21)$$

which, by defining

$$b_i = w_i \beta_i \qquad i = 1, \ldots, n \qquad (22)$$

$$s_{ij} = w_i \epsilon^*_{ij} \qquad i = 1, \ldots, n; \; j = 1, \ldots, n \qquad (23)$$

can be written as

$$w_i \, d \ln q_i = b_i (d \ln m - \sum_j w_j \, d \ln p_j) + \sum_j s_{ij} \, d \ln p_j \qquad i = 1, \ldots n \qquad (24)$$

To apply (24) to real data, we must replace the differentials by finite differences. This means that we replace d ln q_i by

$$\Delta \ln q_{it} = \ln q_{i,t} - \ln q_{i;t-1} \qquad (25)$$

where the subscript t refers to the observation unit. In our case we will refer to *yearly* changes. An analogous transformation is chosen for d ln m and d ln p_j, j = 1, ..., n. The relevant shares then are defined as

$$\bar{w}_{it} = (w_{it} + w_{it-1})/2 \qquad (26)$$

i.e., the average over the two consecutive years. Using (25) and (26) we rewrite (24) as

$$\bar{w}_{it} \, \Delta \ln q_{it} = b_i (\Delta \ln m_t - \sum_j \bar{w}_{jt} \, \Delta \ln p_{jt}) + \sum_j s_{ij} \, \Delta \ln p_{jt} \qquad i = 1, \ldots, n \qquad (25)$$

Equation (25) gives the *basic specification of the Rotterdam model.* It is reproduced as equation (6) in the text.

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