contributions to economic analysis

C. ZEELENBERG

Industrial Price Formation

North-Holland

INDUSTRIAL PRICE FORMATION

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Introduction to the Series

This series consists of a number of hitherto unpublished studies, which are introduced by the editors in the belief that they represent fresh contributions to economic science.

The term "economic analysis" as used in the title of the series has been adopted because it covers both the activities of the theoretical economist and the research worker.

Although the analytical methods used by the various contributors are not the same, they are nevertheless conditioned by the common origin of their studies, namely theoretical problems encountered in practical research. Since for this reason, business cycle research and national accounting, research work on behalf of economic policy, and problems of planning are the main sources of the subjects dealt with, they necessarily determine the manner of approach adopted by the authors. Their methods tend to be "practical" in the sense of not being too far remote from application to actual economic conditions. In addition they are quantitative rather than qualitative.

It is the hope of the editors that the publication of these studies will help to stimulate the exchange of scientific information and to reinforce international cooperation in the field of economics.

The Editors

For *Vera*

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Explanation of symbols:

.	not available
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0	less than half the unit
—	zero

PREFACE

This book is about models of industrial price formation. My purpose is to develop linear and static models that can be used to describe actual price formation.

The research for the book has been done at the Department of Econometrics of the Free University in Amsterdam.

I wish to thank Professors A.H.Q.M. Merkies and W.J. Keller for their stimulating advice and comments, Professor A. Heertje of the University of Amsterdam for his comments on the draft of the book, A. Nieuwenhuis of the Central Planning Bureau for his comments on Part 3, Bert Jaarsma for his research assistance, and José Lohman for her research assistance and for typing the book.

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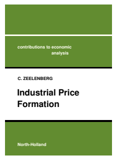

CHAPTER 1

Introduction and summary

This book deals with models of industrial price formation, in particular in an open economy. The aim is to show how models that are derived from the micro-economic theory of producer and consumer behaviour can help to explain price formation in industries. The models will be applied to data for the Netherlands in the period 1961-1979.

There are several reasons why it is useful to study industrial price formation and to use a micro-economic theory. Firstly, application of models of industrial price formation may give an answer to questions as: do more concentrated industries have higher profit margins than less concentrated industries?; are prices in more concentrated industries less flexible than prices in less concentrated industries?; does strong foreign competition lead to low profit margins and to lower price increases?

Secondly, existing models of macro-economic or industrial price formation[1] are often constructed ad hoc, with little theory and with many ‘plausibility’ arguments. In general, this yields little interpretation of the coefficients and thus hardly any restrictions. On the contrary, a micro-economic approach does give a clear interpretation to the coefficients and a theoretical basis to the inclusion of variables.

For example, in studies of industrial price formation the domestic market share (or its complement, the foreign market share) is often used as an explanatory factor of the price-cost ratio; the argument is that a low value of the domestic market share means that foreign competition is heavy, which leads to low profit margins. In Chapter 6 of this book it is shown how this variable arises from a micro-economic model, how its coefficient depends on the elasticity of substitution between domestic and foreign products, and that, according to the theory, this coefficient is positive.

The book consists of three parts. In the first part the relation between costs and prices is studied with an input-output model and a model of historic-cost pricing.

In the second part price formation under pure competition is studied: the law of one price is tested, and a general-equilibrium model of price formation in a small open economy is constructed and estimated.

In the third part price formation under imperfect competition is studied with both partial and general-equilibrium methods; it includes a theoretical basis for a price equation that is much used in industrial-organisation studies, an analysis of the relation between marginal cost, average cost, and capacity utilization, a treatment of the effects of market structure, and a general-equilibrium analysis of price formation under imperfect competition.

[1] See Nordhaus (1972) and Earl (1973, Chapters 1-4) for surveys.

Some limitations of the analysis in this book are: firstly, the models of Parts 2 and 3 are static; secondly, either the prices of the primary inputs are exogenous (in Parts 1 and 3), or the supply of primary inputs is exogenous (in all Parts); thirdly, there is no comparison of the models of Parts 2 and 3; and fourthly, the empirical analysis is mostly confined to estimation of the model as derived from the theory. The empirical analysis is, because of these limitations (in particular the fourth), not intended to be a description of actual price formation in the Netherlands; such a description would require application of model-specification and testing procedures [see Harvey (1981, Chapter 5)] as well as the use of factual knowledge of price formation.

Summary

Part 1 (Chapters 2 and 3) deals with the transmission of price changes through the economy if there are constant technical coefficients of production and firms set their prices by adding a constant mark-up to average cost. I assume that the prices of the primary inputs are exogenous, so that price changes are transmitted only through intermediate cost. In Chapter 2 the properties of a static and a dynamic model are studied. In Chapter 3 a version of the dynamic model is applied to price formation in the Netherlands; the effects of changes in primary-input prices are dynamically simulated.

In Part 2 (Chapters 4 and 5), price formation under pure competition is studied. In Chapter 4 I analyse the law of one price for a small open economy. I assume that each tradable domestic product is traded in a perfect world market, so that the foreign price (measured in domestic currency) is equal to the domestic price. Because of the small-country assumption, we can interpret this equality as a causal relation: the foreign price determines the domestic price. The equality of foreign and domestic prices is important in monetarist models of the balance of payments [Johnson (1972, p. 153-4)] and in 'Scandinavian' models of price formation [Aukrust (1970, 1977), Edgren, Faxén, and Odhner (1970), and Calmfors (1977)].

The law of one price is analysed for five commodity groups; the results show that the law of one price holds only for Fuels. Also the effects that aggregation has on testing of the law of one price are analysed.

A possible explanation of the failure of the law-of-one-price model is that domestic and foreign products are not perfect substitutes. In Chapter 5 I construct a general-equilibrium model where domestic and foreign goods are not perfect substitutes; the law of one price is a limiting case of this model. I show that if a country is small and open, then the prices of foreign goods are exogenous, but the prices of domestic goods are not exogenous. The result rests on the fact that exports of a small open economy are small as compared to income of the rest of the world.[2] After specification of consumer preferences and producer technology by two-stage CES functions I estimate the model on the same data as have been used in Chapter 4. The empirical analysis shows

[2] The proof is a generalization of Keller (1980, pp. 215-26) who analyses an economy without production.

that actual price changes are better explained by this model than by the law of one price.

Part 3 (Chapters 6-9) deals with price formation under imperfect competition. In most of this part I assume that all producers in an industry act in complete collusion, i.e. they form a monopoly. This assumption makes it possible to concentrate on the influence that foreign competition and competition between industries have on price formation. I also assume that prices of foreign products are exogenous.

I derive in Chapter 6 an equation that relates the price-cost ratio of a monopolist to the ratio of domestic sales and competing imports.[3] The monopolist produces under constant returns to scale a consumer product for which there exists a close foreign substitute; these two products are called two variants of the same good. Consumers allocate their budget in two stages: first they allocate the total budget to goods, and then for each good they allocate the expenditure on it to the domestic and the foreign product. I assume in this chapter that the price elasticity of demand for the good is equal to −1. Application of the theory of two-stage budgeting then gives that the price elasticity of demand is a function of the domestic-sales/competing-imports ratio; because the price-cost ratio of a monopolist depends on the price elasticity of demand, the relation between price-cost ratio and domestic-sales/competing-imports ratio then follows. The coefficient of the domestic-sales/competing-imports ratio must be positive and is an increasing function of the elasticity of substitution between the domestic and foreign products; thus the higher the foreign market share is or the more substitutable the domestic and foreign products are, the lower the price-cost ratio is.

A similar foreign competition variable (often the market share of foreign suppliers) appears in many empirical studies on industrial organisation; see Esposito and Esposito (1971), Khalilzadeh-Shirazi (1974), Pagoulatos and Sorensen (1976a, 1976b), Hart and Morgan (1977), Jones, Laudadio, and Percy (1977), Caves and Porter (1978), and De Wolf (1981, 1982). Most of these studies contain cross-section regressions with the profit share as the dependent variable and the foreign market share together with market-structure variables (such as concentration ratio and barriers to entry; see below) as independent variables.

The empirical results show that foreign competition has had a strong negative influence on the mark-up in the industries Other food, Textiles, and Clothing and leather.

In Chapter 7 the model of Chapter 6 is generalized: the restriction on the price elasticity of demand for the good is now lifted and the demand for goods modelled by means of the Rotterdam system, price formation by a monopolist who produces producer goods or both consumer and producer goods is studied, and the relation between marginal cost, average cost, and capacity utilization is analysed. This leads to a model where the price of an industry is determined by average variable cost, average fixed

[3] This ratio is equal to $\frac{1 - \text{foreign market share}}{\text{foreign market share}}$ and is thus inversely related to the foreign market share.

cost, capacity utilization, the domestic market share on the consumer market, the domestic market share on the producer market, and the budget and cost shares of the good (i.e. the share that domestic and foreign producers have in respectively consumer expenditure and producer cost).

The price equation that results from these extensions is estimated for 24 industries in the Netherlands. The empirical results show that average variable cost is the most important determinant of the domestic price; average fixed cost and the budget/cost share are important in about half of the industries; and capacity utilization and the domestic market share are important in about a third of the industries.

In Chapter 8 I investigate the relationship between market structure and price formation, in particular the relationship between degree of concentration and the mark-up.[4] Theoretical analyses of the relation between market structure and price formation have been made by Saving (1970), Modigliani (1958), and Cowling and Waterson (1976).[5] These models are combined with part of the analysis of Chapter 7 into a model in which the price-cost ratio depends on concentration, barriers to entry, the domestic market share, and the budget/cost share. The empirical results show that there is no relation between concentration and profit margins.

I also derive a relation between price, cost, demand (represented by the domestic market share and the budget/cost share), and concentration; it appears from the empirical results that the more concentrated an industry is, the more its price reacts to changes in capacity utilization and the less its price reacts to changes in the budget/cost share.

Chapter 9 deals with the general-equilibrium structure of the model of Chapter 7, i.e. the comparative statics when all transmissions via cost and demand are taken into account. For some two-good cases I show that increases in exogenous primary cost, foreign prices, and income lead to an increase in domestic prices. The empirical analysis for the 24 industries shows that in most industries primary cost and foreign prices are about equally important determinants of price formation.

[4] Surveys are given by Scherer (1970, Chapters 9 and 13) and Devine, Lee, Jones, and Tyson (1979, Chapter 6).

[5] See Friedman (1983) for other oligopoly models; these models are not applied in this book.

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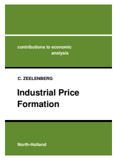

PART 1

Costs and prices

CHAPTER 2

Price formation in input-output models

Part 1 studies, by means of an input-output model, the relationship between input costs and output prices. The output price of an industry is in the model determined by adding a constant mark-up to average cost, which is a linear function of the input prices. Chapter 2 deals with the properties of the model, conditions for positive output prices in the static version of the model, and conditions for stability in the dynamic version of the model. Chapter 3 uses the dynamic version to analyse the lags between changes in primary-input prices and the resulting changes in output prices under historic-cost pricing.

This chapter deals with the theory of price formation in input-output models. Its main purpose is to study the relation between costs and output prices and to provide a model for the simulations in the next chapter.

The main assumptions underlying the analysis are:

— the production function is of the Leontief type, i.e. the technical coefficients of production are independent of the output level and the input and output prices;
— the prices of the primary inputs (imported materials, capital consumption, and labour) are exogenous;
— each industry produces one good;
— output prices are determined by applying a constant mark-up to average cost;
— all producers in an industry have the same production function, have the same mark-up, and face the same input prices.

Mark-up pricing, of which the model of this chapter is an interindustry variant, is according to several enquiries[1] often practised by businessmen. Explanations of this practice have been given in terms of non-marginalist behaviour.[2] However, mark-up pricing is also compatible with profit maximization by a monopolist,[3] for whom the profit-maximizing price is (see also Section 6.1):

$$p = \Delta\left(1 + \frac{1}{\varepsilon}\right)^{-1},$$

[1] See Hall and Hitch (1939) and Kaplan, Dirlam, and Lanzilotti (1958).

[2] See Koutsoyiannis (1975, Chapter 11) for a survey.

[3] See Andriessen (1955, Chapters 7 and 8) and Koutsoyiannis (1975, pp. 278-80).

where p is output price, Δ is marginal cost, and ε is the price elasticity of demand. If the price elasticity of demand is constant and marginal cost is equal to average cost, then we have

$$p = kc,$$

where $k = (1 + 1/\varepsilon)^{-1}$ equals 1 + the mark-up, and c is average cost. Thus mark-up pricing is a special case of profit maximization by a monopolist.

The model of this chapter can be used to analyse the short-term consequences that exogenous cost changes (for example changes in wage rates, indirect taxes, and import prices) have for industrial prices. Some particular instances in which this model can be used are the replacement of a cascade sales tax by a value-added tax, the large increase in crude oil prices in 1973, the indexation of wage rates, devaluation, and lags between cost and price changes. In the next chapter I shall study the lags between cost and price changes with a version of the model.

The static model is described in Section 2.1; this section deals with conditions for positive prices and comparative statics with and without indexation of wage rates. Section 2.2 deals with a dynamic model of price formation and its stability properties; a version of this model will be applied in the next chapter. The analysis of this chapter is quite similar to that of input-output models [see Takayama (1973, Chapters 4 and 6) and Woods (1978, Chapters 2, 4, and 5)]. Appendices 2.1 and 2.2 give a short survey of the properties of nonnegative matrices and difference equations; all 'Definitions' and 'Theorems' can be looked up in these two appendices.

2.1. Static model

In this section the properties of a static interindustry model of mark-up pricing are analysed. The section contains some technical material on conditions for positive output prices and on comparative statics.

Notation

First I establish some notation for comparing matrices. Let A, B, and 0 be matrices of the same size. I write

$A = B$ if $a_{ij} = b_{ij}$ for all i and j;
$A \geqq B$ if $a_{ij} \geq b_{ij}$ for all i and j;
$A \geq B$ if $a_{ij} \geq b_{ij}$ for all i and j with strict inequality for at least one pair (i, j);
$A > B$
if $a_{ij} > b_{ij}$ for all i and j;
A is zero if $A = 0$;
A is nonnegative if $A \geqq 0$;
A is semi-positive if $A \geq 0$;
A is positive if $A > 0$.

The model

Total cost of an industry is the sum of intermediate cost and primary cost:

$$C_j = \sum_{i=1}^{N} p_i q_{ij} + \sum_{h=1}^{M} r_h v_{hj}, \;\; j = 1, 2, \ldots, N, \tag{2.1}$$

where C_j is total cost of industry j, p_i is the price of good i, q_{ij} is the quantity of good i delivered to industry j, r_h is the price of primary input h, v_{hj} is the quantity of primary input h used by industry j, N is the number of industries, and M is the number of primary inputs. Primary inputs are: imported materials, capital consumption, non-commodity indirect taxes and subsidies, and labour (see below for the treatment of commodity taxes). Depending upon the aim of the analysis, a primary input can be taken as homogeneous or inhomogeneous across industries; for example, if all wage rates rise by the same proportion, this is equivalent to a price rise of the homogeneous input labour, whereas if only the wage rate in the textiles industry rises, this is equivalent to a price rise of the inhomogeneous input 'labour in textiles industry'.

Dividing equation (2.1) by output, q_j, of industry j we get

$$\frac{C_j}{q_j} = \sum_{i=1}^{N} p_i \frac{q_{ij}}{q_j} + \sum_{h=1}^{M} r_h \frac{v_{hj}}{q_j}, \;\; j = 1, 2, \ldots, N. \tag{2.2}$$

Assuming that the technical coefficients $a_{ij} = q_{ij}/q_j$ and $b_{hj} = v_{hj}/qsubj$ are independent of the input prices, we can write (2.2) as

$$c_j = \sum_{i=1}^{N} a_{ij} p_i + \sum_{h=1}^{M} b_{hj} r_h, \;\; j = 1, 2, \ldots, N, \tag{2.3}$$

where $c_j = C_j/q_j$ is average cost. I assume that $a_{ij} \geq 0$ and $b_{hj} \geq 0$.

Prices are set by adding a mark-up to average cost:

$$p_j = k_j c_j, \;\; j = 1, 2, \ldots, N, \tag{2.4}$$

where k_j equals 1 + mark-up of industry j. The term k_j is called the mark-up factor or price-cost ratio. I assume that $k_j \geq 1$ and that it is independent of all output and input prices. We have from (2.3) and (2.4)

$$p_j = k_j \left(\sum_{i=1}^{N} a_{ij} p_j + \sum_{h=1}^{M} b_{hj} r_h \right), \;\; j = 1, 2, \ldots, N. \tag{2.5}$$

In matrix notation this reads

$$p = K(A'p + B'r), \tag{2.6}$$

where a prime denotes a transpose and K is the diagonal matrix with elements k_j. It follows that

$$p = (I - KA')^{-1} KB'r. \tag{2.7}$$

If we define average primary cost as

$$l_j = \sum_{h=1}^{M} b_{hj} r_h, \;\; j = 1, 2, \ldots, N,$$

then we can write equation (2.5) as

$$p_j = k_j\left(\sum_{i=1}^{N} a_{ij} p_j + l_j\right), \tag{2.8}$$

equation (2.6) as

$$p = K(A'p + l), \tag{2.9}$$

and equation (2.7) as

$$p = (I - KA')^{-1} Kl. \tag{2.10}$$

Commodity taxes

Commodity taxes can be introduced as follows. Let an ad valorem tax of τ_j be levied on product j. The buyer's price of good i is then

$$p_j^b = (1 + \tau_j)p_j = (1 + \tau_j)k_j c_j.$$

Thus ad valorem taxes can be included in the model by taking the mark-up factor inclusive of the tax rate; in other words profits are to be taken inclusive of ad valorem taxes.

A unit (specific) tax at the rate τ_j leads to

$$p_j^b = p_j + \tau_j = k_j c_j + \tau_j.$$

Thus a unit tax can be seen as an additional absolute profit margin. I assume that all commodity taxes paid by producers are ad valorem taxes and that the mark-up factors k_j include these taxes.

Value-added taxes (i.e. commodity taxes on final output) are easily incorporated by multiplication of the prices from (2.7) by the tax factors $(1 + \tau_j)$ so as to give prices for final buyers.

Two special cases

If in all industries pure profit, and thus the mark-up, is zero, then we have from (2.6)

$$p = A'p + B'r,$$

which is the input-output price model; see for example Woods (1978, Chapter 2). It follows that

$$p = (I - A')^{-1} B'r.$$

The matrix $(I - A')^{-1}$ is called the Leontief inverse and the matrix $(I - A')^{-1}B'$ the matrix of cumulated primary-input coefficients. A more elaborate version of this model where output prices may differ among destinations or uses, has been extensively analysed and applied by Donkers (1981, 1982). As I have said in the introduction, I assume throughout the chapter that output prices of an industry are the same for all destinations, i.e. there is no price differentiation.

If all industries have the same mark-up, i.e. $k_i = k_j$ for $i, j = 1, 2, \ldots, N$, then we can interpret equation (2.6) as a price model where the rate of profit on circulating capital is equal in all industries; this is the price model of the Classical economists; see Sraffa (1960), Schwartz (1961), Medio (1972), and Woods (1973, Chapter 3) for mathematical models.

Conditions for positive prices

To ensure that the price levels following from (2.10) are positive, three assumptions have to be made.

I assume that A is nonnegative and indecomposable;[4] then KA' is also nonnegative and indecomposable. Furthermore I assume that

$$\left.\begin{array}{l}\sum_{i=1}^{N} a_{ij} \leq \dfrac{1}{k_j}, \quad j = 1, 2, \ldots, N \\ \text{with strict inequality for at least one } j\end{array}\right\}, \tag{2.11}$$

and that $l \geq 0$. It then follows from Theorem 2.3 that $(I - KA')^{-1} > 0$; therefore, the price levels given by (2.10) are positive. The first two assumptions can be interpreted as follows.

Indecomposability of the input-output-coefficients matrix

If A is not indecomposable, then there is a set of industries whose products are not used as input by an industry outside the set; then A can be written, possibly after a permutation of industries, as

$$A = \begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix}$$

Thus the products of group 2 are not used as inputs in group 1. Partitioning p, l, and K conformably, we can write equation (2.9) as

$$p_1 = K_1(A'_{11} p_1 + l_1), \tag{2.12}$$

$$p_2 = K_2(A'_{22} p_2 + A'_{12} p_1 + l_2). \tag{2.13}$$

Thus the prices of group 1 are independent of the prices of group 2, whose products group 1 does not use; but the prices of group 2 are not independent of the prices of group 1. We can solve (2.12) for p_1; after substitution of this solution into (2.13) we can solve (2.13) for p_2. If A is not indecomposable, then some elements of $(I - KA')^{-1}$ are zero, and thus for a suitably chosen l some elements of p are zero.

[4] See Definition 2.1 of Appendix 2.1.

Assumption (2.11)

Assumption (2.11) can be interpreted as follows. Define the matrix W by

$$w_{ij} = \frac{p_i a_{ij}}{c_j}, \quad i, j = 1, 2, \ldots, N \tag{2.14}$$

or, in matrix notation,

$$W = PAC^{-1},$$

where P is the diagonal matrix with elements p_j, and C is the diagonal matrix with elements c_j, $j = 1, 2, \ldots, N$. Thus w_{ij} is the value share of intermediate input i in total cost of industry j. Note that $p > 0$ and thus $c = K^{-1}p > 0$; therefore C^{-1} exists.

In reality the following condition is always fulfilled:

$$\left.\begin{array}{l} \sum_{i=1}^{N} w_{ij} \leq 1, \quad j = 1, 2, \ldots, N \\ \text{with strict inequality for at least one } j \end{array}\right\}, \tag{2.15}$$

which means that the sum of the cost shares of the intermediate inputs is in no industry larger than one and in at least one industry less than one. It can be shown that, given that (2.15) holds, the units in which the outputs are measured can be transformed such that (2.11) holds. The proof goes as follows. If the units are transformed, then the input-output coefficients matrix after the transformation is

$$A^* = DAD^{-1},$$

where D is the diagonal matrix with the transformation factors. Condition (2.15) can be written as

$$W'\iota \leq \iota,$$

i.e.

$$C^{-1}A'P\iota \leq \iota.$$

Thus

$$P^{-1}A'P\iota \leq K^{-1}\iota.$$

Therefore, if we choose $D = P$, then condition (2.15) implies

$$A^{*\prime}\iota \leq K^{-1}\iota,$$

i.e. condition (2.11) holds for the transformed input-output coefficients matrix.

It can also be shown that (2.15) holds if the price levels are positive. By definition there holds

$$\sum_{i=1}^{N} w_{ij} + \frac{l_j}{c_j} = 1, \quad j = 1, 2, \ldots, N.$$

Now, $c = K^{-1}p > 0$ and $l \geq 0$. Thus $\sum_{i=1}^{N} w_{ij} \leq 1$ with strict inequality in at least one industry.

Comparative statics

Totally differentiating equation (2.5), dividing by p_j, and using (2.4), we get

$$\tilde{p}_j = \tilde{k}_j + \sum_{i=1}^{N} \frac{p_i a_{ij}}{c_j} \tilde{p}_i + \sum_{h=1}^{M} \frac{r_h b_{hj}}{c_j} \tilde{r}_h, \ j = 1, 2, \ldots, N,$$

where a tilde denotes a relative infinitesimal change [for example, $\tilde{p}_j = (\mathrm{d}p_j)/p_j$]. In matrix notation this equation reads

$$\tilde{p} = \tilde{k} + W'\tilde{p} + S'\tilde{r}, \tag{2.16}$$

where $\tilde{k}$ is the vector with elements $\tilde{k}_j$, W is the matrix with the cost shares of the intermediate inputs [see (2.14)], and S is the matrix with the cost shares of the primary inputs:

$$s_{hj} = \frac{r_h b_{hj}}{c_j}, \ \ h = 1, 2, \ldots, M, \ \ j = 1, 2, \ldots, N.$$

Therefore

$$\tilde{p} = (I - W')^{-1}(\tilde{k} + S'\tilde{r}). \tag{2.17}$$

The elements of the matrix $(I - W')^{-1}S'$, which are the elasticities of the output prices with respect to the primary-input prices, are called the *cumulated primary-cost coefficients*. It follows from (2.15) and Theorem 2.3 that

$$(I - W')^{-1} > 0; \tag{2.18}$$

therefore, all elasticities of output prices with respect to primary costs and mark-up factors are positive.

The sum of the cost shares in an industry is by definition one, i.e. $W'\iota + S'\iota = \iota$; therefore

$$(I - W')^{-1}S'\iota = \iota, \tag{2.19}$$

i.e.

$$\sum_{h=1}^{M} \frac{\partial \log p_j}{\partial \log r_h} = 1, \ \ j = 1, 2, \ldots, N.$$

Thus equation (2.17) is homogeneous of degree one in the primary-input prices, and all elasticities with respect to primary-input prices lie between zero and one.

If we substitute

$$\tilde{l} = (S^*)^{-1}S'\tilde{r},$$

where S^* is the diagonal matrix with as elements the primary-cost shares l_j/c_j, into

(2.17), we can compute the elasticities with respect to primary cost:

$$\tilde{p} = (I - W')^{-1}(\tilde{k} + S^{*}\tilde{l}).$$

Because $S^{*}\iota = S'\iota$, we have $(I - W')^{-1}S^{*}\iota = \iota$, i.e.

$$\sum_{i=1}^{N} \frac{\partial \log p_j}{\partial \log l_i} = 1, \quad j = 1, 2, \ldots, N.$$

Therefore all elasticities with respect to primary cost lie between zero and one.

Because a diagonal element of $(I - W')^{-1}$ is not smaller than the off-diagonal elements in the same column (see Theorem 2.6), we have

$$\frac{\partial \log p_j}{\partial \log l_j} \geq \frac{\partial \log p_i}{\partial \log l_j}, \quad i, j = 1, 2, \ldots, N$$

and

$$\frac{\partial \log p_j}{\partial \log k_j} \geq \frac{\partial \log p_i}{\partial \log k_j}, \quad i, j = 1, 2, \ldots, N.$$

Thus an increase in primary cost or a mark-up factor of an industry leads to higher output prices in all industries; the increase in price is largest in the industry where the change occurred; but the output-price changes are never larger than the original change in primary cost or mark-up factor.

Comparative statics with indexation of wage rates

Let wage rates be indexed to a consumer price index

$$\tilde{p}_c = g'\tilde{p} + g_r'\tilde{r}_c, \tag{2.20}$$

where $\tilde{r}_c$ is the vector containing the changes in the prices of the primary inputs for consumer expenditure (for example imported consumer goods) and g and g_r are vectors containing weights such that $g \geq 0$, $g_r \geq 0$, and $g'\iota + g_r'\iota = \iota$.

The change in the wage rate is the sum of the changes in the real wage rate and the consumer price index:

$$\tilde{r}_1 = \tilde{\gamma} + \tilde{p}_c, \tag{2.21}$$

where labour is taken as the primary input with index 1 and γ is the real wage rate. I assume that the real wage rate is independent of the output prices. For simplicity I also assume that the wage rate is the same in all industries; the extension to different wage rates is fairly straightforward, in particular if the primary-cost formulation (2.8) is used. We have

$$S'\tilde{r} = s_1\tilde{r}_1 + S_2'\tilde{r}_2, \tag{2.22}$$

where s_1 is the first column of S', S_2' contains the last $M - 1$ columns of S', and r_2 is the vector with primary-input prices other than the wage rate.

Using (2.20), (2.21), and (2.22) we get from (2.16)

$$\tilde{p} = \tilde{k} + W'\tilde{p} + s_1\tilde{\gamma} + s_1 g'\tilde{p} + s_1 g_r'\tilde{r}_c + S_2'\tilde{r}_{2.}$$

Therefore

$$\tilde{p} = (I - W' - s_1 g')^{-1}(\tilde{k} + s_1\tilde{\gamma} + s_1 g_r'\tilde{r}_c + S_2'\tilde{r}_2). \tag{2.23}$$

Because $W' + s_1 g' > W'$, we have from Theorem 2.5

$$(I - W' - s_1 g')^{-1} > (I - W')^{-1}.$$

The elasticities in the model with indexation (2.23) are therefore larger than those in the model without indexation (2.17). Thus price increases caused by an increase in mark-up factors or in primary-input prices other than the wage rate, are higher when the wage rate is indexed than when the wage rate is not indexed.

2.2. Dynamic model

This section deals with the stability of a model in which output prices depend on prices of the current and previous periods. I shall analyse a model with a one-period lag on the assumption that all primary-input prices are growing at the same constant rate; the results for a more general model where the lag is arbitrary and the growth rates may differ among primary inputs will be given without proof.

I assume that cost changes are reflected in output prices one period later. Thus

$$p_t = K(A'p_{t-1} + B'r_{t-1}). \tag{2.24}$$

Suppose the price of every primary input grows with a constant growth factor α:

$$r_t = \alpha^t r_0.$$

The difference equation (2.24) then becomes

$$p_t = KA'p_{t-1} + \alpha^t KB'r_0. \tag{2.25}$$

Solution

The solution of equation (2.25) is the sum of a particular solution and the solution of the homogeneous part.[5] The solution of the homogeneous part

$$p_t^h = KA'p_{t-1}^h$$

is found by iteration:

$$p_t^h = (KA')^t p_0^h. \tag{2.26}$$

A particular solution can be found by trying

$$p_t^* = \alpha^t p_0^*.$$

[5] The reader is referred to Appendix 2.2 for a survey of difference equations.

Substituting this into (2.25) and rearranging, we get

$$p_0^* = (\alpha I - KA')^{-1} KB' r_0.$$

Therefore a particular solution is

$$p_t^* = \alpha^t (\alpha I - KA')^{-1} KB' r_0. \tag{2.27}$$

A sufficient condition for $(\alpha I - KA')^{-1}$, and thus for the particular solution, to be positive is

$$\left.\begin{array}{l} \sum_{i=1}^{N} a_{ij} \le \dfrac{\alpha}{k_j}, \quad j = 1, 2, \ldots, N \\ \text{with strict inequality for at least one } j \end{array}\right\}. \tag{2.28}$$

I assume that this condition holds. Note that if $\alpha \ge 1$, condition (2.28) is implied by (2.11).

The solution of (2.25) is the sum of (2.26) and (2.27):

$$\begin{aligned} p_t &= p_t^h + p_t^* \\ &= (KA')^t p_0^h + \alpha^t (\alpha I - KA')^{-1} KB' r_0. \end{aligned}$$

For $t = 0$ this yields

$$p_0^h = p_0 - (\alpha I - KA')^{-1} KB' r_0.$$

The general solution of (2.25) is therefore

$$p_t = (KA')^t [p_0 - (\alpha I - KA')^{-1} KB' r_0] + \alpha^t (\alpha I - KA')^{-1} KB' r_0. \tag{2.29}$$

Stability

It follows from (2.28) and Theorem 2.3 that α is strictly larger than the largest characteristic root of KA'. From Theorem 2.9 we then have that

$$\lim_{t\to\infty} \frac{\alpha^t p_{0j}^*}{p_{0j}} = 1, \quad j = 1, 2, \ldots, N. \tag{2.30}$$

Thus all output prices grow in the limit at the same growth rate, namely the growth rate of the primary-input prices. Therefore we call $p_t^* = \alpha^t p_0^*$ a *balanced growth path*, and because of (2.30) we call it *relatively stable*.

Consider as an example the case where r_t is constant for $t < 0$, changes at $t = 0$ to r_0, and remains constant at the new level r_0 for $t > 0$; then $\alpha = 1$. It follows from (2.29) that

$$p_t = (KA')^t [p_0 - (I - KA')^{-1} KB' r_0] + (I - KA')^{-1} KB' r_0.$$

If (2.28) holds, which amounts in this example to (2.11), then p_t will converge to its new, positive, equilibrium $(I - KA')^{-1}KB'r_0$.

Generalizations

Generalizations of model (2.25) and its results are possible in two directions.[6] Firstly, we may allow the growth rates of the primary-input prices to differ among inputs; secondly, we may allow for an arbitrary distributed lag in (2.24).

If the growth factors (α_h, $h = 1, 2, \ldots, M$) of the primary-input prices differ, then we define $\alpha = \max_h \alpha_h$. If (2.28) holds for this α, then it can be shown that (2.30) holds. Thus in the limit all output prices grow with the same growth rate, namely the maximum of the growth rates of the primary-input prices.

If output prices are an arbitrary distributed lag of costs, then (2.24) changes to

$$p_t = K(\sum_{\tau=0}^{u} A'_\tau p_{t-\tau} + B'_\tau r_{t-\tau}), \tag{2.31}$$

where u is the maximum lag length.

I assume that

$$A_\tau \geqq 0, \quad \tau = 0, 1, \ldots, u,$$

$$\sum_{\tau=0}^{u} A_\tau = A, \tag{2.32}$$

$$B_\tau \geqq 0, \quad \tau = 0, 1, \ldots, u,$$

$$\sum_{\tau=0}^{u} B_\tau = B. \tag{2.33}$$

The assumptions (2.32) and (2.33) ensure that the long-run solution of (2.31) is the same as those of (2.6) and (2.24). Let the prices of the primary inputs grow at a constant rate and let (2.28) hold for $\alpha = \max_h \alpha_h$. It can be shown that if $\alpha \geq 1$ all output prices grow in the limit at the same rate, namely the maximum growth rate $(\alpha - 1)$ of the primary-input prices. Note it is required here that $\alpha \geq 1$, whereas this is not needed for the relative stability of (2.25).

2.3. Summary

I have analysed an interindustry model where output prices are set by adding a constant mark-up to average cost; the technology is of the Leontief type, so that average cost is a linear function of the input prices.

Two conditions are together sufficient for positive output prices in the static version of this model. Firstly, the matrix of intermediate deliveries must be indecomposable,

[6] Proofs of the results that follow are not very illuminating and are therefore omitted. The proofs are analogous to the proofs of similar properties of dynamic input-output models; see Woods (1978, Chapters 4 and 5).

i.e. all industries must be, directly or indirectly, connected via intermediate deliveries. Secondly, the sum of the intermediate input-output coefficients must in no industry be larger than the inverse of the mark-up factor, and in at least one industry it must be smaller.

These two conditions make it also possible to derive definite comparative-statics results. If in an industry primary cost or the mark-up factor increases, then the output prices of all industries will increase, the change in output price is largest in the industry where the disturbance occurred, but in no industry is the change in output price larger than the change in primary cost or mark-up factor that caused the disturbance. If the price of a primary input is indexed to the output prices, then the output price changes due to a disturbance are larger than if there is no indexation.

For the dynamic version of the model, where the output prices are a distributed lag of the input prices, the conditions for stability are similar to the conditions for positive output prices in the static model; only the upperbound for the sum of the intermediate input-output coefficients is now the ratio of the maximum growth factor of the primary-input prices and the mark-up factor. If the stability conditions hold, then every output price will eventually grow with the same growth rate, namely the maximum of the growth rates of the primary-input prices.

Appendix 2.1. Nonnegative matrices

Some theorems on nonnegative matrices that are used in the main text are stated, but no attempt is made to give a complete survey. The reader is referred to Takayama (1973, Chapter 4) and Woods (1978, Chapter 2) for a fuller treatment.

Definition 2.1 Let A be a square matrix. A is *decomposable* if there exists a permutation of rows, such that with the same permutation of columns A can be written as

$$\begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix}$$

with A_{11} and A_{22} square. A is *indecomposable* if A is not decomposable.

Theorem 2.1 (Perron-Frobenius) Let A be a square nonnegative matrix. Then

1. A has a real characteristic root $\lambda^*(A) \geq 0$ with characteristic vector $x^* \geq 0$.
2. For any other characteristic value λ_i of A there holds $|\lambda_i| \leq \lambda^*(A)$.
3. Let B be a matrix such that $A \geq B \geq 0$. Then $\lambda^*(A) \geq \lambda^*(B)$.

If in addition A is indecomposable, then

4. $\lambda^*(A)$ is unique and positive [i.e. $\lambda^*(A) > 0$ and $|\lambda_i| < \lambda^*(A)$]; the corresponding characteristic vector x^* is positive and unique up to a scalar.
5. If $A \geq B \geq 0$ then $\lambda^*(A) > \lambda^*$.

Proof See Takayama (1973, pp. 372-5). □

Definition 2.2 $\lambda^*(A)$ is called the *Frobenius root* of A.

Theorem 2.2 Let A be a square nonnegative matrix and α a scalar. Then $(\alpha I - A)^{-1} \geq 0$ if and only if $\alpha > \lambda^*(A)$. If in addition A is indecomposable then $(\alpha I - A)^{-1} > 0$ if and only if $\alpha > \lambda^*(A)$.

Proof See Takayama (1973, pp. 385 and 387). □

Theorem 2.3 Let A be a nonnegative indecomposable (n, n)-matrix. Define $S_j = \sum_{i=1}^{n} a_{ij}$ for $j = 1, 2, \ldots, n$ and $R_i = \sum_{j=1}^{n} a_{ij}$ for $i = 1, 2, \ldots, n$.

If either $\alpha \geq S_j$ for all j with strict inequality for at least one j or $\alpha \geq R_i$ for all i with strict inequality for at least one i, then $\alpha > \lambda^*(A)$ and $(\alpha I - A)^{-1} > 0$.

Proof See Takayama (1973, p. 388-9). □

Theorem 2.4 Let A be a square matrix and $\alpha > 0$ a scalar such that $(\alpha I - A)^{-1} \geq 0$. Then

$$(\alpha I - A)^{-1} = \frac{1}{\alpha} \sum_{k=0}^{\infty} \frac{A^k}{\alpha^k}.$$

Proof See Woods (1978, p. 71). □

Theorem 2.5 Let A be an indecomposable matrix and $\alpha > 0$ a scalar such that $(\alpha I - A)^{-1} > 0$. Let B be an indecomposable matrix such that $A > B \geq 0$. Then $(\alpha I - B)^{-1} > 0$ and $(\alpha I - A)^{-1} > (\alpha I - B)^{-1}$.

Proof We have from Theorem 2.2: $\alpha > \lambda^*(A)$ and from Theorem 2.1: $\lambda^*(A) > \lambda^*(B)$. Thus $\alpha > \lambda^*(B)$ and therefore $(\alpha I - B)^{-1} > 0$. Applying the series expansion given in Theorem 2.4 to $(\alpha I - A)^{-1}$ and $(\alpha I - B)^{-1}$, we get $(\alpha I - A)^{-1} > (\alpha I - B)^{-1}$. □

Theorem 2.6 Let A be a nonnegative (n, n)-matrix and let $B = (I - A)^{-1} > 0$. Then for all i we have $b_{ii} \geq b_{ji}$ for $j = 1, 2, \ldots, n$.

Proof See Woods (1978, pp. 39-40). □

Appendix 2.2. Difference equations

This Appendix contains a short treatment of difference equations and their stability. A fuller treatment is given by Samuelson (1947, Appendix B), Goldberg (1956), Takayama (1973, pp. 507-17), and Woods (1978, pp. 139-61).

Consider the homogeneous difference equation

$$x_t = Ax_{t-1}, \quad t = 1, 2, \ldots,$$

where x_t and x_{t-1} are $(n, 1)$-vectors and A is a (n, n)-matrix. By iterating the equation we find that its solution is

$$x_t = A^t x_0, \quad t = 1, 2, \ldots,$$

where x_0 is the initial value. Suppose A has n distinct real roots λ_j with real characteristic vectors x^j, $j = 1, 2, \ldots, n$. It can be shown that the solution can be written as

$$x_t = \sum_{j=1}^{n} \beta_j \lambda_j^t x^j, \tag{2.34}$$

where the β_j, $j = 1, 2, \ldots, n$, are scalars determined by the initial condition.

Definition 2.3 The difference equation $x_t = Ax_{t-1}$ is *stable* if $\lim_{t\to\infty} x_t = 0$ for any initial condition.

It follows from (2.34) that if A has n distinct real roots, then $x_t = Ax_{t-1}$ is stable if $|\lambda_j| < 1$ for $j = 1, 2, \ldots, n$. It can be shown that the same holds if A has multiple and complex roots. Thus the following theorem holds.

Theorem 2.7 The solution of the difference equation $x_t = Ax_{t-1}$ is stable if and only if the modulus of each root of A is less than 1.

Suppose that $x_t^* = \mu^t \bar{x}$ with μ a scalar is a particular solution of $x_t = Ax_{t-1}$; thus every component of x_t^* grows with growth factor μ. The solution $x_t^* = \mu^t \bar{x}$ is called a *balanced growth path*.

Definition 2.4 If every solution of $x_t = Ax_{t-1}$ converges to the balanced growth path $x_t^* = \mu^t \bar{x}$, in the sense that for every initial condition

$$\lim_{t\to\infty} \frac{x_{jt}}{x_{jt}^*} = c, \quad j = 1, 2, \ldots, n,$$

with c a constant independent of j, then the balanced growth path is *relatively stable*.

It is clear from (2.34) that the following theorem holds if A has n distinct real roots; the theorem also holds if A has multiple or complex roots, but at least one real root.

Theorem 2.8 There exists a balanced growth path for the difference equation $x_t =$

Ax_{t-1} if and only if there exists a real root λ_i of A such that $|\lambda_i| \geq |\lambda_j|$ for $j = 1, 2, \ldots, n$.

We now consider the inhomogeneous difference equation

$$x_t = Ax_{t-1} + f_t. \tag{2.35}$$

It can be proved that the general solution of (2.35) is equal to the sum of a particular solution and the solution of the homogeneous difference equation $x_t^{hom} = Ax_{t-1}^{hom}$. The solution of $x_t^{hom} = Ax_{t-1}^{hom}$ is of course $x_t^{hom} = A^t x_0^{hom}$. A particular solution can often be found by trying a formula for x_t that resembles the form of f_t. I shall look only at the case where f_t is given by

$$f_t = \alpha^t f_0,$$

where α is a scalar.

Try the particular solution $x_t^{part} = \alpha^t x_0^{part}$ and substitute this in (2.35):

$$\alpha^t x_0^{part} = \alpha^{t-1} x_0^{part} + \alpha^t f_0.$$

Assuming that α is not a root of A,[7] we obtain

$$x_0^{part} = \alpha(\alpha I - A)^{-1} f_0.$$

The solution of (2.35) is therefore

$$x_t = A^t x_0^{hom} + \alpha^{t+1}(\alpha I - A)^{-1} f_0.$$

Taking $t = 0$, we get

$$x_0 = x_0^{hom} + \alpha(\alpha I - A)^{-1} f_0;$$

thus

$$x_0^{hom} = x_0 - \alpha(\alpha I - A)^{-1} f_0.$$

The general solution of (2.35) is therefore

$$x_t = A^t[x_0 - \alpha(\alpha I - A)^{-1} f_0] + \alpha^{t+1}(\alpha I - A)^{-1} f_0. \tag{2.36}$$

The first term on the right-hand side of (2.36) can be written as $\sum_{j=1}^n \beta_j \lambda_j^t x^j$. It follows that (2.36) is relatively stable either if $|\alpha| > |\lambda_j|$ for $j = 1, 2, \ldots, n$ or if there exists a real root λ_i such that $|\lambda_i| > |\lambda_j|$ for $j = 1, 2, \ldots, n$, $j \neq i$ and $|\lambda_i| > |\alpha|$. If the first condition holds, then the balanced growth path is $\alpha^t(\alpha I - A)^{-1} f_0$; if the second condition holds, then the balanced growth path is $\lambda_i^t x^i$.

The condition for relative stability given above also holds when A has at least one real root.

[7] It appears that if α is a root of A we cannot obtain a particular solution without knowing the numerical values of A, α, and f_0.

Theorem 2.9 There exists a relatively-stable balanced-growth path for the difference equation

$$x_t = Ax_{t-1} + \alpha^t f_0$$

if and only if either there exists a real root λ_i such that $|\lambda_i| \geq |\lambda_j|$ for $j = 1, 2, \ldots, n$ and $|\lambda_i| \geq |\alpha|$ or $|\alpha| \geq |\lambda_j|$ for $j = 1, 2, \ldots, n$.

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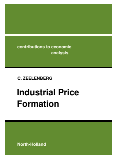

CHAPTER 3

Dynamics of price formation

In this chapter I shall analyse and apply a model where firms set prices by adding a constant mark-up to historic cost. The lag between cost and price changes is in such a model related to the production-period, i.e. the time between receipt of the materials and shipment of the finished product. Because output prices then depend on cost of the previous periods, the model is a version of model (2.31) in Section 2.2.

In Section 3.1 the production-period is investigated; formulae are derived whereby the production-period can be computed from data on stocks and output, shipments, and consumption of materials; estimates of the production-period by industry are given for the years 1974-1980.

In Section 3.2 the total production-period is introduced; it measures the average time that is needed to produce a final product including the time needed to produce the necessary inputs.

In Section 3.3 a model of historic-cost pricing is described; it is shown that the total production-period of an industry is a weighted average of the mean lags between the industry's output price and the primary-input prices.

In Section 3.4 the movement of output prices under historic-cost pricing is simulated for several changes in primary-input prices: a general wage increase of 10 per cent, an increase of 10 per cent in crude oil prices, and an increase of 10 per cent in all import prices.

3.1. The production-period

The *production-period* is defined as the time between receipt of the materials and shipment of the finished products. I shall study the production-period in a firm that produces to stock;[1] then the production-period can be divided into three parts: the time from the moment the materials are received until the moment they enter the production process (the *waiting time of materials*), the time from the start until the end of the production process (the *physical production-period*), and the time from the end of the production process until the shipment of the finished product (the *waiting time of finished products*). In Figure 3.1, at t_0 the materials are delivered, at t_1 the production-period is started, at t_2 it is ended, and at t_3 the finished product is shipped.

Thus, the period (t_0, t_1) is the waiting time of materials, (t_1, t_2) is the physical production-period, and (t_2, t_3) is the waiting time of finished products; they will be

[1] A similar analysis can be made for a firm producing to order. It can be shown that the formulae that are below derived for a firm producing to stock also hold for a firm producing to order.

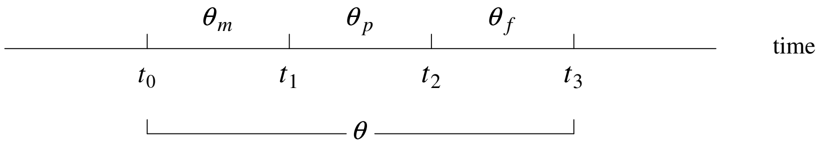

Figure 3.1 *Composition of the production-period*

denoted by θ_m, θ_p, and θ_f respectively. The production-period, θ, is the sum of its three parts:

$$\theta = \theta_m + \theta_p + \theta_f. \tag{3.1}$$

Note that the production-period is defined as the time between delivery of the materials and shipment of the finished products and not as the time between buying the materials and selling the finished products. This is done because I wish to measure cost or price changes at date of delivery or date of shipment; this accords with the practice of the Netherlands Central Bureau of Statistics.

The waiting time of materials

I assume that the firm holds a constant stock of materials, that its consumption of materials per unit of time is constant, and that it uses the FIFO (first-in, first-out) system. Thus the materials that enter the stock at time t_0 will leave the stock at time $t_0 + \theta_m$. The stock of materials of this firm is depicted in Figure 3.2, where U is the consumption of materials per unit of time. We see that the stock of materials, G, is equal to

$$G = \theta_m U.$$

Thus

$$\theta_m = \frac{G}{U}. \tag{3.2}$$

Figure 3.2 *Stock of materials*

The physical production-period[2]

During the physical production-period materials and other inputs such as labour and capital are gradually added until at the end the finished product appears. Assuming that the rate of addition and the rate of output are constant, we can show the production process of a single product as in Figure 3.3 and work-in-process at time t_1 as in Figure 3.4.

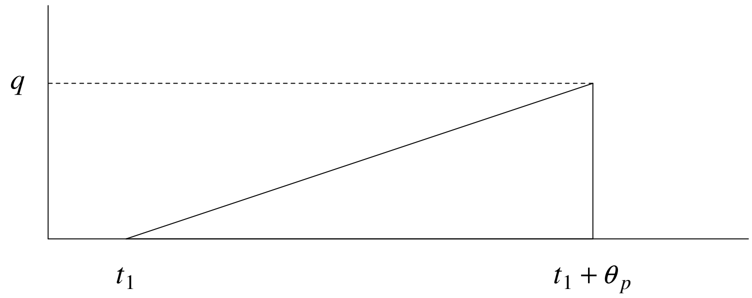

Figure 3.3 *Production process of a single product*

For example, of the product that will appear as finished at time $t_1 + \tau$ an amount of Z_τ is completed at time t_1. Thus at time t_1 total stocks of work-in-process, Z, are equal to the shaded area in Figure 3.4. Therefore we have

[2] This subsection draws upon Abramovitz (1950, pp. 171-5), Carlson (1973) and Coutts, Godley, and Nordhaus (1978, Chapter 3).

$$Z = \frac{1}{2}\,\theta_p q$$

and thus

$$\theta_p = 2\,\frac{Z}{q}\,. \tag{3.3}$$

Equation (3.3) allows us to compute the physical production-period from data on output and stocks of work-in-process.

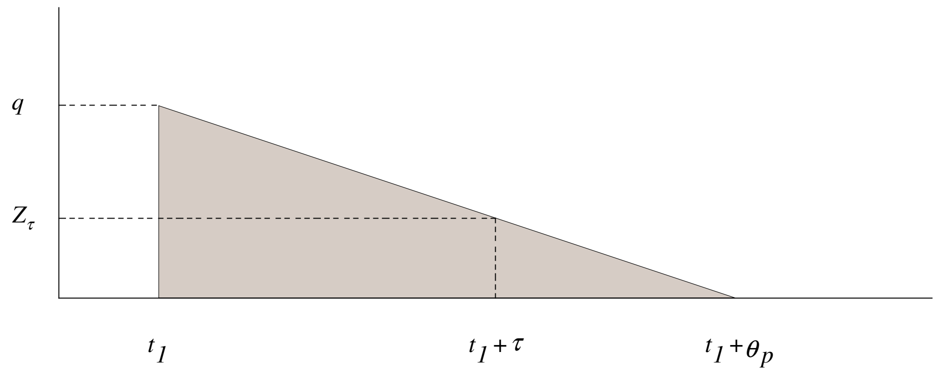

Figure 3.4 *Work-in-process at time t_1*

The waiting time of finished products

I assume that the firm holds a constant stock of finished products, that the rate of shipments per unit of time is constant, and that it uses the FIFO system. Thus the finished products that enter the stock at time t_2 will leave the stock at time $t_2 + \theta_f$. The stock of materials of this firm is depicted in Figure 3.5, where X is the rate of shipments. Thus the stock of finished products is equal to

$$F = \theta_f X$$

and thus

$$\theta_f = \frac{F}{X}\,. \tag{3.4}$$

Figure 3.5 *Stock of finished products*

Limitations

There are several reasons why formulae (3.2), (3.3), and (3.4) give only an approximation to the components of the production-period:
- production and shipment are not constant, but vary over time;
- some inputs may be added at the beginning;
- there may be internal deliveries within firms.

It is possible to take these considerations into account: see Carlson (1973, p. 75) and Coutts, Godley, and Nordhaus (1978, pp. 53-5). They show that if some inputs are added at the beginning, then the physical production-period is shorter than (3.3) indicates; if *all* inputs are added at the beginning, there holds $\theta_p = Z/X$. Carlson shows that one cannot indicate how the production-period changes if the other two considerations are accounted for.

Some other limitations arise if we use value data by industry instead of quantity data by firm:
- there may be internal deliveries within an industry, so that some finished products are in fact work-in-process;
- the prices used in valuing the stocks may not be equal to the prices used in valuing the other data;
- firms need not attribute profit in the valuation of stocks (see the next subsection).

The second consideration may be illustrated as follows for the physical production-period. We wish to compute

$$\theta_p = \frac{Z}{q},$$

but we are computing

$$\theta_p' = \frac{p_z Z}{p_q q},$$

where p_z is the price used to value stocks, and p_q is the output price. Because most firms in the Netherlands value stocks at the lowest of historic-cost price and market value (see below), there holds in times of inflation $p_z < p_q$ and thus $\theta'_p < \theta_p$.

Measurement of stocks[3]

In the next subsection I shall use balance-sheet data on stocks to compute the production-period. It is useful, therefore, to review briefly the systems by which stocks are valued on the balance sheet. The courts allow two basic systems for the valuation of stocks.[4]

Under the first system, stocks may be valued in one of three ways: at historic prices, at market value on balance-sheet-day, or at the lowest of these two; market value is equal to purchase price, unless sales price is considerably lower. The firm may change the way in which stocks are valued, though not for one year only. The value of work-in-process must include the cost of labour and materials expended and allowances for general costs and depreciation of equipment; however, profit and depreciation of buildings may be excluded. Farmers may value work-in-process at zero.

Under the second system, stocks may be valued either at replacement prices or at fixed base-year prices. Because the courts have restricted the use of this system in the profits-and-loss-account, it is not much used in the balance sheet either: in 1971 only 5 per cent of the companies quoted at the Amsterdam Stock Exchange valued stocks in this way [see Klaassen (1975, p. 67)].

The production-period in the Netherlands, 1974-1980

In Table 3.1 I give the length of the production-period by industry for the years 1974-1979 and, where data are available, for 1980. The production-period is computed by means of formulae (3.1)-(3.4). The necessary data have been taken mainly from the yearly Production Statistics published by the Netherlands Central Bureau of Statistics (CBS).[5] The average stock during the year has been approximated by the average of the stock at the beginning of the year and the stock at the end of the year.

It appears from Table 3.1 that the production-period is fairly stable over time, at least when it is rounded off to integers; also, the length of the production-period over industries does not seem implausible. For some industries there are data available for the years 1948-1974; it appears that, apart from cyclical fluctuations, the production-period has been reasonably stable over these years.

In Table 3.2 it is shown how the three parts contribute to the production-period. The length of the physical production-period is not inconsistent with what might a priori be expected.

[3] See Slot (1977) and Sanders, Groeneveld, and Burgert (1975, pp. 176-90).

[4] The laws stipulate only that stocks are to be valued according to the ‘good practices of the trade’.

[5] The sources of the data are given in Appendix C.1.

Table 3.1 *Production-period (in months), 1974-1980*

	1974	1975	1976	1977	1978	1979	1980	average 1974-1980
1. Agriculture	.	.	5.7	5.9	6.3	6.7	.	6.2
2. Other mining	.	.	.	.	.	.	.	.
3. Meat and dairy	0.8	0.7	0.7	0.6	0.7	0.7	.	0.7
4. Other food	1.3	1.5	1.4	1.4	1.5	1.5	.	1.4
5. Drink and tobacco	5.7	5.4	5.3	5.0	5.4	5.2	.	5.3
6. Textiles	4.8	5.6	5.2	5.2	5.0	4.8	4.8	5.1
7. Clothing	3.6	4.0	3.7	3.9	3.8	4.0	.	3.8
8. Leather, footwear	3.8	4.0	3.6	3.8	3.8	3.9	4.1	3.8
9. Timber, furniture	4.3	4.7	4.3	4.2	4.1	4.5	.	4.3
10. Paper	2.2	2.9	2.5	2.4	2.4	2.4	2.2	2.4
11. Printing, publishing	2.8	3.1	2.7	2.6	2.2	2.3	2.4	2.6
12. Gas and oil	.	.	.	.	.	.	2.6	2.6
13. Chemical, allied prod.	2.2	3.2	2.3	2.5	2.5	2.2	.	2.5
14. Stone, clay, glass	3.0	3.1	2.8	2.7	2.7	3.0	3.1	2.9
15. Primary metal prod.	4.0[a]	.	.	.	.	.	.	4.0
16. Metal prod., mach.	6.5	7.4	7.5	7.6	7.8	7.2	.	7.3
17. Electrical products	7.5	8.6	8.4	8.3	7.9	7.4	.	8.0
18. Transport equipment	9.6	10.0	9.1	9.6	10.9	10.0	.	9.8
19. Optical, other prod.	.	.	.	.	.	.	.	.
20. Electr., gas, water	.	.	0.5	0.4	0.5	0.5	.	0.5
21. Construction	.	.	.	11.8	12.0	13.4	13.0	12.6
22-34. Other industries	.	.	.	.	.	.	.	.

Source: see Appendix C.1.
[a] 1971

It may be of some interest to compare the production-period in the Netherlands with that in other countries; this is done in Tables 3.3 and 3.4 for the UK and the US, respectively. Because the data for these two countries are not detailed enough (the sources are secondary), the production-period is computed in Table 3.3 as $2(G + Z + F)/X$, whereas in Table 3.4 the physical production-period is given; in both cases the stocks refer to the end of the year. It appears that production-periods in the Netherlands are generally somewhat shorter than those in the UK and are longer than those in the US. A part of the difference may be ascribed to differences in accounting practices, to cyclical factors, or to differences in industrial classification. For Machinery and Electrical products, however, the difference between the Netherlands and the United Kingdom on the one hand and the United States on the other hand is remarkably large; I have been unable to find an explanation for this

Table 3.2 *Composition of the production-period (in months), average 1974-1980*

	Waiting time of materials	Physical production period	Waiting time of finished products	Production period[a]
1. Agriculture	.	5.9	0.2	6.2
2. Other mining	.	.	.	.
3. Meat and dairy	0.2	0.0	0.4	0.7
4. Other food	0.8	0.0	0.6	1.4
5. Drink and tobacco	4.2	0.6	0.5	5.3
6. Textiles	2.3	1.3	1.4	5.1
7. Clothing	2.0	0.9	0.9	3.8
8. Leather, footwear	1.9	1.1	0.9	3.8
9. Timber, furniture	2.8	1.0	0.6	4.3
10. Paper	1.5	0.2	0.6	2.4
11. Printing, publishing	1.6	0.6	0.3	2.6
12. Gas and oil	1.3	.	1.3	2.6
13. Chemical, allied prod.	1.2	0.3	1.0	2.5
14. Stone, clay, glass	1.3	0.5	1.1	2.9
15. Primary metal products	1.8	0.9	1.4	4.0
16. Metal prod., mach.	2.5	4.3	0.5	7.3
17. Electrical products	2.6	4.0	1.4	8.0
18. Transport equipment	2.2	7.3	0.3	9.8
19. Optical, other prod.	.	.	.	.
20. Electr., gas, water	0.5	.	.	0.5
21. Construction	.	12.6	.	12.6
22-34. Other industries	.	.	.	.

Source: see Appendix C.1.
[a] May not be equal to the sum of the first three columns because of rounding errors.

difference.

3.2. The total production-period of final products

The figures in Table 3.1 refer to the production-period of a single industry; however, because a part of the inputs is itself produced, the total production-period of final products is longer. I assume that the production-period of primary inputs is zero, except that of imported materials, which have a production-period equal to the waiting time of materials. Then we have

Table 3.3 *Production period (in months) in the Netherlands and the United Kingdom, 1963*

	Netherlands	United Kingdom
Textiles	7.2	8.6
Clothing and footwear	4.4	4.5
Paper	3.1	6.4
Machinery	12.0[a]	10.6
Electrical products	8.6	11.2

Source: Netherlands: see Appendix C.1; United Kingdom: computed from Table 3.1 in Coutts, Godley, and Nordhaus (1978, p. 40).
[a] Including structural engineering.

$$\phi_j = \theta_j + \sum_{i=1}^{N} a_{ij}\phi_i - \sum_{h=2}^{M} b_{hj}\theta_{mj}, \; j = 1, 2, \ldots, N, \tag{3.5}$$

where ϕ_j is the total production-period of industry j, a_{ij} and b_{hj} are input coefficients (a_{ij} is the amount of good i and b_{hj} the amount of primary input h that is used for a unit production of industry j), and import of materials is taken as the primary input with index $h = 1$.

In matrix notation equation (3.5) reads

$$\phi = \theta + A'\phi - B_2^*\theta_m,$$

where B_2^* is the diagonal matrix with elements $b_{2jj}^* = \sum_{h=2}^{M} b_{hj}$, $j = 1, 2, \ldots, N$. Thus

$$\phi = (I - A')^{-1}(\theta - B_2^*\theta_m). \tag{3.6}$$

By Theorem 2.5 of Appendix 2.1 we have $(I - A')^{-1} \geq I$ and thus $\phi \geq \theta - B_2^*\theta_m$.

The total production-period measures the average time that a final product has been on its way through the economic system; alternatively, it can be seen as the average time that the product of a primary input will be on its way through the economic system.

One-good/one-factor example

These two interpretations may be illustrated with a one-good/one-factor factor model, where output is partly final output and partly input that produces, with labour, θ months later again output. I assume that the waiting time of materials θ_m is zero. Thus equation (3.6) reduces to

$$\phi = (I - A')^{-1}\theta = \frac{\theta}{1 - a},$$

Table 3.4 *Physical production-period (in months) in the Netherlands and the United States, 1965*

	Netherlands	United States
Tobacco	0.2	0.2
Textiles	1.8	1.0
Clothing	0.8	0.6
Leather and footwear	1.4	0.7
Paper	0.2	0.3
Printing and publishing	1.2[a]	0.5
Rubber and plastic	0.6[b]	0.5
Stone, clay, and glass	1.4[c]	0.4
Metal products	1.3[d]	1.3
Machinery	8.8[e]	2.3
Electrical products	3.8	1.9
Transport equipment	8.0[f]	1.7

Source: Netherlands: see Appendix C.1; United States: Carlson (1973, p. 78, Table 1, column 1).
[a] Excluding publishing.
[b] Excluding plastic.
[c] Excluding glass.
[d] Excluding structural engineering.
[e] Including structural engineering.
[f] Excluding aircraft.

where a is the input-output coefficient. In Figure 3.6 a quantity q of output is produced at time t by inputs aq and $v = bq$ (where b is the primary-input-output coefficient), which have been entered at time $t - \theta$. To make a quantity aq available at time $t - \theta$, inputs a^2q and $av = abq$, were needed at time $t - 2\theta$; to make a quantity a^2q available at time $t - 2\theta$, inputs a^3q and $a^2v = a^2bq$ were needed at time $t - 3\theta$, etc. Thus the total product has been θ months on its way; a fraction a has been θ months longer on its way; a fraction a^2 has been again θ months longer on its way; etc. The average time the final product has been on its way is therefore $\theta + a\theta + a^2\theta + a^3\theta + \cdots = \theta/(1 - a)$.

In Figure 3.7 we see how the primary input labour that enters at time t runs through the system. Together with input aq it produces at time $t + \theta$ output q; a fraction $1 - a$ of this output is final output and a fraction a produces, together with labour, output q at time $t + 2\theta$; etc. Thus a fraction $1 - a$ of the product of of the labour entering at time t leaves the system (i.e. is final output) after θ months, a fraction $a(1 - a)$ after 2θ months, a fraction $a^2(1 - a)$ after 3θ months, etc. The average time the product of the original input is in the system is therefore $(1 - a)\theta + 2a(1 - a)\theta + 3a^2(1 - a)\theta + \cdots = \theta/(1 - a)$ [note that $\sum_{i=0}^{\infty} ia^{i-1} = \mathrm{d}(\sum_{i=0}^{\infty} a^i)/\mathrm{d}a =$

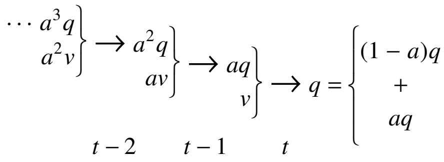

Figure 3.6 *Production process leading to output q at time t*

$1/(1 - a)^2$].

These interpretations of the total production-period originate with Böhm-Bawerk (1888, Vol. 2.1, pp. 117-20; Vol. 2.2, pp. 57-74), who takes in particular capital goods and their production-period into account. If we had enough information about consumption of capital goods by type in each industry, we could compute also Böhm-Bawerk's total production-period.

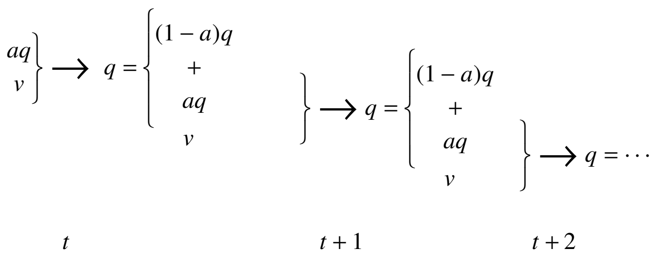

Figure 3.7 *Production process resulting from labour input v at time t*

The total production-periods of final expenditures and primary inputs

When there is more than one industry we can compute the total production-period of final expenditure categories, such as household consumption, capital formation, and exports, as a weighted average of the total production-periods of the industries, given by (3.6); the weight of an industry is the fraction it produces of the respective final expenditure category.

Similarly the total production-period of a primary input (i.e. the average time its product is on its way) can be computed as a weighted average of the total production-periods of the industries; the weight of an industry is the fraction it uses of the primary input.

The total production-period in the Netherlands

Before we can compute the total production-period by means of formula (3.6), we must make some changes in and additions to the data in Table 3.2. Firstly, some allowance must be made for the fact that a part of deliveries passes Distribution, which lengthens the waiting time of finished products. For Wholesale distribution I have computed the waiting time by type of product using data from the Census of Wholesale distribution in 1967, see CBS (1974-1975). If one takes into account that a part of deliveries does not pass Wholesale distribution, it appears that for almost all industries involved the additional waiting time of finished products can be set at 1 month. The data from the Production Statistics that are available for some parts of Wholesale distribution for 1978 and later years do not suggest that any marked change has occurred. For some parts of Retail distribution, accounting for about 50 per cent of Retail margins, data are available from the 1979 Production Statistics; for the other parts of Retail distribution the waiting time has been guessed. Note that the additional waiting time caused by Retail distribution affects only private consumer expenditure.

Secondly, we must guess the length of the production-period in the industries for which no data are available. For Other mining the production-period has been set at one month, for Optical and other products it has been set equal to the production-period in Metal products and machinery, and for all other industries it has been set at zero.

Except the input-output-coefficient matrices A and B, the data that are needed to compute the total production-period, are given in Table 3.5. The matrices A and B have been set equal to the 1975 matrices with cost shares, which are computed from CBS (1960-1983, Part 7, Table 21).[6] Thus the total production-period is computed as

$$\phi = (I - W')^{-1}(\theta - S_2^* \theta_m), \tag{3.7}$$

where W is the matrix with intermediate cost shares ($w_{ij} = p_i a_{ij} / c_j$, with p_i output price of industry i and c_j unit cost of industry j), S is the matrix with primary-cost shares ($s_{hj} = r_h b_{hj} / c_j$, with r_h price of primary input h), and S_2^* is the diagonal matrix with elements $S^*_{2\,jj} = \sum_{h=2}^{M} s_{hj}$.

In Table 3.6 I give the total production-period of the individual industries, the primary inputs, and the final expenditure categories. The figures in the table are

[6] I have made one adjustment to the original table. Because interest margin is treated as a negative input of the industry Banking and insurance, the sum of the cost shares of Banking and insurance is larger than one. Therefore I have changed interest margin from a negative input to a positive final output (delivery of Banking and insurance to the fictitious final buyer ‘Interest margin’).

Table 3.5 *Waiting time of materials, production-period, and waiting time in distribution (in months)*

	Waiting time of materials[a] (1)	Produ-ction-period[a] (2)	Waiting time in Wholesale distri-bution (3)	(4)= (2)+(3)	Waiting time in Retail distri-bution (5)
1. Agriculture	-	6.2	0.5	6.7	1
2. Other mining	-	1	0.2	1.2	0
3. Meat and dairy	0.2	0.7	0.5	1.2	0.4
4. Other food	0.8	1.4	0.6	2.0	0.8
5. Drink and tobacco	4.2	5.3	0.9	6.2	1.4
6. Textiles	2.3	5.1	1	6.1	3.0
7. Clothing	2.0	3.8	1	4.8	3.0
8. Leather, footwear	1.9	3.8	1	4.8	3.5
9. Timber, furniture	2.8	4.3	1	5.3	2
10. Paper	1.5	2.4	1	3.4	1
11. Printing, publishing	1.6	2.6	1	3.6	2.6
12. Gas and oil	1.3	2.6	0.5	3.1	1
13. Chemical, allied prod.	1.2	2.5	1	3.5	1
14. Stone, clay and glass	1.3	2.9	1	3.9	1
15. Primary metal prod.	1.8	4.0	1	5.0	1
16. Metal prod., mach.	2.5	7.3	1	8.3	2
17. Electrical products	2.6	8.0	1	9.0	2
18. Transport equipment	2.2	9.8	1	10.8	3
19. Other prod.	2.5	7.4	1	8.4	2
20. Electr., gas, water	0.5	0.5	-	0.5	-
21. Construction	-	12.6	-	12.6	-
22-34. Other industries	-	-	-	-	-

Source: see Appendix C.1.
[a] Average 1974-1980, from Tables 3.1 and 3.2.

computed by means of formula (3.6) with θ equal to column (4) from Table 3.5. To compute the total production-period of private consumption, the waiting time in Retail distribution is added to the total production-periods of the industries.

It appears that the total production-period is in general one or two months longer than the corresponding production-period. The only exceptions are Meat and dairy products, where the difference is 8 months, and Primary metal products, where the difference is 6 months; this is caused by the fact that intermediate inputs are a large

Table 3.6 *Total production-period (in months)*

1. Agriculture	10.1
2. Other mining	2.7
3. Meat and dairy products	9.0
4. Other food products	4.1
5. Drink and tobacco products	6.2
6. Textiles	6.9
7. Clothing	5.3
8. Leather and footwear	5.0
9. Timber and furniture	5.4
10. Paper	4.1
11. Printing and publishing	4.8
12. Natural gas production and mineral oil refining	3.4
13. Chemical and allied products	4.6
14. Stone, clay, and glass products	4.6
15. Primary metal products	10.3
16. Metal products and machinery	9.3
17. Electrical products	8.7
18. Transport equipment	13.4
19. Optical and other products	9.4
20. Electricity, gas and water	2.7
21. Construction	15.2
22. Distribution	0.7
23. Hotels, cafe's, and restaurants	1.9
24. Repair services	1.4
25. Sea and air transport services	0.7
26. Other transport services	0.9
27. Communication services	0.6
28. Banking and insurance services	0.6
29. Housing services	4.6
30. Business services	0.3
31. Health services	0.8
32. Cultural and recreational services	0.9
33. Other services	0.3
34. N.e.c.	0.7
Imports	3.8
Capital consumption	4.0
Wages	3.7
Social insurance premiums	3.7
Exports	5.4
Private consumption	2.6
Public consumption	1.0
Public capital formation	10.8
Private capital formation	7.7
Stock formation	17.1

fraction of output of these industries (82 and 60 per cent respectively).

The differences in magnitude of the total production-periods of the final expenditure categories reflect the differences in composition: the greater part of Exports is produced by Agriculture and Manufacturing; a large fraction of Private consumption is produced by the services industries; Public consumption consists for about 85 per cent of primary inputs; Public capital formation is for about 65 per cent produced by Construction; and Private capital formation is for about 40 per cent produced by Construction, whereas about 25 per cent is imported. The large value for Stock formation arises because in 1975 stock formation consisted of negative and positive components (the negative components represent decreases in stocks).

3.3. Costs and prices under historic-cost pricing

In this section I shall describe a model in which output prices are determined by a mark-up on historic costs, which are a function of prices during the production-period; the model is a special case of the model analysed in Section 2.2. It will be shown that the total production-period of an industry is equal to a weighted average of the mean lags between the industry's output price and the primary-input prices.

Similar models have been applied by Agarwala and Goodson (1970), Haig and Wood (1976), Stromback and Trivedi (1976), and Coutts, Godley and Nordhaus (1978). Using actual input prices, they let the model generate 'predicted' price and cost changes, which are used in regressions explaining actual price changes of industries or consumer goods. Such applications are not made in this book.

Historic costs in a single industry[7]

Historic costs of a product are by definition the costs that are made in producing the product. To show how these costs are to be evaluated I first analyse the case of one input. If the price of the input is determined before the input is delivered, unit cost of output shipped at time t is

$$c_t = ar_{t-\theta},$$

where r_t is the price of the input at time t, a is the input-output coefficient, and θ is the production-period. On the other hand, if the input is added gradually and its price can change during the production process, we have

$$c_t = a \sum_{\tau=0}^{\theta} \frac{1}{\theta} r_{t-\tau}.$$

If there are two inputs, one of which is purchased before the production process has started and one of which is added gradually, we have

$$c_t = ar^A_{t-\theta} + b \sum_{\tau=0}^{\theta-\theta_m} \frac{1}{\theta - \theta_m} r^B_{t-\tau}, \tag{3.8}$$

[7] Cf. Coutts, Godley, and Nordhaus (1978, pp. 41-7).

where θ_m is the waiting time of materials, a and b are input coefficients, r_t^A is the price of the first input and r_t^B is the price of the second input. Note that the summation sign runs from zero to $\theta - \theta_m$ because the second input is not used during the waiting time of materials.

If there are more than two inputs that can be classified into one of the classes A and B, equation (3.8) can easily be adapted. In general, materials belong to class A and the other inputs, such as labour and capital, to class B.

Historic-cost pricing

In an interindustry analysis unit cost of output shipped at time t is

$$c_j(t) = \sum_{i=1}^{N} a_{ij} p_i(t - \theta_j) + b_{1j} r_{1j}(t - \theta_j)$$

$$+ \sum_{\tau=0}^{\theta_j - \theta_{mj}} \sum_{h=2}^{M} \frac{1}{\theta_j - \theta_{mj}} b_{hj} r_{hj}(t - \tau), \quad j = 1, 2, \ldots, N, \tag{3.9}$$

where import of materials is taken as the primary input with index $h = 1$, and, for typographical reasons, the time period is now indicated by a function argument instead of a subscript; prices of primary inputs may differ between industries.

Prices are determined by adding a constant relative profit margin to historic cost [cf. equation (2.4)]

$$p_j(t) = k_j c_j(t), \quad j = 1, 2, \ldots, N. \tag{3.10}$$

It is easily shown that (3.9) and (3.10) yield for price index numbers

$$\bar{p}_j(t) = \sum_{i=1}^{N} w_{ij} \bar{p}_i(t - \theta_j) + s_{1j} \bar{r}_{1j}(t - \theta_j)$$

$$+ \sum_{\tau=0}^{\theta_j - \theta_{mj}} \sum_{h=2}^{M} \frac{1}{\theta_j - \theta_{mj}} s_{hj} \bar{r}_{hj}(t - \tau), \quad j = 1, 2, \ldots, N \tag{3.11}$$

where a bar denotes an index [for example $\bar{p}_j(t) = p_j(t)/p_j(0)$],

$$w_{ij} = \frac{p_i(0) a_{ij}}{c_j(0)}, \quad i, j = 1, 2, \ldots, N,$$

and

$$s_{hj} = \frac{r_{hj}(0) b_{hj}}{c_j(0)}, \quad h = 1, 2, \ldots, M, \quad j = 1, 2, \ldots, N;$$

thus the matrices W and S contain the cost shares in the base period.

If all input prices are determined before the start of the production process, or if the firm computes historic cost on the basis of the prices at the beginning of the production process, equation (3.11) reduces to

$$\bar{p}_j(t) = \sum_{i=1}^{N} w_{ij}\bar{p}_i(t-\theta_j) + s_{1j}\bar{r}_{1j}(t-\theta_j) + \sum_{h=2}^{M} s_{hj}\bar{r}_{hj}(t-\theta_j+\theta_{mj}),$$

$$j = 1, 2, \ldots, N. \tag{3.12}$$

It is not a priori clear that equation (3.11) is more realistic than equation (3.12): for example wage rates change only once in six months; also, firms may prefer the simpler costing procedure that lies behind (3.12).

Stability properties

Models (3.11) and (3.12) are obviously special cases of (2.31) in Section 2.2. Thus all stability properties that were derived for (2.31) hold for (3.11) and (3.12). Therefore if all $\bar{r}_{hj}$ are growing with a constant growth factor α_{hj} and at least one growth factor is not smaller than one, then a sufficient condition for (3.11) and (3.12) to be relatively stable is

$$\sum_{i=1}^{N} w_{ij} \leq \alpha^* = \max_{h,j} \alpha_{hj,} \quad j = 1, 2, \ldots, N$$

with strict inequality for at least one j.

The first part of this condition will be fulfilled because by definition the sum of the cost shares in an industry is one:

$$\sum_{i=1}^{N} w_{ij} + \sum_{h=1}^{M} s_{hj} = 1;$$

the second part will be fulfilled if in at least one industry a primary input has a positive cost share. Then all output prices will eventually grow with the same growth rate, namely the maximum growth rate of the primary-input prices.

The total production-period and the mean lag between primary-input prices and output prices

Because the total production-period measures the average time a primary input is in the system, it is plausible that there exists a relationship between the total production-period and the mean lag between primary-input prices and output prices. I shall show that there exists such a relationship for the model (3.12). For simplicity I assume that the waiting time of materials is zero, and that the price index numbers of the primary-inputs are the same in all industries:

$$\theta_{mj} = 0, \quad j = 1, 2, \ldots, N, \tag{3.13}$$

$$\bar{r}_{hj}(t) = \bar{r}_h(t), \quad j = 1, 2, \ldots, N. \tag{3.14}$$

Then equation (3.12) can be written as

$$\bar{p}_j(t) - \sum_{i=1}^{N} w_{ij} \bar{p}_i(t - \theta_j) = \sum_{h=1}^{M} s_{hj} \bar{r}_h(t - \theta_j), \quad j = 1, 2, \ldots, N.$$

In matrix notation this can be written as[8]

$$D(L)\bar{p}(t) = G(L)\bar{r}(t),$$

where $D(L)$ and $G(L)$ are matrices whose elements are polynomials in the lag operator L:

$$D_{ij}(L) = \delta_{ij} - w_{ji} L^{\theta_i}, \quad i, j = 1, 2, \ldots, N,$$

$$G_{ih}(L) = s_{hi} L^{\theta_i}, \quad i = 1, 2, \ldots, N, \quad h = 1, 2, \ldots, M,$$

δ_{ij}: Kronecker delta ($\delta_{ij} = 1$ if $i = j$; $\delta_{ij} = 0$ if $i \neq j$),

$$L^{\theta_i} \bar{p}_j(t) = \bar{p}_j(t - \theta_i).$$

Thus

$$\bar{p}(t) = E(L)\bar{r}(t),$$

with $E(L) = [D(L)]^{-1} G(L)$. This equation means that each output price index is a distributed lag of the primary-input price indices:

$$\bar{p}_j(t) = \sum_{h=1}^{M} E_{jh}(L) \bar{r}_{hj}(t) = \sum_{h=1}^{M} \sum_{\tau=0}^{\infty} E_{jh\tau} L^{\tau} \bar{r}_h(t) = \sum_{h=1}^{M} \sum_{\tau=0}^{\infty} E_{jh\tau} \bar{r}_h(t - \tau),$$

where the $E_{jh\tau}$ are the coefficients of the polynomial $E_{jh}(L)$.

The mean lag between output price index $\bar{p}_j$ and input price index $\bar{r}_h$ is [see Harvey (1981, p. 234)]

$$\mu_{jh} = \frac{\sum_{\tau=0}^{\infty} \tau E_{jh\tau}}{\sum_{\tau=0}^{\infty} E_{jh\tau}} = \frac{E'_{jh}(1)}{E_{jh}(1)}, \quad j = 1, 2, \ldots, N, \quad h = 1, 2, \ldots, M,$$

[8] See Dhrymes (1970, pp. 509-17) for a survey of lag operators.

where $E'_{jh}(1)$ is the derivative of $E_{jh}(L)$ with respect to L, evaluated in $L = 1$.

We have[9]

$$E'(L) = \frac{\mathrm{d}E(L)}{\mathrm{d}L} = \frac{\mathrm{d}[D(L)]^{-1}}{\mathrm{d}L} G(L) + [D(L)]^{-1} \frac{\mathrm{d}G(L)}{\mathrm{d}L}$$

$$= -[D(L)]^{-1} \frac{\mathrm{d}D(L)}{\mathrm{d}L} [D(L)]^{-1} G(L) + [D(L)]^{-1} \frac{\mathrm{d}G(L)}{\mathrm{d}L},$$

and thus

$$E'(1) = -[D(1)]^{-1} D'(1)[D(1)]^{-1} G(1) + [D(1)]^{-1} G'(1).$$

Now $D'_{ij}(L) = -\theta_i w_{ji} L^{\theta_i - 1}$ and $G'_{ih}(L) = \theta_i s_{hi} L^{\theta_i - 1}$. Thus

$$D'(1) = -\Theta W'$$

and

$$G'(1) = \Theta S',$$

where Θ is the diagonal matrix with elements θ_j. Also, $D(1) = I - W'$ and $G(1) = S'$. Therefore we have

$$E(1) = (I - W')^{-1} S'$$

and

$$E'(1) = (I - W')^{-1} \Theta W' (I - W')^{-1} S' + (I - W')^{-1} \Theta S'$$

$$= (I - W')^{-1} \Theta [W'(I - W')^{-1} + I] S'$$

$$= (I - W')^{-1} \Theta (I - W')^{-1} S'$$

$$= (I - W')^{-1} \Theta E(1).$$

Thus the mean lag between output price index $\bar{p}_j$ and input price index $\bar{r}_h$ is

$$\mu_{jh} = \sum_{i=1}^{N} (I - W')^{-1}_{ji} \theta_i \frac{E_{ih}(1)}{E_{jh}(1)},$$

$$j = 1, 2, \ldots, N, \quad h = 1, 2, \ldots, M, \tag{3.15}$$

whereas the total production-period of industry j is [cf. (3.7) with $\theta_m = 0$]

$$\phi_j = \sum_{i=1}^{N} (I - W')^{-1}_{ji} \theta_i, \quad j = 1, 2, \ldots, N. \tag{3.16}$$

Using the fact that $(I - W')^{-1} S' \iota = \iota$ [see (2.19)] (i.e. $\sum_{h=1}^{M} E_{ih}(1) = 1$), we now get from (3.15) and (3.16) that

[9] See Theil (1971, pp. 30-3) for a survey of matrix differentiation.

$$\phi_j = \sum_{h=1}^{M} E_{jh}(1)\mu_{jh}, \quad j = 1, 2, \ldots, N.$$

The matrix $E(1) = (I - W')^{-1}S'$ contains the cumulated primary-cost coefficients. Thus the total production-period of an industry is equal to a weighted average of the mean lags between the industry's output price and the primary-input prices; the weights are the cumulated primary-cost coefficients.

3.4. Simulations

In this section I present the results of simulations concerning once-and-for-all changes of 10 per cent in all wage rates, crude oil prices, and all import prices. The results will be presented in tables giving the price increase of the final expenditure categories after 3, 6, 9, 12, and 15 months and the total price increase (i.e. the increase after equilibrium has been restored); all increases are with respect to the base period. A similar table gives the price increases by industry in the first simulation; in the other simulations these price increases are either small and therefore not interesting or roughly similar to those in the first simulation. The results of simulations when employees are compensated for price changes and when the primary input prices are changing every month at the same rate are briefly discussed.

The simulations have been carried out by means of equation (3.12); note that for once-and-for-all changes equations (3.11) and (3.12) give the same results. The matrices W and S have been computed from the 1975 input-output table; interest margin has been classified as a separate final expenditure category instead of as a negative primary input (see footnote 6 of Section 3.2). The lags θ_{mj} and θ_j have been taken from Table 3.5, columns (1) and (4); they have been rounded off to integers.

The first simulation concerns a general increase of 10 per cent in wage rates; because social insurance premiums are linked to nominal wage rates they have been also increased with 10 per cent. We see from Table 3.7 that in many industries a large fraction of the total price change has been reached after 3 or 6 months. It is only in the metal industries and Construction that the adjustment takes 12 or 15 months. It appears from an inspection of the monthly price changes (which are not reproduced here) that the first change that occurs is the largest of all monthly price changes. The later changes are negligible in industries with small intermediate inputs, whereas in other industries they may account for one third or one half of the total price change.

Differences in the movement of the prices of the final expenditure categories reflect differences in composition: the prices of Public and Private capital formation, which consist mainly of metal products and construction, adjust much slower than the prices of Private and Public consumption, which consist for a great part of respectively services and labour. The speed of adjustment of the price of Exports is somewhere between these two extremes. The cumulated price increases for the six final expenditure categories are shown in Figures 3.8-3.13.

It has been shown in the previous section that the total production-period is an approximation of the average lag between output price and primary-input prices.

Table 3.7 *Effects of a general wage increase of 10 per cent*

	Percentage price increase after					Total price increase
	3 months	6 months	9 months	12 months	15 months	
1. Agriculture	-	-	2.9	3.2	3.6	4.2
2. Other mining	5.2	5.3	5.5	5.6	5.7	5.8
3. Meat and dairy	1.4	1.5	3.4	3.8	4.1	4.6
4. Other food	2.2	2.5	2.8	3.0	3.1	3.3
5. Drink, tobacco	2.8	3.5	4.1	4.4	4.5	4.7
6. Textiles	-	3.1	3.3	3.9	3.9	4.1
7. Clothing	2.6	3.0	3.5	3.6	3.6	3.7
8. Leather, footwear	4.0	4.6	5.2	5.3	5.4	5.5
9. Timber, furniture	3.9	4.6	5.1	5.3	5.4	5.5
10. Paper	3.4	3.9	4.1	4.2	4.2	4.3
11. Printing, publ.	3.5	5.5	5.8	6.2	6.3	6.5
12. Gas and oil	0.6	0.7	0.7	0.8	0.8	0.8
13. Chemical prod.	2.4	3.4	3.5	3.7	3.8	3.9
14. Stone, clay, glass	3.8	5.1	5.6	5.7	5.8	5.9
15. Primary metal prod.	1.4	1.6	2.3	2.5	3.0	3.6
16. Metal prod., machin.	-	4.0	4.3	4.5	5.0	5.5
17. Electrical prod.	-	3.8	4.2	4.3	4.4	4.6
18. Transport equipm.	-	-	3.0	3.3	3.5	5.0
19. Other products	-	3.5	3.9	4.1	4.7	5.0
20. Electr., gas, water	2.3	2.5	2.6	2.7	2.8	2.8
21. Construction	-	-	-	-	4.8	6.3
22. Distribution	6.8	6.9	7.0	7.0	7.0	7.1
23. Hotels, cafe's, rest.	5.5	5.7	5.9	6.0	6.1	6.1
24. Repair services	5.3	5.8	5.9	5.9	6.0	6.0
25. Sea, air transp. serv.	3.4	3.4	3.5	3.6	3.6	3.6
26. Other transp. serv.	6.0	6.1	6.2	6.2	6.3	6.4
27. Communication serv.	7.2	7.3	7.3	7.3	7.4	7.4
28. Banking, insurance	7.8	7.9	8.0	8.0	8.0	8.1
29. Housing services	0.2	0.2	0.2	0.2	1.7	2.1
30. Business services	8.7	8.8	8.8	8.8	8.8	8.9
31. Health services	7.6	7.7	7.7	7.7	7.8	7.9
32. Cultural, recr. serv.	7.7	7.8	7.9	7.9	8.0	8.1
33. Other services	8.9	9.0	9.0	9.0	9.0	9.0
34. N.e.c.	0.8	1.0	1.1	1.1	1.1	1.1
Exports	1.8	2.7	3.3	3.4	3.6	3.9
Private consumption	3.2	3.5	3.8	3.9	4.1	4.2
Public consumption	8.3	8.4	8.5	8.5	8.7	8.8
Public capital form.	0.7	1.0	1.1	1.1	4.3	5.3
Private capital form.	0.7	1.1	1.2	1.3	3.3	4.0
Stock formation	1.5	2.9	6.2	6.3	6.7	8.0

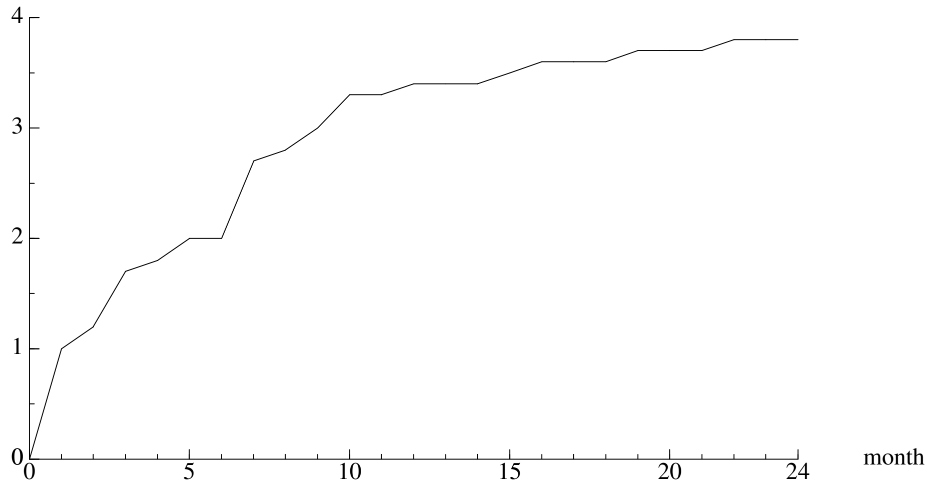

Figure 3.8 *Exports: cumulated percentage price increase after a 10 per cent wage increase*

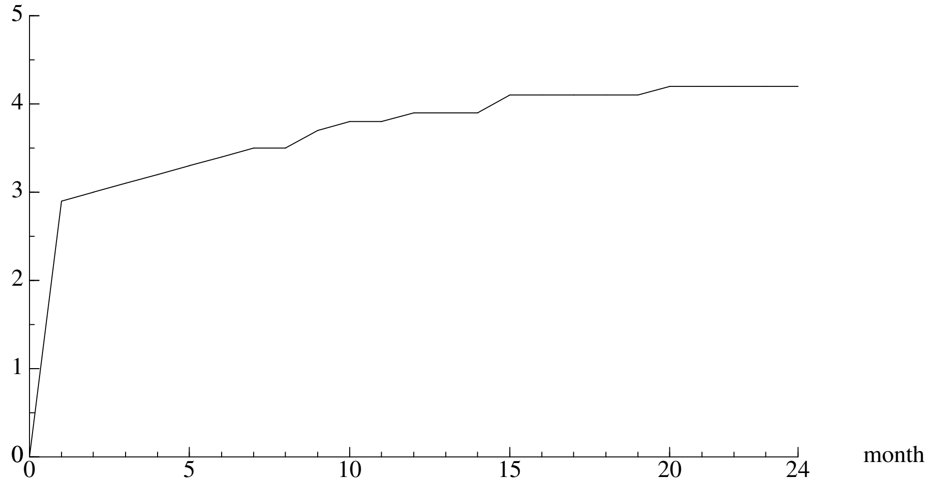

Figure 3.9 *Private consumption: cumulated percentage price increase after a 10 per cent wage increase*

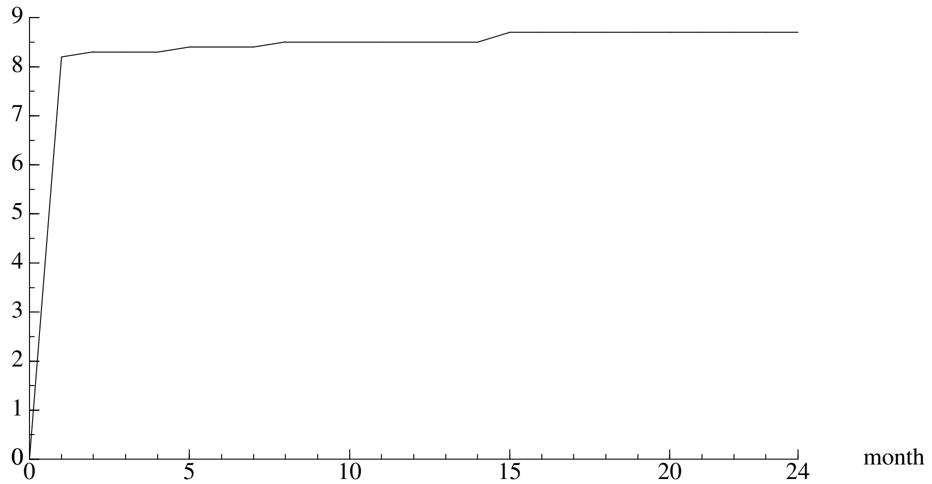

Figure 3.10 *Public consumption: cumulated percentage price increase after a 10 per cent wage increase*

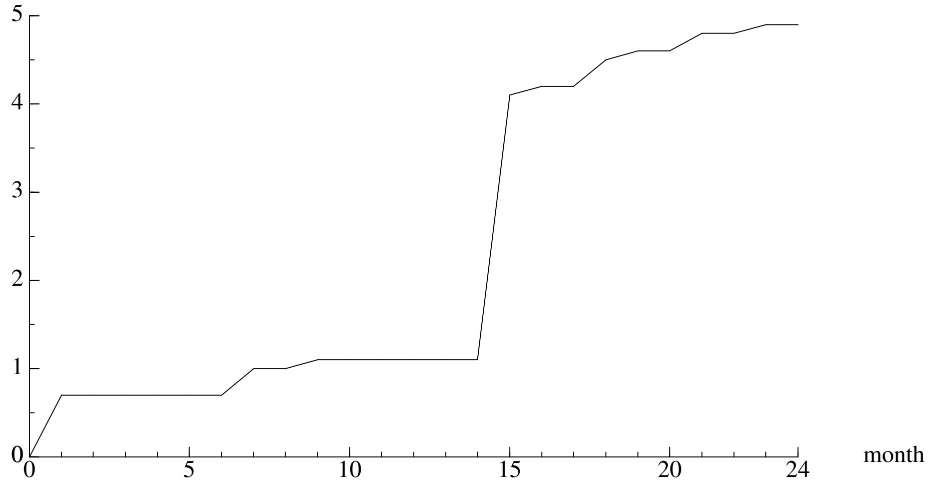

Figure 3.11 *Public capital formation: cumulated percentage price increase after a 10 per cent wage increase*

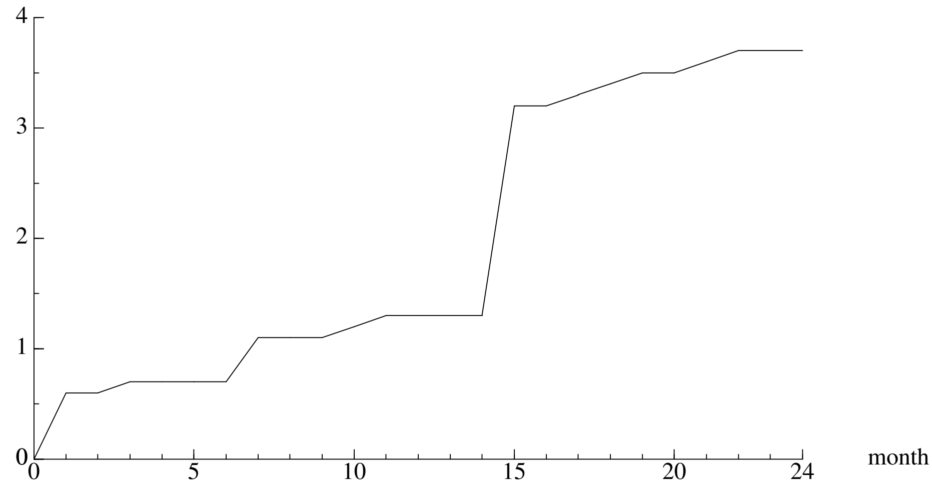

Figure 3.12 *Private capital formation: cumulated percentage price increase after a 10 per cent wage increase*

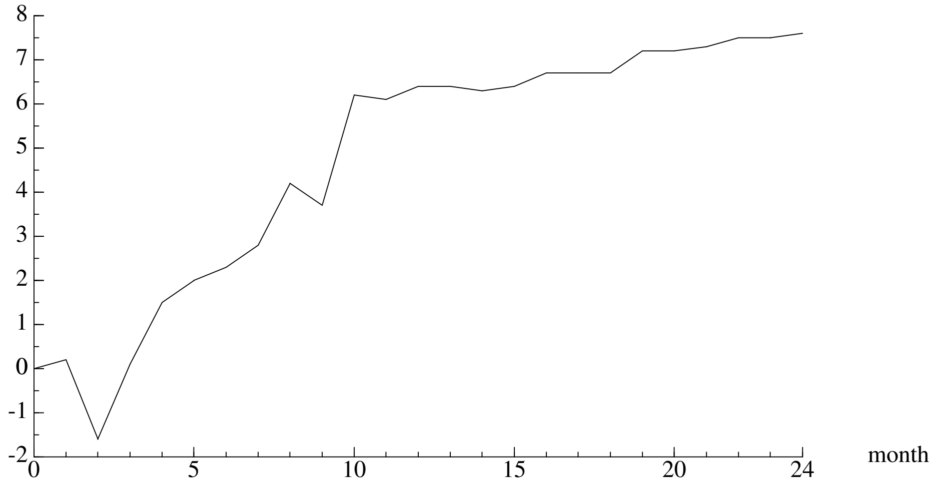

Figure 3.13 *Stock formation: cumulated percentage price increase after a 10 per cent wage increase*

It appears indeed from Table 3.8 that the total production-period is in general a good indicator of the adjustment period, although for most industries the production-period is an equally good one. In Public and Private capital formation the price increase after the total production-period is less than 30 per cent of the total price rise; however, the price increase after the total production-period plus two months is about 80 per cent of the total price rise.

In general the distribution of the lag between an output price and a primary-input price has a declining ‘saw-tooth’ pattern as shown in Figures 3.14-3.19. This shape arises because the intermediate inputs generate echo effects. There are several local peaks, the first of which occurs at the production-period. Although the lag length is infinite, it may be represented by a finite number because the price changes in later months are negligible. However, in an analysis of the lag between final-output prices and primary-input prices, cutting off the lag distribution at the production-period, as has been done by Nordhaus and Godley (1972), can be wrong; in general, it is better to cut off at the total production-period or at the total production-period plus two months. Note that in an analysis of industry prices, such as Coutts, Godley, and Nordhaus (1978), the length of the lag between price and cost is not longer than the production-period [cf. (3.12)]; it is only when final prices (e.g. of an aggregate of industries as manufacturing) are to be explained by exogenous input prices that the lag length is longer than the production-period.

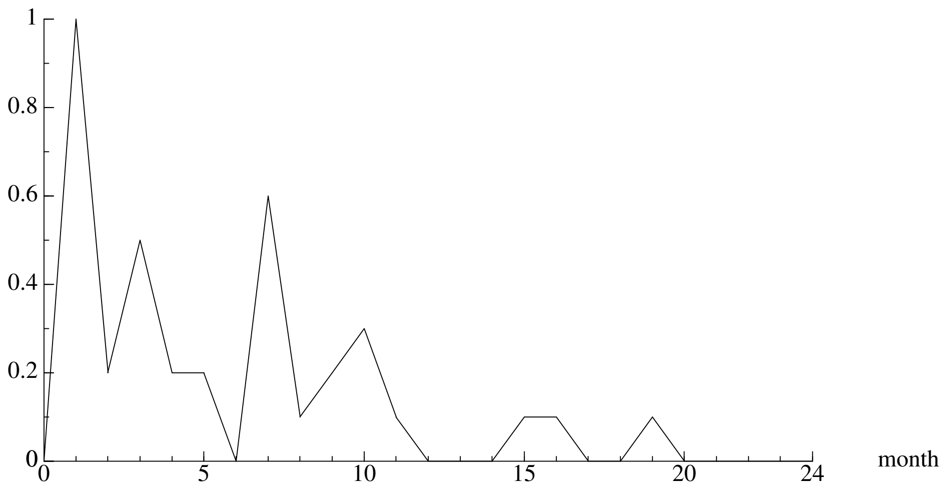

Figure 3.14 *Exports: monthly percentage price increase after a 10 per cent wage increase*

Table 3.8 *Percentage of total price increase achieved after the production-period and the total production-period*

	after the production-period	after the total production-period
1. Agriculture	47	75
2. Other mining	87	90
3. Meat and dairy products	29	79
4. Other food products	68	76
5. Drink and tobacco products	77	77
6. Textiles	77	77
7. Clothing	81	81
8. Leather and footwear	84	84
9. Timber and furniture	83	83
10. Paper	79	89
11. Printing and publishing	66	66
12. Natural gas production and mineral oil refining	73	73
13. Chemical and allied products	76	77
14. Stone, clay and glass products	79	85
15. Primary metal products	44	69
16. Metal products and machinery	80	81
17. Electrical products	90	90
18. Transport equipment	66	70
19. Optical and other products	77	79
20. Electricity, gas and water	72	83
21. Construction	73	82
22. Distribution	93	93
23. Hotels, cafe's and restaurants	83	89
24. Repair services	87	88
25. Sea and air transport services	91	91
26. Other transport services	93	93
27. Communication services	95	95
28. Banking and insurance services	95	95
29. Housing services	10	10
30. Business services	97	97
31. Health services	95	95
32. Cultural and recreational services	94	94
33. Other services	97	97
34. N.e.c.	49	49
Exports		69
Private consumption		76
Public consumption		94
Public capital formation		21
Private capital formation		28
Stock formation		90

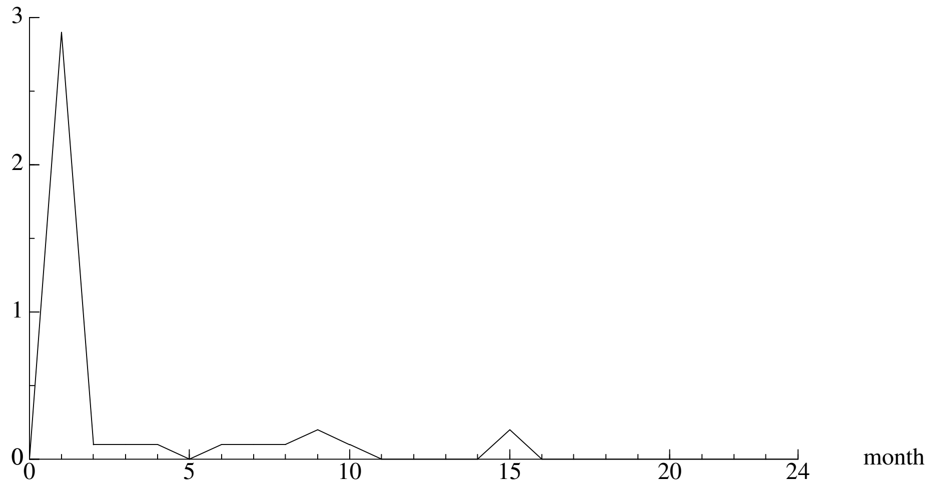

Figure 3.15 *Private consumption: monthly percentage price increase after a 10 per cent wage increase*

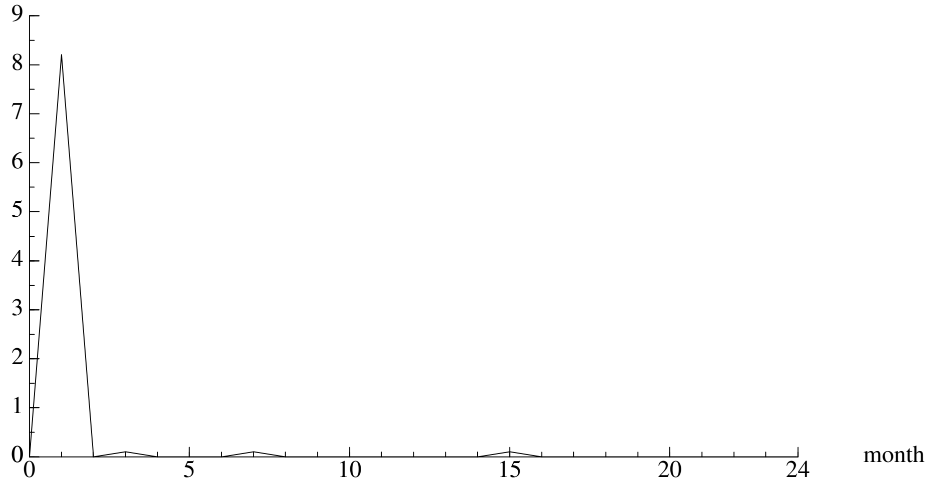

Figure 3.16 *Public consumption: monthly percentage price increase after a 10 per cent wage increase*

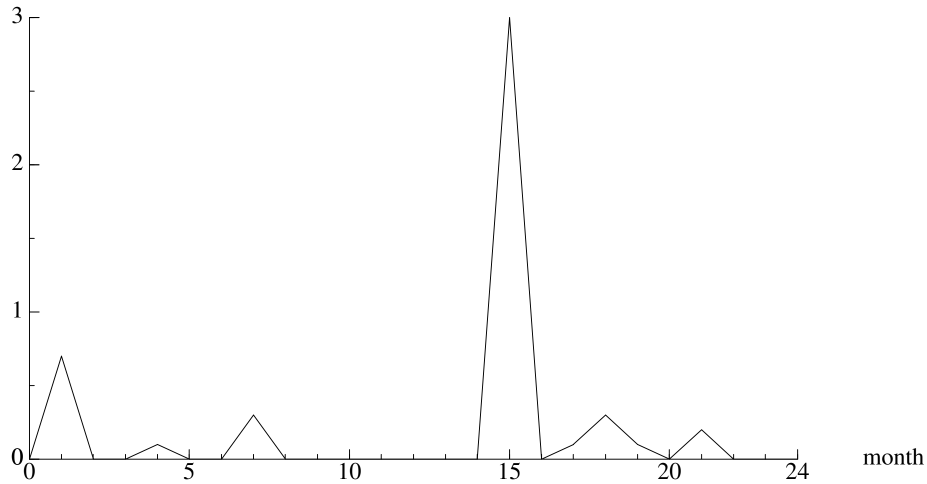

Figure 3.17 *Public capital formation: monthly percentage price increase after a 10 per cent wage increase*

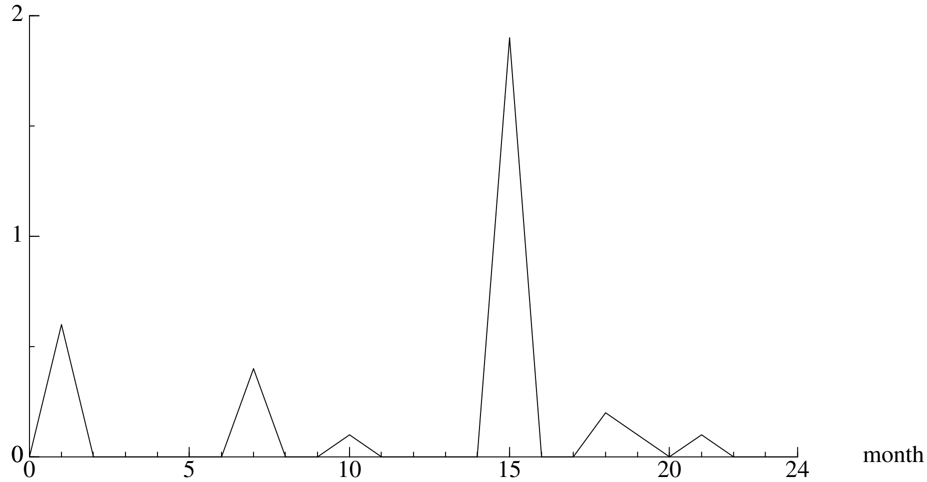

Figure 3.18 *Private capital formation: monthly percentage price increase after a 10 per cent wage increase*

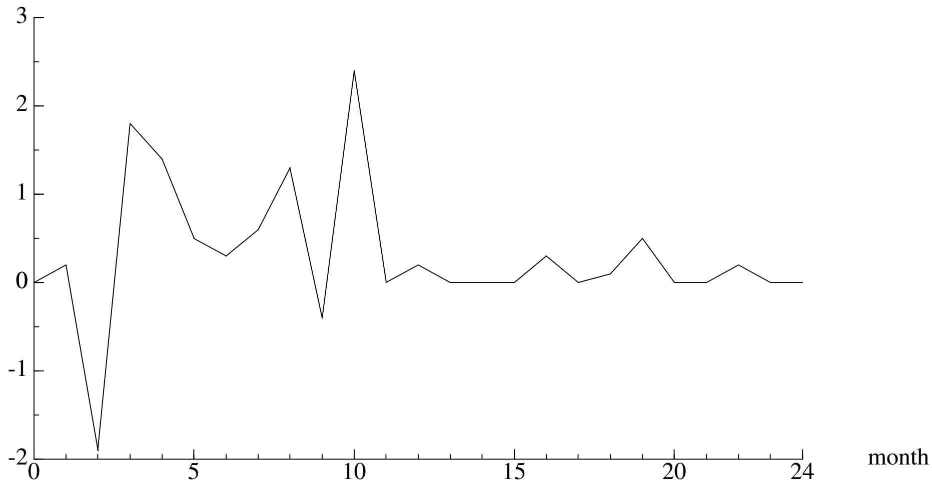

Figure 3.19 *Stock formation: monthly percentage price increase after a 10 per cent wage increase*

The second simulation concerns a rise of 10 per cent in crude oil prices, i.e. an increase of 10 per cent in the import price of Natural gas production and mineral oil refining. The only industry prices that change ultimately with more than one per cent are those of Natural gas production and mineral oil refining (8.5%), Chemical and allied products (1.1%), and Electricity, gas, and water (4.5%). The final expenditure categories that are most affected are Exports (1.4%) and Stock formation (6.1%); see Table 3.9. The total production-period indicates the adjustment period reasonably well only for Natural gas production and mineral oil refining, Exports, and Stock formation. This is to be expected since the total production-period measures approximately the average lag between output price and the price of *aggregate* imports.

The third simulation I have carried out concerns a general increase of 10 per cent in import prices. Prices of most service industries rise with 1 or 2 per cent; prices of the other industries and the final expenditure categories increase with 3 to 5 per cent; see Table 3.10. The adjustment periods and patterns are roughly similar to those in the first simulation.

I have also carried out the same three simulations using model (3.12) with employees compensated for price changes. The total production-period is now adjusted to take the indexation into account by computing it as (see Section 2.1 below (2.20) and Section 3.2 for the meaning of the symbols):

$$\phi = (I - W' - s_1 g')^{-1} \; (\theta - S_2^* \theta_m).$$

The total price changes appear to be larger than those in the model without indexation; the adjustment patterns are roughly similar, but the adjustment periods are

Table 3.9 *Effects of an increase of 10 per cent in crude oil prices*

	Percentage price increase after					Total price increase
	3 months	6 months	9 months	12 months	15 months	
Exports	1.1	1.1	1.3	1.3	1.4	1.4
Private consumption	0.0	0.3	0.3	0.4	0.4	0.4
Public consumption	0.1	0.1	0.1	0.2	0.2	0.2
Public capital formation	0.0	0.0	0.0	0.0	0.0	0.2
Private capital formation	0.0	0.1	0.1	0.1	0.1	0.2
Stock formation	5.0	5.0	5.8	6.0	6.1	6.1

Table 3.10 *Effects of an increase of 10 per cent in import prices*

	Percentage price increase after					Total price increase
	3 months	6 months	9 months	12 months	15 months	
Exports	2.6	3.4	4.3	4.8	4.9	5.2
Private consumption	2.1	2.6	2.9	3.1	3.2	3.4
Public consumption	0.0	0.1	0.2	0.2	0.3	0.4
Public capital formation	0.3	0.4	0.7	0.7	1.9	2.8
Private capital formation	2.8	2.9	3.2	3.3	4.1	4.7
Stock formation	−8.4	−5.7	−3.4	−1.3	−1.3	−0.1

longer. Again, in the first and the third simulation the total production-period is a good indicator of the adjustment period.

Finally, I have carried out similar simulations in which the same change of 10 per cent occurs every month. Ultimately all output prices will change every month with the same percentage. When all wage rates increase each month with 10 per cent, it takes six years before the monthly change in all prices is 10 per cent (in most industries the 10 per cent change is reached within three or four years); when the price of crude oil rises every month with 10 per cent the adjustment to the equilibrium growth path takes seven years; and when there is each month a devaluation of 10 per cent the adjustment takes five years. When the prices of all primary inputs increase each month with 10 per cent, the equilibrium is reached within a year.

3.5. Summary

Under historic-cost pricing the lag between output price and cost is a function of the production-period, i.e. the time from delivery of the materials until shipment of the finished product. The total production-period, which measures the average time that is needed to produce final output, is an approximation to the mean lag between the output price and the primary-input prices.

The simulations that have been carried out for once-and-for-all changes in primary input prices show that the total price change until the total production-period is in general a large fraction of the total price change; this holds both when employees are compensated for price changes and when they are not.

The distribution of the lag between an output price and a primary-input price has often a declining 'saw-tooth' pattern and thus has several local peaks; this shape arises owing to echo effects caused by the existence of intermediate inputs. Although the lag length is infinite, it may be represented by a finite number because the monthly price changes become eventually negligible. However, the approximation must in general be longer than the production-period.

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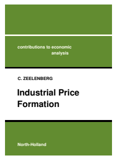

PART II

Price formation under pure competition

CHAPTER 4

The law of one price for a small open economy

In Part 2 (Chapters 4 and 5) I shall study price formation under pure competition [i.e. producers and consumers take prices as given; cf. Lloyd (1967, p. 157) and Malinvaud (1972, p. 56)]. I do not assume that competition is perfect (i.e. competition is pure and there is free entry and exit), but the zero-profits condition, which holds in the long run under perfect competition, can be incorporated into the analysis. In Chapter 4 I shall analyse for a small open economy the law of one price, and in Chapter 5 I shall analyse price formation in a small open economy by means of a general-equilibrium model.

The ‘law of one price’ says that in a perfect market there exists only one price (a market is called perfect if three conditions hold: there is perfect arbitrage, the products sold in the market are perfect substitutes, and there are no transfer costs).[1] Note that the law of one price applies to any market that is perfect, regardless of the number of sellers and buyers (thus regardless whether there is pure competition, oligopoly, monopoly, etc.).

In this chapter, the law of one price will be used in the following way. I assume that for each tradable domestic product there exists a perfectly substitutable foreign product, that there is perfect price arbitrage for these products, and that transfer costs are zero. Thus the market for these two products (the ‘world market’) is perfect, and the price of the domestic product must be equal to the price of the foreign product when both prices are measured in the same currency.

In the theory of international trade, it is often assumed that for a small country foreign prices[2] are exogenous.[3] Then the law of one price can be interpreted as a *causal* relation: if the world market is perfect and the foreign price is given, then the

[1] The law of one price has a long history: it occurs for example with Jevons (1871, p. 136-7), who called it the ‘law of indifference’; applications to international trade were already made by Classical economists [see Viner (1937, p. 316) and Frenkel (1976, pp. 32-3)].

[2] Foreign price means price of the foreign product measured in domestic currency.

[3] In Section 5.4 I shall show that under pure competition this exogeneity indeed holds for a small economy.

foreign price determines the domestic price. This causal relation is often used in monetarist models [Johnson (1972, p. 153-4), Frisch (1983, p. 141)] as well as in 'Scandinavian' models [Aukrust (1970, 1977), Edgren, Faxén, and Odhner (1970), Calmfors (1977), and Frisch (1983, p. 164)].

If the foreign price is exogenous and the world market is perfect, then domestic consumers and producers can buy and sell any quantity at the foreign price. Thus under these two conditions, domestic price formation of tradable goods takes place under pure competition. This is the reason why a discussion on the law of one price, which holds in any perfect market, is placed in this part of the book and precedes treatment of different market structures. Also, from an observed difference in prices between two products one may conclude that the market is not perfect, either because the products are not perfect substitutes or because the market is segmented.

There are two versions of the law of one price in international trade: the absolute version and the relative version. The absolute version is the law of one price as set out above: domestic and foreign prices of a tradable good are equal, because the market is assumed to be perfect. The relative version drops the assumption that transfer costs are zero, and assumes instead that transfer costs are a constant fraction of the price; then the changes[4] in the domestic and foreign prices are equal.[5] It will be shown in Section 4.1 that when using price index numbers one can test only the relative version. In the remainder of this chapter and in Chapter 5, the phrase 'law of one price' will refer to this equality of domestic and foreign prices (or price changes) of a tradable good, with the causality running from the foreign price to the domestic price.

Related to the law of one price is the purchasing-power-parity hypothesis (PPP), which in its absolute version says that the aggregate foreign price level (measured in foreign currency) and the aggregate domestic price level determine the exchange rate; in the relative version of the PPP, the changes in these price levels determine the change in the exchange rate.[6] When aggregate domestic and foreign prices or price changes are found to be equal [see for example Genberg (1978) and Vaubel (1978)], it is difficult to determine whether the law of one price holds or the PPP holds. An empirical test of the law of one price must therefore be made at a disaggregated level, where, unless one commodity accounts for a large part of total trade, the exchange rate is more or less exogenous [see Kravis and Lipsey (1977, 1978), Isard (1977), Coutts, Godley, and Nordhaus (1978, Chapter 7) for such analyses].

In Section 4.1 an empirical analysis of the law of one price is made for five commodity groups. Section 4.2 deals with the effects that aggregation of individual

[4] Change always means relative change.

[5] In Section 5.4 I shall show that the relative version of the law of one price is a special case of price formation in general equilibrium.

[6] The origin of the modern PPP is in the work of Cassel in the 1920's. Surveys of the PPP have been given by Officer (1976), De Roos (1981), and Caves and Jones (1973, Chapter 19). The law of one price and the PPP are not always distinguished from each other; some authors, for example Krueger (1983, p. 24), regard them as the same theory.

products to commodity groups has on tests of the law of one price. The Appendix makes a comparison between price index numbers and unit values.

4.1. The law of one price for the Netherlands

The model

As mentioned in the introduction, there are two versions of the law of one price: the absolute version, which says that domestic and foreign price *levels* are equal, and the relative version, which says that domestic and foreign price *changes* are equal. Both versions are embodied in

$$\log p_{dt} = \alpha^* + \gamma^* \log p_{mt}, \tag{4.1}$$

where p_{dt} is the domestic price in period t, p_{mt} is the foreign price (measured in domestic currency) in period t, and α^* and γ^* are constants. The absolute version holds if $\alpha^* = 0$ and $\gamma^* = 1$; the relative version if $\gamma^* = 1$ [it is assumed that $\Delta \log p_{dt}$ is equal to $(p_{dt}/p_{d,t-1}) - 1$]; if γ^* is not equal to 1, then price changes are proportional, but not equal.

Usually, price index numbers and not absolute prices are available; dividing both prices in (4.1) by corresponding base-year prices p_{d0} and p_{m0}, we get

$$\log \frac{p_{dt}}{p_{d0}} = \alpha^* - \log p_{d0} + \gamma^* \log p_{m0} + \gamma^* \log \frac{p_{mt}}{p_{m0}}. \tag{4.2}$$

It follows from (4.1) that

$$\log p_{d0} = \alpha^* + \gamma^* \log p_{m0}.$$

Therefore (4.2) can be written as

$$\log \bar{p}_{dt} = \gamma^* \log \bar{p}_{mt}, \tag{4.3}$$

where $\bar{p}_{dt} = p_{dt}/p_{d0}$ and $\bar{p}_{mt} = p_{mt}/p_{m0}$ are price index numbers. Because α^* does not appear in (4.3), it follows that if we use price index numbers we can discriminate only between equality and proportionality of price changes; the absolute version cannot be tested with (4.3).

To allow for lags, I have estimated the following model:

$$\log \bar{p}_{dt} = \alpha + \beta \log \bar{p}_{d,t-1} + \gamma \log \bar{p}_{mt} + \delta \log \bar{p}_{m,t-1} + \varepsilon_t, \tag{4.4}$$

where ε_t is a disturbance. The long-run solution of (4.4) is, apart from the disturbance,

$$\log \bar{p}_{dt} = \frac{\alpha}{1-\beta} + \frac{\gamma + \delta}{1-\beta} \log \bar{p}_{mt}.$$

Thus, in the long run the relative version of the law of one price holds if $\beta + \gamma + \delta = 1$ and $\alpha = 0$; if $\beta + \gamma + \delta = 1$ and $\alpha \neq 0$, then domestic and foreign price changes are in the long run proportional. In the short run, the relative version holds if $\alpha = 0$, $\beta = 0$, $\gamma = 1$, and $\delta = 0$; proportionality between domestic and foreign price changes holds in the short run if $\beta = 0$, $\gamma = 1$, and $\delta = 0$. Note that equation (4.4) is stable if $|\beta| < 1$.

If $\beta + \gamma + \delta = 1$, then equation (4.4) can be written as

$$\Delta \log \bar{p}_{dt} = \gamma \Delta \log \bar{p}_{mt} - (\gamma + \delta)(\log \frac{\bar{p}_{d,t-1}}{\bar{p}_{m,t-1}} - \frac{\alpha}{\gamma + \delta}) + \varepsilon_t, \tag{4.5}$$

or

$$\Delta \log \bar{p}_{dt} = \kappa + \lambda \Delta \log \bar{p}_{mt} + \mu \log \frac{\bar{p}_{d,t-1}}{\bar{p}_{m,t-1}} + \varepsilon_t, \tag{4.6}$$

where Δ is the first-difference operator, $\kappa = \alpha$, $\lambda = \gamma$, and $\mu = -(\gamma + delta)$. Equation (4.5) contains the error-correction mechanism of Davidson, Hendry, Yeo, and Srba (1979): the change in the domestic price level is proportional to the change in the foreign price level, but if in the previous period the ratio $\bar{p}_d/\bar{p}_m$ was off its long-run value $\alpha/(1 - \beta)$, then an additional change is made in the domestic price. Note that, because $\beta = \mu + 1$, equation (4.6) is stable if $-2 < \mu < 0$.

Data

The empirical analysis has been carried out for the Netherlands, using yearly data on five commodity groups; the estimation period is 1961-1979. The five commodity groups, which cover agriculture, mining, and manufacturing, are

1. Agricultural and food products (SITC 0+1),
2. Fuels (SITC 3),
3. Chemical products (SITC 5),
4. Machinery and transport equipment (SITC 7),
5. Other manufactures (SITC 6+8).

For these five groups, dollar unit-values of exports of developed countries are published in the UN Yearbook of International Trade Statistics; these unit values divided by the US-dollar/guilder exchange rate are used as the foreign price index numbers in the empirical analysis. These foreign price index numbers exclude transport costs and import taxes.

The domestic price index numbers are price index numbers of domestic sales by domestic producers; they are aggregated from price indices available at a lower level of aggregation (see Appendix C.3) with as weights the shares in developed countries' exports of the group products in 1970. If not these shares, but the corresponding shares in domestic sales had been used, aggregation problems would have hindered the tests of the coefficients (see Section 4.2).

Because almost all industries produce products belonging to SITC sections 2+4 (raw materials), no domestic industry could be matched with these sections; therefore, these sections are left out from the analysis. All series are given in Appendix C.2.

Estimation results

I have first estimated the following equation, which is equal to (4.4) with a subscript i added to identify groups:

$$\log \bar{p}_{dit} = \alpha_i + \beta_i \log \bar{p}_{di,t-1} + \gamma_i \log \bar{p}_{mit} + \delta_i \log \bar{p}_{mi,t-1} + \varepsilon_{it},$$
$$i = 1, 2, \ldots, 5. \tag{4.7}$$

I assume that $\varepsilon_{.t} = (\varepsilon_{1t}, \varepsilon_{2t}, \ldots, \varepsilon_{5t})'$ is normally distributed with mean 0 and covariance matrix Σ. Thus the errors are assumed to be correlated between groups, but uncorrelated between time periods.

The results of maximum-likelihood estimation of (4.7) are presented in Table 4.1. It appears that the hypothesis $\beta_i + \gamma_i + \delta_i = 1$ cannot be rejected, except for Other manufactures. The results for Machinery and transport equipment are unsatisfactory: β_i is significantly larger than one, the equation is therefore unstable, and as a consequence the change in the fitted value lags one year behind the change in the actual value.

Therefore, I have estimated for all commodity groups the following equation:

$$\Delta \log \bar{p}_{dit} = \kappa_i + \lambda_i \, \Delta \log \bar{p}_{mit} + \mu_i \log \frac{\bar{p}_{di,t-1}}{\bar{p}_{mi,t-1}} + \varepsilon_{it}, \;\; i = 1, 2, \ldots, 5, \tag{4.8}$$

which is equation (4.7) under the restriction $\beta_i + \gamma_i + \delta_i = 1$. The results are presented in Table 4.2; the actual and fitted values (multiplied by 100) are shown in Figures[7] 4.1-4.5. The coefficient of $\Delta \log p_m$ is significant in all commodity groups; but only for Fuels and Chemical products is the $\bar{R}^2$ reasonably high. The significance of the constant term in all groups except Fuels indicates also that a part of the annual price change is not explained by the model; possibly some relevant variables are left out. The error-correction term is significant only for Fuels and Machinery and transport equipment; but in the last case it has the wrong sign: if in the previous year the domestic price has been larger than the foreign price, the divergence is made even larger in the current year, i.e. the equation is unstable.

We see that the foreign price explains the domestic price satisfactorily only in the groups Fuels and Chemical products: Fuels is characterized by an error-correction mechanism and Chemical products by a linear relation between price changes. Thus, only for Fuels the relative version of the law of one price cannot be denied; for the other groups the law of one price can be rejected. Possible explanations for this

[7] Note that the vertical scales of most of the figures are different.

Table 4.1 *Results of maximum-likelihood estimation of equation (4.7)*

	Coefficient of					
	con-stant	domestic price previous year	foreign price current year	foreign price previous year		
	α_i	β_i	γ_i	δ_i	DW	$\beta_i + \gamma_i + \delta_i$
Agricultural and food products	0.04	0.96[a]	0.51[a]	−0.48[a]	2.1	1.00[a]
	(0.15)	(0.08)	(0.10)	(0.11)		(0.03)
Fuels	0.25	0.74[a]	0.37[a]	−0.17[a]	2.4	0.95[a]
	(0.20)	(0.12)	(0.03)	(0.07)		(0.04)
Chemical products	−0.10	1.00[a]	0.48[a]	−0.46[a]	1.6	1.03[a]
	(0.08)	(0.03)	(0.03)	(0.03)		(0.02)
Machinery and transport equipment	0.23[a]	1.17[a]	0.12[a]	−0.34[a]	1.1	0.96[a]
	(0.11)	(0.05)	(0.05)	(0.05)		(0.02)
Other manufactures	2.20[a]	1.69[a]	−0.12	−1.05[a]	2.3	0.52[a b]
	(0.57)	(0.17)	(0.14)	(0.25)		(0.10)
Log likelihood	228.374					

Asymptotic standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.
[b] Significantly different from 1 at 5% level.

failure of the law of one price are firstly that the composition of the commodity groups in the domestic market may differ much from the composition in the world market, secondly that foreign and domestic products may not be perfect substitutes, and thirdly that price formation may not take place under pure competition. The first explanation will be investigated in Section 4.2, the second in Chapter 5, and the third in Part 3.

Table 4.2 *Results of maximum-likelihood estimation of equation (4.8)*

	Coefficient of				
	constant	change in foreign price	ratio of domestic and foreign price in previous year		
	κ_i	λ_i	μ_i	$\bar{R}^2$	DW
Agricultural and food products	0.02[a] (0.007)	0.45[a] (0.10)	–0.08 (0.08)	0.26	2.0
Fuels	0.01 (0.01)	0.39[a] (0.03)	–0.12[a] (0.03)	0.85	2.7
Chemical products	0.03[a] (0.004)	0.52[a] (0.04)	0.03 (0.03)	0.89	2.0
Machinery and transport equipment	0.04[a] (0.006)	0.16[a] (0.07)	0.12[a] (0.06)	0.20	1.1
Other manufactures	0.03[a] (0.01)	0.34[a] (0.12)	0.09 (0.07)	0.36	1.9
Log likelihood	221.838				

Asymptotic standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

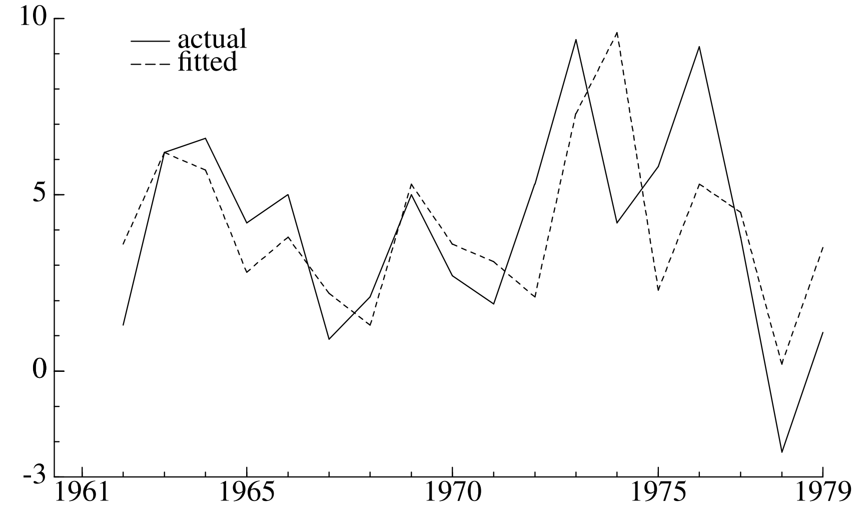

Figure 4.1 *Agricultural and food products: actual and fitted values (× 100) of equation (4.8)*

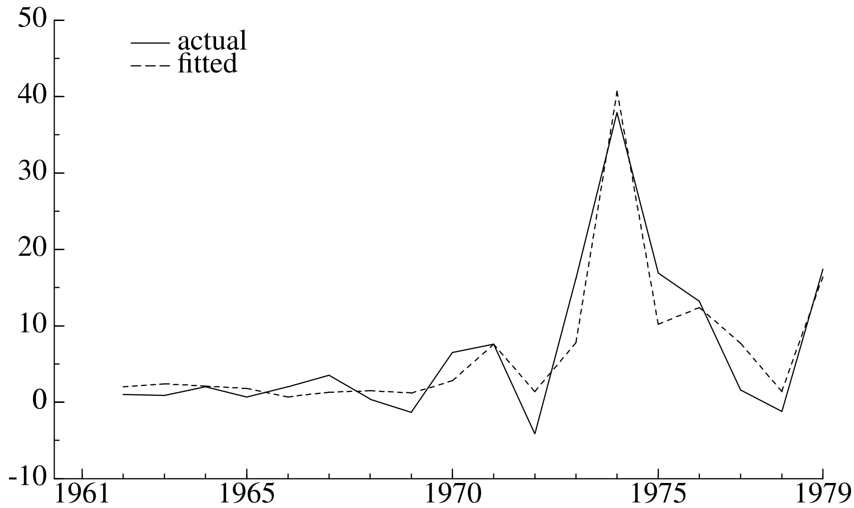

Figure 4.2 *Fuels: actual and fitted values (× 100) of equation (4.8)*

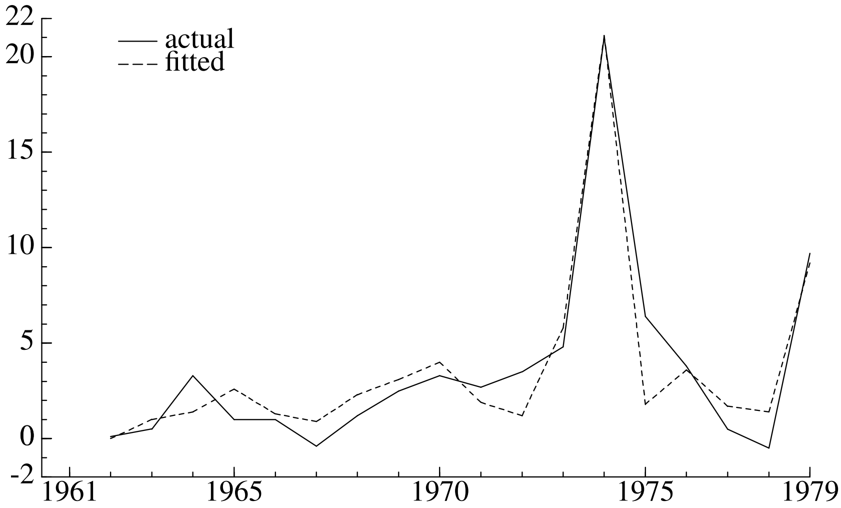

Figure 4.3 *Chemical products: actual and fitted values (× 100) of equation (4.8)*

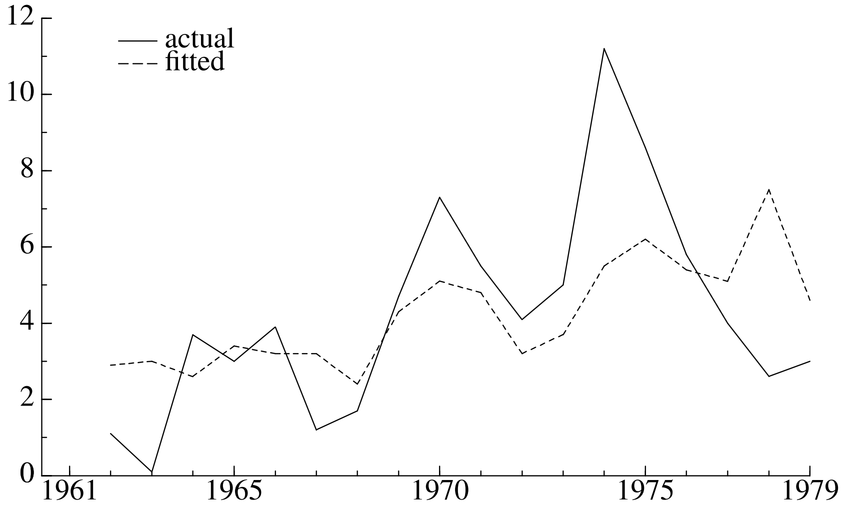

Figure 4.4 *Machinery and transport equipment: actual and fitted values (× 100) of equation (4.8)*

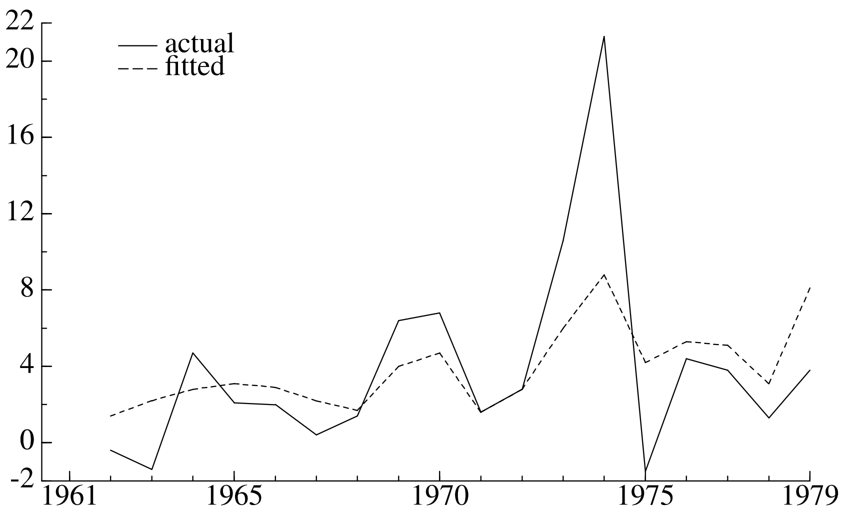

Figure 4.5 *Other manufactures: actual and fitted values (× 100) of equation (4.8)*

4.2. Aggregation and the law of one price

There are several ways in which aggregation problems may impede an analysis of the law of one price. Firstly, it is possible that domestic and foreign price index numbers of an aggregate are available and the weights with which the individual prices are aggregated differ for both aggregates. The question then arises whether the law of one price holds for the aggregate if it holds for the individual goods.

Secondly, it is possible that domestic prices are available at a lower level of aggregation than foreign prices. For example, in the Netherlands price index numbers are published for three-digit industries and sometimes for an even more detailed classification, whereas the only available foreign prices are world-market unit values corresponding to aggregates of two-digit industries (see Section 4.1).[8] One can follow three ways in testing the law of one price with such data:

— aggregate the domestic prices to the level of the foreign prices;
— replace the unknown individual foreign price by the known relevant aggregate foreign price;

[8] Recently the UNCTAD has published detailed world-market prices for three-digit SITC items; see UNCTAD (1982).

— extend the model, with for example equations for export prices, in such a way that all coefficients can be estimated.

To carry out the first solution we must decide which weights we use; this takes us back to the first problem. If we follow the second solution[9] the question is: what error is being made if the foreign prices of the goods are not identical to the relevant aggregate one?

I shall analyse these problems for a simple two-good model where domestic prices are a linear function of foreign prices:

$$p_{d1t} = \gamma_1 p_{m1t} + \varepsilon_{1t},$$

$$p_{d2t} = \gamma_2 p_{m2t} + \varepsilon_{2t},$$

where p_{dit} is the domestic price of good i in period t, p_{mit} is the foreign price of good i in period t, γ_i is a constant, and ε_{it} is a disturbance ($i = 1, 2$; $t = 1, 2, \ldots, T$). The law of one price holds if $\gamma_1 = \gamma_2 = 1$.

Although the model is written in levels, the variables can also be interpreted as logarithms or differences of logarithms; any aggregate index number must then be interpreted as a Divisia (Törnqvist)-index number.

I assume that the variables are measured in deviations from their means and that

$$\mathrm{E}(\varepsilon_{it}) = 0;$$

$$\mathrm{E}(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij};$$

$$\mathrm{E}(\varepsilon_{it}\varepsilon_{js}) = 0, \;\; t \neq s;$$

$$\operatorname*{plim}_{T\to\infty} \frac{1}{T} \sum_{t=1}^{T} p_{mit}\varepsilon_{jt} = 0;$$

$$i, j = 1, 2; \;\; t = 1, 2, \ldots, T.$$

Thus the disturbances may be correlated between the two goods, but not between time periods; the final assumption means that the foreign prices and the disturbances are asymptotically uncorrelated.

The first of the problems mentioned at the beginning of the section occurs if not p_{dit} and p_{mit} ($i = 1, 2$) are known, but only the aggregates p_{dt} and p_{mt}:

$$p_{dt} = g_1 p_{d1t} + g_2 p_{d2t}, \tag{4.9}$$

$$p_{mt} = h_1 p_{m1t} + h_2 p_{m2t}, \tag{4.10}$$

where g_i and h_i ($i = 1, 2$) are weights such that $g_1 + g_2 = 1$ and $h_1 + h_2 = 1$. The g_i will be referred to as the domestic weights, the h_i as the foreign weights, and the p_{dit} and p_{mit} as the individual prices. The problem is then whether a regression of p_{dt} on p_{mt} can be a valid test of the law of one price; i.e. whether regression of p_{dt} on p_{mt}

[9] Such a solution has been followed by Winters (1981, Chapter 4) in his study of export price equations [see Winters (1981, p. 222)]. His model contains other explanatory variables besides the world-market price, but the analysis of this section can be easily adapted to Winters' model.

yields an estimated coefficient that is equal to 1, if $\gamma_1 = \gamma_2 = 1$.

The second problem occurs if the individual domestic prices p_{dit} (i = 1, 2) as well as the aggregate foreign price p_{mt} are known, but the individual foreign prices p_{mit} (i = 1, 2) not. The model is then

$$p_{d1t} = \gamma_1 p_{m1t} + \varepsilon_{1t}; \tag{4.11}$$

$$p_{d2t} = \gamma_2 p_{m2t} + \varepsilon_{2t}; \tag{4.12}$$

$$p_{mt} = h_1 p_{m1t} + h_2 p_{m2t}, \tag{4.13}$$

where p_{m1t} and p_{m2t} are unobservable. The first two solutions referred to are:
— aggregate p_{d1t} and p_{d2t} to p_{dt} and regress p_{dt} on p_{mt}; we are now back with the first problem;
— regress p_{dit} (i = 1, 2) on p_{mt}; the question is whether this yields a valid test of the law of one price.

Thus, we have to investigate two problems:
— when does a regression of p_{dt} on p_{mt} make possible a test of the law of one price?
— when does a regression of p_{dit} on p_{mt} make possible a test of the law of one price?

Regression of the aggregate domestic price index on the aggregate foreign price index

Ordinary-least-squares estimation of the equation

$$p_{dt} = \gamma p_{mt} + \varepsilon_t$$

yields as estimator of γ

$$\hat{\gamma} = \frac{p'_m p_d}{p'_m p_m},$$

where p_d and p_m are (T, 1)-vectors with elements p_{dt} and p_{mt}, respectively. Therefore, the probability limit of $\hat{\gamma}$ is

$$\operatorname*{plim}_{T\to\infty} \hat{\gamma} = \operatorname*{plim}_{T\to\infty} \frac{p'_m p}{p'_m p_m} = \operatorname*{plim}_{T\to\infty} \frac{g_1 p'_m p_1 + g_2 p'_m p_2}{p'_m p_m} =$$

$$\operatorname*{plim}_{T\to\infty} \frac{\gamma_1(g_1 h_1 p'_{m1} p_{m1} + g_1 h_2 p'_{m2} p_{m1}) + \gamma_2(g_2 h_1 p'_{m1} p_{m2} + g_2 h_2 p'_{m2} p_{m2})}{h_1^2 p'_{m1} p_{m1} + 2h_1 h_2 p'_{m1} p_{m2} + h_2^2 p'_{m2} p_{m2}}, \tag{4.14}$$

where the second equality sign is based on (4.9) and the third on (4.10). Define

$$\chi = \operatorname*{plim}_{T\to\infty} \frac{(p'_{m1} p_{m1})^{\frac{1}{2}}}{(p'_{m2} p_{m2})^{\frac{1}{2}}},$$

and

$$\rho = \operatorname*{plim}_{T\to\infty} \frac{p'_{m1} p_{m2}}{(p'_{m1} p_{m1})^{\frac{1}{2}} (p'_{m2} p_{m2})^{\frac{1}{2}}},$$

assuming these probability limits exist. Thus χ is the ratio of the asymptotic standard errors of p_{m1} and p_{m2}, and ρ is the asymptotic correlation coefficient between p_{m1} and p_{m2}. We now get from (4.14)

$$\operatorname*{plim}_{T\to\infty} \hat{\gamma} = \frac{\gamma_1(g_1 h_1 \chi + g_1 h_2 \rho) + \gamma_2(g_2 h_1 \rho + g_2 h_2 \chi^{-1})}{h_1^2 \chi + 2h_2 h_2 \rho + h_2^2 \chi^{-1}} . \tag{4.15}$$

Thus, if $\gamma_1 = \gamma_2 = 1$, then $\text{plim}_{T\to\infty}\hat{\gamma}$ is equal to 1 only if either[10]

$$g_1 = h_1 \quad \text{and} \quad g_2 = h_2 \tag{4.16}$$

or

$$\chi = 1 \quad \text{and} \quad \rho = 1. \tag{4.17}$$

Condition (4.16) means that the weights used in the aggregation of the individual domestic prices are the same as those used in aggregation of the individual foreign prices. Condition (4.17) means that, asymptotically, the individual foreign prices have the same variance and are perfectly correlated, i.e. they are asymptotically identical; the lower the level of aggregation, the more probable it is that products are perfect substitutes and this condition holds.

Thus, even if the law of one price holds at the level of goods, it is possible that a regression of the aggregate domestic price on the aggregate foreign price leads to a rejection of the law.

Implications for testing the law of one price

I have shown that testing of the law of one price for aggregated data is possible if domestic and foreign prices have been aggregated with the same weights; if not the same weights have been used we have to rely on the equality of the individual foreign prices in order to test the law of one price.

These aggregation problems may have caused the rejection of the law of one price in the previous section, in particular for heterogeneous commodity groups such as Machinery and transport equipment and Other manufactures.

Replacement of the individual foreign price by the aggregate foreign price

Replacing in (4.11) p_{m1t} by p_{mt} and estimating the equation

$$p_{d1t} = \gamma_1 p_{mt} + \varepsilon_{1t}$$

by ordinary least squares amounts to taking $g_1 = 1$ and $g_2 = 0$ in (4.9). Therefore, the results of the previous subsection carry over to this one. Hence, the condition for $\text{plim}_{T\to\infty}\hat{\gamma}_1 = \gamma_1$ is either

[10] The results (4.16) and (4.17) can also be derived by means of the methods of Theil (1971, Section 11.3), but the derivation I have used is more direct.

$$h_1 = 1 \text{ and } h_2 = 0$$

or

$$\chi = 1 \text{ and } \rho = 1. \tag{4.18}$$

The first part of this condition is so special that it will be neglected. Thus for $\text{plim}_{T\to\infty}\hat{\gamma}_1 = \gamma_1$ condition (4.18) must hold, i.e. p_{m1} and p_{m2} must be asymptotically identical. This may be plausible at a very low level of aggregation, but not at the level that is used in this study; therefore I have not followed this solution.

Extension of the model

Model (4.11)-(4.13) can be viewed as a latent-variable model.[11] The three observable variables p_1, p_2, and p_m yield six covariances; there are eight unknowns: γ_1, γ_2, σ_{11}, σ_{12}, σ_{22}, the variances of p_{m1} and p_{m2}, and the covariance between p_{m1} and p_{m2}. The model is therefore identified only if at least two unknowns, for example σ_{12} and the covariance between p_{m1} and p_{m2}, are set equal to zero. In particular a zero covariance between p_{m1} and p_{m2} seems unwarranted, however. It is therefore preferable to enlarge the model, so that it becomes identified.

Suppose that we have export price index numbers at the same level of aggregation as the domestic price index numbers. If there exists a relation between export price and foreign price, the model becomes

$$p_{d1t} = \gamma_1 p_{m1t} + \varepsilon_{1t},$$

$$p_{d2t} = \gamma_2 p_{m2t} + \varepsilon_{2t},$$

$$p_{e1t} = \zeta_1 p_{m1t} + v_{1t},$$

$$p_{e2t} = \zeta_2 p_{m2t} + v_{2t},$$

$$p_{mt} = h_1 p_{m1t} + h_2 p_{m2t},$$

where p_{eit} is the export price of good i and v_{it} is a disturbance.

I assume that

$$\text{E}(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij},$$

$$\text{E}(\varepsilon_{it}\varepsilon_{js}) = 0,\quad t \neq s,$$

$$\text{E}(v_{it}v_{jt}) = \tau_{ij},$$

$$\text{E}(v_{it}v_{js}) = 0,\quad t \neq s,$$

$$\text{E}(\varepsilon_{it}v_{it}) = \phi_i,$$

$$\text{E}(\varepsilon_{it}v_{is}) = 0,\quad t \neq s,$$

$$\text{E}(\varepsilon_{it}\varepsilon_{js}) = 0,\quad i \neq j.$$

[11] See Goldberger (1977) for a survey.

Thus, disturbances from different time periods are uncorrelated; of the disturbances from the same time period, those of the domestic price equations are correlated, those of the export price equations are correlated, and those of the domestic and export price equations are correlated if the goods are the same and are uncorrelated if the goods are different.

We now have 15 covariances between the observable variables p_{d1t}, p_{d2t}, p_{e1t}, p_{e2t}, and p_{mt} and 15 unknowns: γ_1, γ_2, ζ_1, ζ_2, σ_{11}, σ_{12}, σ_{22}, τ_{11}, τ_{12}, τ_{22}, ϕ_1, ϕ_2, the variances of p_{m1} and p_{m2}, and the covariance between p_{m1} and p_{m2}. Therefore, the model is identified and the unknowns can be estimated. It is easily shown that the model remains identified if the number of goods is larger than two.

4.3. Summary

In this chapter, I have investigated the law of one price for a small open economy (the 'home country'). I have assumed that each domestic product is traded in a perfect world market, so that the foreign price is equal to the domestic price ('the law of one price'). I have also assumed that foreign prices are exogenous to the home country ('the small-country assumption'). Under these two assumptions, the domestic price is equal to and is determined by the foreign price. I have tested the relative version of the law of one price (equality of domestic and foreign price changes) for five commodity groups covering agriculture, mining, and manufacturing. The empirical results show that only for Fuels the long-run law of one price cannot be rejected; for Chemical products there exists a linear relation between domestic and foreign price changes; and for the other three commodity groups the existence of any influence of the foreign price on the domestic price can be denied. It seems sensible, therefore, to look for another, more elaborate, explanation of domestic prices. This will be the subject of the next chapters.

Testing of the law of one price may be hampered in several ways by aggregation problems. Firstly, if only aggregate price index numbers are available and the law of one price holds for the individual goods, it is possible that a regression of the aggregate domestic price index on the aggregate foreign price index leads, wrongly, to rejection of the law of one price. Only if either the domestic and foreign weights used in computing the aggregate price index numbers are identical or the individual foreign price index numbers are identical, then regression with aggregate price index numbers yields a valid test of the law of one price.

Secondly, if domestic price index numbers are available at a lower level of aggregation than the foreign ones, a correct test of the law of one price can be made after aggregating the domestic prices with foreign weights. The alternative of replacing the individual foreign price by the relevant aggregate price leads to a correct test only if the individual foreign prices are identical. Another correct solution is to extend the model, for example with equations for export prices.

Appendix 4.1. Unit values and price index numbers

It is frequently assumed that unit values are poor measurements of true prices, for example because of quality changes; see Angermann (1979).

Since in the empirical part of this chapter foreign prices have been represented by world-market unit values, it is useful to look at these measurement problems. The outlook is empirical: for seven commodity groups export price indices and export unit values are compared. The unit values are taken from the External Trade Statistics of the Netherlands, published by the Netherlands Central Bureau of Statistics (CBS); they are Fisher chain index numbers, computed from about ten thousand items of the External Trade Statistics. The price index numbers have been aggregated from price index numbers published in the Monthly Bulletin of Price Statistics (CBS); they are recorded in the month of delivery and are Laspeyres index numbers with base years shifting every five years. Differences between price index numbers and unit values can therefore be due to measurement errors in unit values, differences in weights (Laspeyres or Fisher) or time lags (because of different time points of measurement). Although the data used in this Appendix concern exports and not imports, they may give an impression of the quality of unit values for broad commodity groups.

It appears from the figures that the yearly price changes are roughly equal to the yearly changes in the unit values. The only exception is Mining and quarrying; this is possibly due to the rise of the share of natural gas exports during the period, which is reflected in the unit value but not in the price index. For all commodity groups except Mining and quarrying the price levels stay also close to the unit value levels (these figures are not reproduced here).

I have ran OLS-regressions of the change in the unit-value on a constant and the change in the price index. The results show that for all commodity groups, except Food, drink, and tobacco products, one cannot reject the hypothesis that the coefficient of the constant is equal to 0 and the coefficient of the price index is equal to 1; the $\bar{R}^2$ lie for most of the groups between 0.7 and 1.0. The exception for Food is due to the years 1974 and 1975; when these two years are omitted, the results become comparable to those for the other groups.

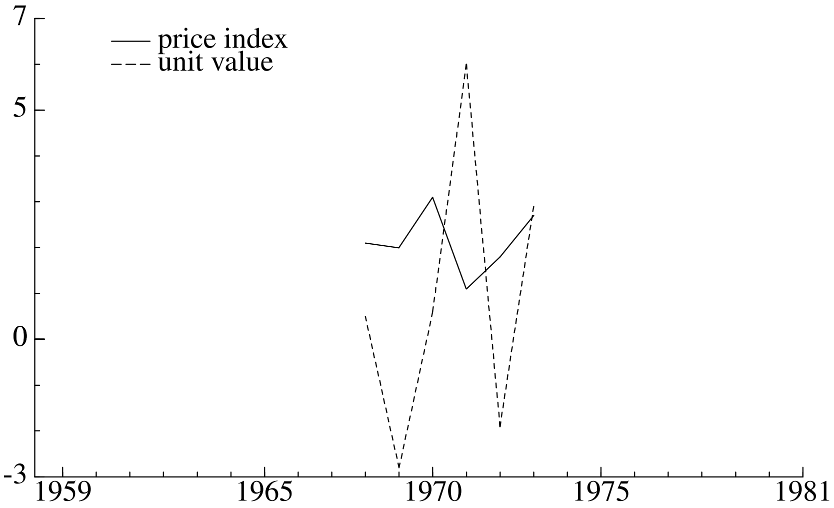

Figure 4.6 *Mining and quarrying: price index and unit value of exports (percentage change)*

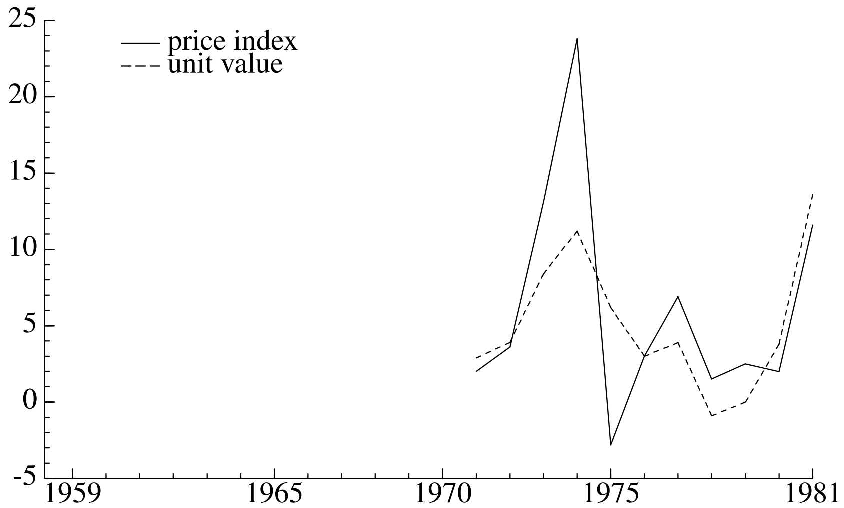

Figure 4.7 *Food, drink, and tobacco products: price index and unit value of exports (percentage change)*

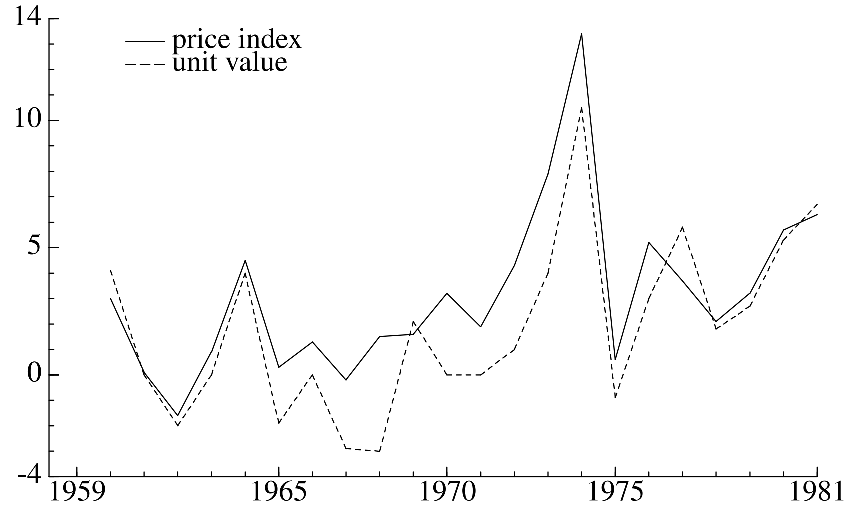

Figure 4.8 *Textiles and clothing: price index and unit value of exports (percentage change)*

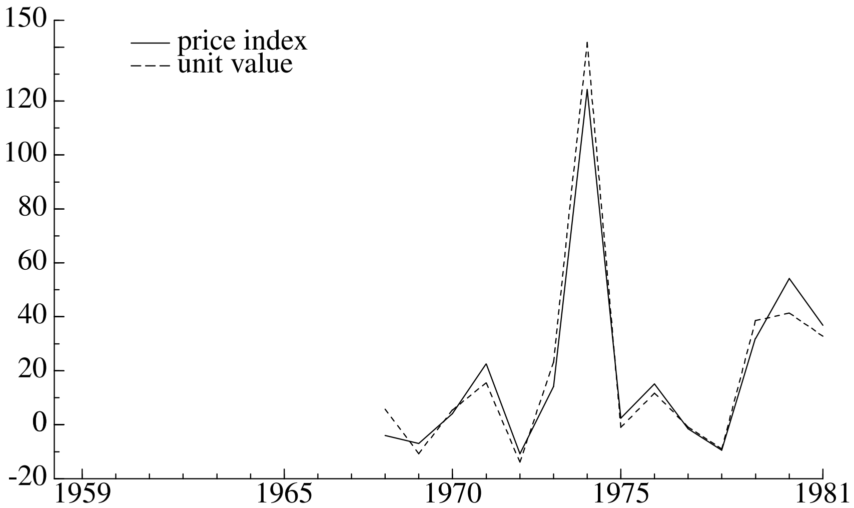

Figure 4.9 *Mineral oil refining: price index and unit value of exports (percentage change)*

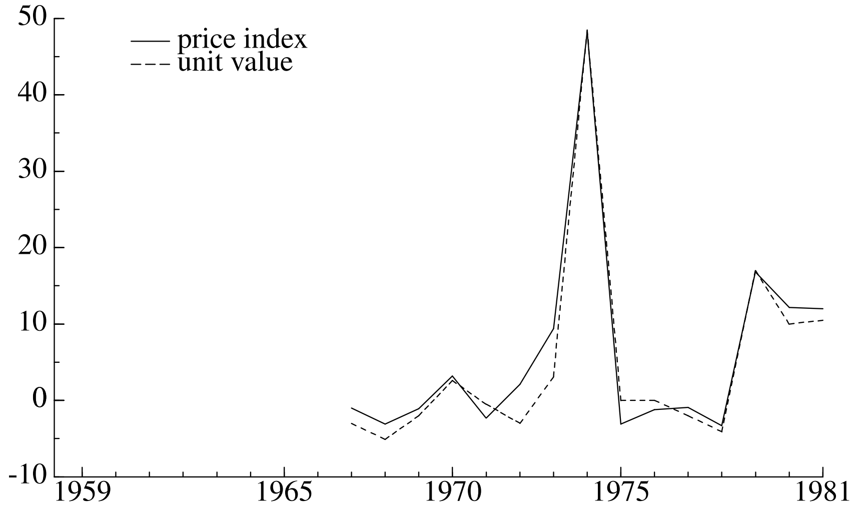

Figure 4.10 *Chemical, rubber, and plastic products: price index and unit value of exports (percentage change)*

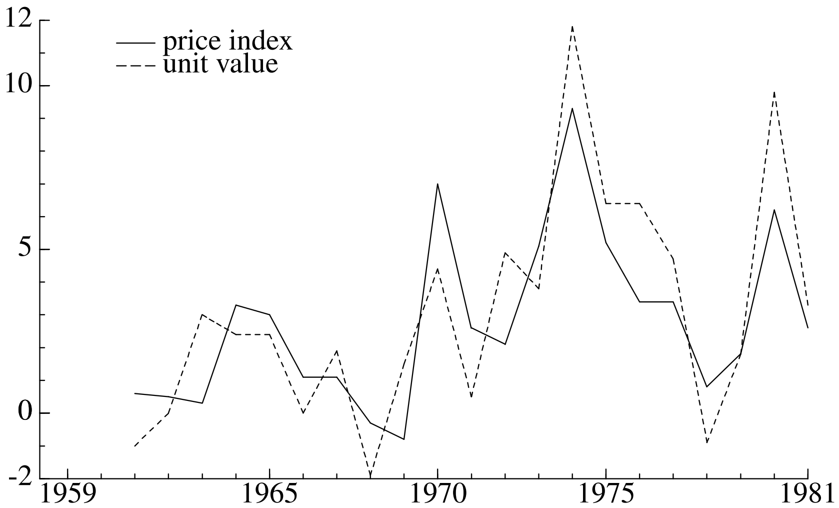

Figure 4.11 *Metal products: price index and unit value of exports (percentage change)*

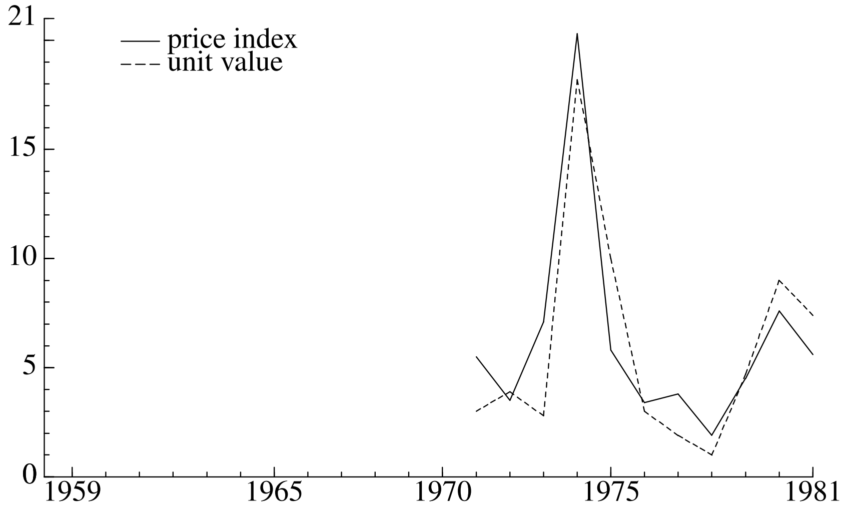

Figure 4.12 *Other manufactures: price index and unit value of exports (percentage change)*

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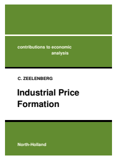

CHAPTER 5

Price formation in general equilibrium

In this chapter I shall show how price formation in a small open economy can be described by general-equilibrium methods. In Section 5.1 the basic general-equilibrium model of a closed economy is presented by means of duality theory. In Section 5.2 it is shown that the excess-demand functions of an economy can be regarded as net-demand functions of a fictitious utility-maximizing consumer; the income and substitution effects of this consumer are expressed in terms of the income and substitution effects of the original consumer and producer. In Section 5.3 the results of Section 5.2 are applied to the foreign excess-demand functions of an open economy (which are equal to the net-export demand functions of the home country); it is shown that in net-export demand substitution effects between domestic goods and income effects of domestic goods are zero and that substitution effects between foreign goods are infinite. The implication of this result is shown in Section 5.4: for small open countries, foreign prices are determined only by foreign conditions, and domestic prices are determined by both foreign and domestic conditions; thus foreign prices are exogenous to the home country. Sections 5.2-5.4 generalize results obtained for an economy without production by Keller (1980, pp. 215-26). Section 5.5 deals with the case where for a domestic product there exists a perfectly substitutable domestic product; it is shown that the law-of-one-price model of Chapter 4 can be seen as a special case of the general-equilibrium model of Chapter 5. In Section 5.6 the model is further specified by means of nested CES utility and transformation functions. In Section 5.7 the model is estimated for five groups of traded commodities with the same data as in Chapter 4.

5.1. General equilibrium

In this section I shall show the basic relations of demand, supply, and general equilibrium; the exposition is based on Dixit and Norman (1980, Chapter 2), where demand and supply are analysed by duality methods. I shall not give proofs of most of the statements and properties; see Diewert (1982), McFadden (1978), Varian (1978, Chapters 1 and 3), and Woodland (1983, Chapter 2) for a more complete analysis. As a simple example of the comparative statics I analyse the effect of a change in factor supply. In this section the economy is assumed to be closed; foreign trade will be considered in Section 5.3.

Demand

I assume that there exists a representative consumer,[1] whose preferences are represented by his expenditure function

$$e(p, u) = \min_{q_H} \{p' q_H : u(q_H) \geq u\},$$

where p is vector of prices, q_H is the vector of quantities,[2] $u(q_H)$ is the utility function, and u is a utility level. Thus, the expenditure function gives the minimal costs that are necessary to reach utility level u when prices are equal to p. It can be shown that if preferences are monotonous, the expenditure function is homogeneous of degree one and concave in the prices. I assume that the expenditure function is twice continuously-differentiable; because the expenditure function is concave, its matrix with second-order partial derivatives (e_{pp}) is then negative semi-definite.

Inversion of the expenditure function with respect to income gives the indirect utility function

$$\psi(p, y) = \max_{q_H} \{u(q_H) : p' q_H \leq y\},$$

where y is income; it gives maximum utility that can be reached with income y when prices are equal to p. The indirect utility function is homogeneous of degree zero in (p, y): doubling prices and income leaves the constraint $p' q_H \leq y$ unchanged.

As the expenditure function and the indirect utility function are each other's inverse, they are related by the identities

$$e[p, \psi(p, y)] = y \tag{5.1}$$

and

$$\psi[p, e(p, u)] = u, \tag{5.2}$$

i.e. minimal expenditure necessary to reach utility level $\psi(p, y)$ is equal to y, and maximal utility that can be obtained from income $e(p, u)$ is equal to u.

The compensated demand functions are given by Shephard's Lemma:

$$h(p, u) = \frac{\partial e(p, u)}{\partial p} =: e_p(p, u). \tag{5.3}$$

The market demand functions are given by Roy's Identity:

$$q_H(p, y) = -\left[\frac{\partial \psi(p, y)}{\partial y}\right]^{-1} \frac{\partial \psi(p, y)}{\partial p}.$$

[1] See Deaton and Muellbauer (1980, Section 6.2) for the restrictions on individual preferences that are necessary for the existence of a representative consumer. For the analysis in this chapter it is not necessary to assume that there exists a representative consumer. It is sufficient to assume that there exist aggregate demand functions that satisfy the Slutsky conditions; see Van Daal and Merkies (1984, Section 3.6). The assumption of a representative consumer simplifies the analysis somewhat.

[2] The subscript H is derived from 'household'.

Note that h, q_H, e_p, and $\partial\psi/\partial p$ are vectors. Because the partial derivatives of a function that is homogeneous of degree k are homogeneous of degree $k-1$, the compensated demand functions are homogeneous of degree zero in p and the market demand functions are homogeneous of degree zero in (p, y). The following two equalities relate the compensated and market demand functions:

$$h(p, u) = q_H[p, e(p, u)] \tag{5.4}$$

and

$$q_H(p, y) = h[p, \psi(p, y)]. \tag{5.5}$$

These equalities can be proved by differentiating (5.1) and (5.2) with respect to p, u, and y and using Shephard's Lemma and Roy's Identity.

There exists a relationship between the partial derivative of the compensated demand function with respect to utility and the marginal propensities to consume: differentiating equation (5.4) with respect to u we obtain

$$\frac{\partial h}{\partial u} = \frac{\partial e}{\partial u}\frac{\partial q_H}{\partial y},$$

or

$$e_{pu} = e_u c, \tag{5.6}$$

where $e_{pu} = \partial^2 e/(\partial p \partial u)$, $e_u = \partial e/\partial u$, and $c = \partial q_H/\partial y$ is the vector with the marginal propensities to consume. Note that e_{pu} and c are vectors and e_u is a scalar. It can be shown that $e_u = (\partial\psi/\partial y)^{-1}$; thus e_u is the inverse of the marginal utility of income.

Define the income elasticities, the uncompensated price elasticities, the compensated price elasticities, and the elasticities of substitution by respectively

$$\eta_{Hi} = \frac{y}{q_{Hi}}\frac{\partial q_{Hi}}{\partial y},$$

$$\varepsilon_{Hij} = \frac{p_j}{q_{Hi}}\frac{\partial q_{Hi}}{\partial p_j},$$

$$\varepsilon^*_{Hij} = \frac{p_j}{h_i}\frac{\partial h_i}{\partial p_j},$$

$$\sigma_{Hij} = \frac{\varepsilon^*_{Hij}}{w_{Hj}} = e\,\frac{\dfrac{\partial^2 e}{\partial p_i \partial p_j}}{\dfrac{\partial e}{\partial p_i}\dfrac{\partial e}{\partial p_j}},$$

$$i, j = 1, 2, \ldots, N,$$

where $w_{Hj} = p_j q_{Hj}/y$ is the budget share of good j. Because e_{pp} is negative semi-definite we have $\partial^2 e/\partial p_i^2 \leq 0$, and thus

$$\sigma_{Hii} \leq 0$$

and

$$\varepsilon^*_{Hii} \le 0.$$

By differentiating (5.5) with respect to p and using (5.6) one easily proves the Slutsky equation, which in elasticity notation reads

$$\varepsilon_{Hij} = \varepsilon^*_{Hij} - w_{Hj}\eta_{Hi} = w_{Hj}(\sigma_{Hij} - \eta_{Hi}).$$

The differential relative change in demand is

$$\tilde{q}_{Hi} = \sum_{j=1}^{N} \varepsilon_{Hij}\tilde{p}_j + \eta_{Hi}\tilde{y} = \sum_{j=1}^{N} w_{Hj}(\sigma_{Hij} - \eta_{Hi})\tilde{p}_j + \eta_{Hi}\tilde{y},\ i = 1, 2, \ldots, N, \quad (5.7)$$

where a tilde denotes a relative change [for example $\tilde{y} = (\mathrm{d}y)/y$].

Since the compensated demand functions are homogeneous of degree zero in the prices, we have from Euler's Theorem

$$\sum_{j=1}^{N} p_j \frac{\partial h_i}{\partial p_j} = 0,\ i = 1, 2, \ldots, N;$$

thus

$$\sum_{j=1}^{N} \varepsilon^*_{Hij} = 0,\ \ i = 1, 2, \ldots, N$$

and

$$\sum_{j=1}^{N} w_{Hj}\sigma_{Hij} = 0,\ \ i = 1, 2, \ldots, N. \quad (5.8)$$

Supply

Let v be the vector with aggregate primary inputs and q_F the vector with aggregate net outputs (thus intermediate inputs are measured as negative outputs).[3] I assume that the supply of primary inputs is exogenously determined and independent of prices. The aggregate production possibilities are represented by the revenue function

$$g(p, v) = \max_{q_F} \{p'q_F\colon (-v, q_F) \in S\},$$

where S is the aggregate production possibility set containing all possible combinations of primary inputs v and net outputs q_F; thus, the revenue function is the dual of the transformation function. The revenue function gives for each primary input vector v the

[3] The subscript F comes from 'firm'.

maximum amount of revenue (defined as the difference between gross output and intermediate deliveries) that can be obtained at prices p; total revenue is therefore equal to gross national product. The revenue function is homogeneous of degree one in the prices p: doubling all prices doubles revenue. I assume that S is convex; then it can be shown that g is convex in p and concave in v. I assume also that g is twice continuously-differentiable; because g is convex in the prices p, the matrix with second-order partial derivatives with respect to the prices (g_{pp}) is positive semi-definite. Note that this formulation of producer behaviour does not exclude joint products and intermediate deliveries.

The supply functions of net output are given by Shephard's Lemma (in the case of the producer sometimes called Hotelling's Lemma):

$$q_F(p, v) = \frac{\partial g(p, v)}{\partial p} =: g_p(p, v). \tag{5.9}$$

The inverse demand functions for primary inputs are given by

$$r = \frac{\partial g(p, v)}{\partial v} =: g_v(p, v), \tag{5.10}$$

where r is the vector of primary-input prices. Since I have assumed that v is exogenous, (5.10) gives the equilibrium values for the primary-input prices. Because the revenue function is homogeneous of degree one in the prices p, the supply and demand functions are homogeneous of degree zero in the prices p.

The price elasticities of net output and the elasticities of substitution are respectively

$$\varepsilon_{Fij} = \frac{p_j}{q_{Fi}} \frac{\partial q_{Fi}}{\partial p_j},$$

$$\sigma_{Fij} = \frac{\varepsilon_{Fij}}{w_{Fj}} = g \frac{\dfrac{\partial^2 g}{\partial p_i \partial p_j}}{\dfrac{\partial g}{\partial p_i} \dfrac{\partial g}{\partial p_j}},$$

where $w_{Fj} = p_j q_{Fj}/g$ is the revenue share of good j. Because g_{pp} is positive semi-definite, there holds $\partial^2 g/\partial p_i^2 \geq 0$ and thus

$$\sigma_{Fii} \geq 0.$$

If a good is supplied then its revenue share is nonnegative; thus

$$\varepsilon_{Fii} \geq 0 \quad \text{if } q_{Fi} \geq 0,$$

i.e. if a good is supplied, then its own price elasticity is nonnegative. If a good is demanded, then its revenue share is nonpositive; thus

$$\varepsilon_{Fii} \leq 0 \quad \text{if } q_{Fi} \leq 0,$$

i.e. if a good is demanded, then its own price elasticity is nonpositive.

The differential relative change in net output is

$$\tilde{q}_{Fi} = \sum_{j=1}^{N} \varepsilon_{Fij} \tilde{p}_j + \sum_{h=1}^{M} \phi_{Fih} \tilde{v}_h$$

$$= \sum_{j=1}^{N} w_{Fj}\sigma_{Fij}\tilde{p}_j + \sum_{h=1}^{M} \phi_{Fih}\tilde{v}_h,\ i = 1, 2, \ldots, N, \tag{5.11}$$

where $\phi_{Fih} = (v_h/q_{Fi})(\partial q_{Fi}/\partial v_h)$ is the elasticity of net output of good i with respect to the quantity of primary input h.

Since the net supply functions are homogeneous of degree zero in the prices, there holds

$$\sum_{j=1}^{N} \varepsilon_{Fij} = 0,$$

and thus

$$\sum_{j=1}^{N} w_{Fj}\sigma_{Fij} = 0. \tag{5.12}$$

General equilibrium

In general equilibrium demand and supply for every good are equal:

$$q_H = q_F,$$

or, because of (5.3), (5.4), and (5.9),

$$e_p(p, u) = g_p(p, v). \tag{5.13}$$

Profits, which are equal to the difference between revenue and factor payments, are assumed to be distributed to the consumers; thus total income of the representative consumer equals factor payments plus profits:

$$y = r'v + [g(p, v) - r'v] = g(p, v),$$

or, because of (5.1),

$$e(p, u) = g(p, v). \tag{5.14}$$

Equation (5.14) represents the equality of national income and national product. Using the definitions of e and g we can also write it as Walras' Law:

$$p'q_H = p'q_F,$$

i.e. the total value of demand equals the total value of supply.

Because of the homogeneity properties of e, g, q_H, and q_F, multiplication of all prices by the same factor leaves the equilibrium conditions (5.13) and (5.14) unchanged; one of the prices can therefore be fixed at one. Take one of the goods, label it with index zero, and set its price at one. The general equilibrium model then becomes

$$e(1, p, u) = g(1, p, v), \tag{5.15}$$

$$e_0(1,\ p,\ u) = g_0(1,\ p,\ v), \tag{5.16}$$

$$e_p(1,\ p,\ u) = g_p(1,\ p,\ v), \tag{5.17}$$

$$r = g_v(1,\ p,\ v), \tag{5.18}$$

where p now excludes the price with index zero. Because of Walras' Law one of the equations may be deleted, for example equation (5.16), the equilibrium condition for the numeraire market. Equation (5.18) may also be deleted, if one is not interested in the factor prices. The existence of an equilibrium price vector will be taken for granted.

Example: changes in factor supply

As an example of the comparative statics of general equilibrium I shall analyse the effects of a change in the supply of primary inputs. Totally differentiating (5.15) we get

$$e_p' \mathrm{d}p + e_u \mathrm{d}u = g_p' \mathrm{d}p + g_v' \mathrm{d}v. \tag{5.19}$$

Using (5.17) and (5.18) we obtain

$$e_u \mathrm{d}u = r' \mathrm{d}v. \tag{5.20}$$

Thus, the change in welfare is proportional to the Divisia change in real value added. Total differentiation of (5.17) yields

$$e_{pp} \mathrm{d}p + e_{pu} \mathrm{d}u = g_{pp} \mathrm{d}p + g_{pv} \mathrm{d}v.$$

Using (5.6) and (5.20) we get

$$(e_{pp} - g_{pp}) \mathrm{d}p = (g_{pv} - cr') \mathrm{d}v,$$

where c is the vector with marginal propensities to consume; therefore

$$\mathrm{d}p = (e_{pp} - g_{pp})^{-1} (g_{pv} - cr') \mathrm{d}v. \tag{5.21}$$

Using the definitions of the income elasticities η_{Hi}, the elasticities of substitution σ_{Hij} and σ_{Fij}, and the primary-input elasticities ϕ_{Fih}, and the facts that in equilibrium $q_H = q_F$ and $y = g$, we can write (5.21) as

$$\tilde{p} = \hat{w}_H^{-1} (\sigma_H - \sigma_F)^{-1} (\phi_F - \eta_H a') \tilde{v}, \tag{5.22}$$

where $\hat{w}_H$ is the diagonal matrix with as elements the budget shares w_{Hi}, $\sigma_H = (\sigma_{Hij})$, $\sigma_F = (\sigma_{Fij})$, and $\phi_F = (\phi_{Fih})$ are matrices with as elements the substitution and primary-input elasticities, $a = (a_h)$ is the vector with the revenue shares of the primary inputs ($a_h = r_h v_h / g$), and $\eta_H = (\eta_{Hi})$ is the vector with the income elasticities.

5.2. Excess-demand functions

The excess-demand functions are the difference between consumer demand q_H and producer net output q_F. In a closed economy the equilibrium condition is that excess demand is zero; in a open economy excess demand is equal to net imports. This section deals with the properties of the excess-demand functions. I shall first show that the excess-demand functions can be regarded as net-demand functions of a utility-maximizing consumer. Thereafter I shall express the income elasticities and the elasticities of substitution of excess-demand behaviour in the income elasticities and the elasticities of substitution of the consumer and producer behaviour.

Define the surplus function as the difference between the consumer expenditure function and the producer revenue function:

$$s(p, u, v) = e(p, u) - g(p, v).$$

There holds

$$\frac{\partial s}{\partial p} = \frac{\partial e}{\partial p} - \frac{\partial g}{\partial p};$$

thus

$$x := \frac{\partial s}{\partial p}[p, \psi(p, y), v] = q_H - q_F,$$

i.e. the partial derivatives of the surplus function give the excess-demand functions.

If the consumer receives only factor incomes and profits, then $e(p, u) = y = g(p, v)$, and thus $s(p, u, v) = 0$ if there is equilibrium. If the consumer has also an exogenous income b (for example from borrowing or from abroad), then in equilibrium $e(p, u) = y = g(p, v) + b$, and thus $s(p, u, v) = b$. The excess-demand functions are then functions of p, b, and v:

$$x(p, b, v) = \frac{\partial s}{\partial p}\{p, \psi[p, g(p, v) + b], v\}.$$

I shall follow the second, more general, way, where there may be exogenous income. Because the expenditure function is homogeneous of degree one in p, concave in p, non-decreasing in p and in u, and the revenue function is homogeneous of degree one in p, convex in p, and non-decreasing in p, we have that the surplus function is homogeneous of degree one in p, concave in p, and non-decreasing in p and in u. Therefore the surplus function has all the properties of an expenditure function of a consumer, except that it may take negative values. Woodland (1980) has shown that there exists indeed a utility function whose dual is the surplus function; this socalled direct (or Meade) trade utility function is defined as

$$U(x, v) = \max_{q_H} \{u(q_H) \colon (-v, q_H - x) \in S\};$$

i.e. U gives maximal utility that can be obtained with given excess demand x, if production is efficient. Thus we can regard the excess-demand functions as net-demand functions of a utility-maximizing consumer, and we can define price and income elasticities and elasticities of substitution that satisfy the restrictions of consumer behaviour:

$$\varepsilon_{ij} = \frac{p_j}{x_i}\frac{\partial x_i}{\partial p_j}, \quad i, j = 1, 2, \ldots, N, \quad \text{(price elasticity)}$$

$$\eta_i = \frac{z}{x_i}\frac{\partial x_i}{\partial b}, \quad i = 1, 2, \ldots, N, \quad \text{(income elasticity)}$$

$$\sigma_{ij} = z \frac{\dfrac{\partial^2 s}{\partial p_i \partial p_j}}{\dfrac{\partial s}{\partial p_i}\dfrac{\partial s}{\partial p_j}} = \frac{\varepsilon_{ij} + w_j \eta_i}{w_j}, \quad i, j = 1, 2, \ldots, N,$$

(elasticity of substitution)

where w_j is the share of good j in gross expenditure:

$$w_j = \frac{p_j x_j}{z} = w_{Hj}\frac{y}{z} - w_{Fj}\frac{g}{z}, \quad j = 1, 2, \ldots, N,$$

$$z = \sum_{x_i > 0} p_i x_i.$$

Because b may be zero, the income effects $\partial x_i / \partial b$ are multiplied by z/x_i and not by b/x_i to get income elasticities; a similar remark holds for the elasticities of substitution σ_{ij}. Note that w_j is negative if the excess demand is negative (i.e. $q_{Hj} < q_{Fj}$). There holds

$$\sum_{w_j > 0} w_j = 1 \quad \text{and} \quad \sum_{j=1}^{N} w_j = \frac{b}{z}.$$

If the budget constraint $b = p'x$ holds (i.e. 'net income' equals 'net expenditure'), then

$$z = b + Z$$

(where $Z = -\sum_{x_i < 0} p_i x_i$ is gross income from supply of goods), i.e. 'gross expenditure' equals 'gross income'.

Since the surplus function is concave in the prices, the matrix with second-order partial derivatives is negative semi-definite; therefore

$$\sigma_{ii} \leq 0.$$

The concepts introduced in this subsection may be illustrated for an open economy. Surplus s is equal to the difference between national expenditure and national product, i.e. to the trade deficit. Excess demand is equal to the difference between demand and supply, i.e. to net imports. Gross expenditure z is equal to the total value of gross imports, gross income Z from supply of goods is equal to the total value of gross exports, and the shares w_j are the shares in gross imports. If exogenous income b is zero, then the total values of gross imports and gross exports are equal when there is equilibrium, i.e. the trade deficit is zero. If b consists only of net transfers from abroad, then $g + b$ is equal to disposable national income, and the surplus on the current account is zero.

Because net *export*-demand is the excess demand of the rest of the world, we can regard the rest of the world as a household, whose utility function is the direct trade utility function and who demands exports and supplies imports.

The elasticities of the excess-demand functions

In this subsection I shall express the income elasticities and the elasticities of substitution of the excess-demand functions in the income elasticities and the elasticities of substitution of the demand and supply functions.

Since b may be zero I shall take the relative differential of b with respect to z: $\tilde{b} = \mathrm{d}b/z$. Total differentiation of the excess-demand functions gives

$$\begin{aligned}\tilde{x}_i &= \sum_{j=1}^{N} \varepsilon_{ij}\tilde{p}_j + \eta_i\tilde{b} + \sum_{h=1}^{M} \phi_{ih}\tilde{v}_h \\ &= \sum_{j=1}^{N} w_j(\sigma_{ij} - \eta_i)\tilde{p}_j + \eta_i\tilde{b} + \sum_{h=1}^{M} \phi_{ih}\tilde{v}_h, \ \ i = 1, 2, \ldots, N, \qquad (5.23)\end{aligned}$$

where $\phi_{ih} = (v_h/x_{i)}(\partial x_i/\partial v_h)$ is the primary-input elasticity of excess demand.

From the definition of the excess-demand functions we have

$$\tilde{x}_i = \frac{q_{Hi}}{x_i}\,\tilde{q}_{Hi} - \frac{q_{Fi}}{x_i}\,\tilde{q}_{Fi}. \qquad (5.24)$$

Total income is $y = g(p, v) + b$, so that

$$\tilde{y} = \frac{g}{y}\sum_{j=1}^{N} w_{Fj}\tilde{p}_j + \frac{g}{y}\sum_{h=1}^{M} a_h\tilde{v}_h + \frac{z}{y}\,\tilde{b}, \qquad (5.25)$$

where $a_h = r_h v_h/g$ is the revenue share of primary input h.

Using (5.7), (5.11), and (5.25) we get from (5.24)

$$\begin{aligned}\tilde{x}_i = &\sum_{j=1}^{N}[\frac{q_{Hi}}{x_i}\,w_{Hj}(\sigma_{Hij} - \eta_{Hi}) - \frac{q_{Fi}}{x_i}\,w_{Fj}\sigma_{Fij} + \frac{q_{Hi}}{x_i}\,\frac{g}{y}\,w_{Fj}\eta_{Hi}]\tilde{p}_j \\ &+ \frac{q_{Hi}}{x_i}\,\frac{z}{y}\,\eta_{Hi}\tilde{b} + \sum_{h=1}^{M}[\frac{q_{Hi}}{x_i}\,\frac{g}{y}\,a_h\eta_{Hi} - \frac{q_{Fi}}{x_i}\,\phi_{Fih}]\tilde{v}_h. \qquad (5.26)\end{aligned}$$

From a comparison of (5.23) and (5.26) we get

$$\eta_i = \frac{w_{Hi}}{w_i}\,\eta_{Hi}, \ \ i = 1, 2, \ldots, N, \qquad (5.27)$$

$$\sigma_{ij} = \frac{w_{Hi}}{w_i}\,\frac{w_{Hj}}{w_j}\,\frac{y}{z}\,\sigma_{Hij} - \frac{w_{Fi}}{w_i}\,\frac{w_{Fj}}{w_j}\,\frac{g}{z}\,\sigma_{Fij}, \ \ i, j = 1, 2, \ldots, N, \qquad (5.28)$$

$$\phi_{ih} = \frac{w_{Hi}}{w_i}\,\frac{g}{z}\,a_h\eta_{Hi} - \frac{w_{Fi}}{w_i}\,\frac{g}{z}\,\phi_{Fih}, \ \ \ i = 1, 2, \ldots, N, \ \ h = 1, 2, \ldots, M. \qquad (5.29)$$

Thus an income elasticity of excess-demand behaviour is proportional to the corresponding income elasticity of consumer behaviour, an elasticity of substitution of excess-demand behaviour is a weighted average of the corresponding elasticities of substitution of consumer and producer behaviour, and a primary-input elasticity of excess-demand behaviour is a weighted average of the corresponding income elasticity of consumer behaviour and the corresponding primary-input elasticity of producer behaviour.

5.3. The net-export functions of a small open economy

In this section it is shown that in a general-equilibrium model import prices of a small open economy are exogenous. The result depends on the fact that foreign budget and revenue shares of domestic goods are small.

First I shall enlarge the general-equilibrium model of Section 5.1 with a foreign sector. Thereafter I shall use the results of Section 5.2 to show that in net-export demand of a small open economy, substitution effects between domestic goods and income effects of domestic goods are zero, and that substitution effects between foreign goods are infinite.

General equilibrium with a foreign sector

If a foreign sector is introduced, we have to split demand and supply according to origin, and we have both for the home country and the rest of the world the equality of national income and product. I assume that goods are mobile between countries and that primary inputs are immobile between countries. I shall distinguish foreign functions and variables by writing capitals. The general-equilibrium model then becomes

$$e(p, u) = g(p, v) + b, \tag{5.30}$$

$$E(P, U) = G(P, V) + B, \tag{5.31}$$

$$e_p(p, u) + E_p(P, U) = g_p(p, v) + G_p(P, V), \tag{5.32}$$

$$r = g_v(p, v), \tag{5.33}$$

$$R = G_V(P, V). \tag{5.34}$$

The vector P is the vector with prices of the goods in foreign currency; in the absence of trade taxes and other distortions there holds

$$P = p \cdot \mathrm{ER} \tag{5.35}$$

where ER is the exchange rate (the foreign price of domestic currency).

Equations (5.30) and (5.31) are the equalities of national income and product; b is the value of exogenous transfers: if b is positive then the home country receives a transfer, and if b is negative then the home country makes a transfer. I assume that there is no other exogenous income, so that $B = -b \cdot \mathrm{ER}$. Equation (5.32) is the equality of demand and supply, and equations (5.33) and (5.34) give domestic and foreign primary-input prices.

Because the demand and supply functions are homogeneous of degree zero in the prices and the national-income = national-product equations are homogeneous of degree one in the prices, we can normalize the price vectors; I take the normalizations ER = 1 (so that $p = P$) and $p_0 = 1$ for some good with index 0. Because of Walras' Law, the equilibrium condition for the numeraire market may be deleted. The general-equilibrium model can now be written as

$$e(1,\ p,\ u) = g(1,\ p,\ v) + b, \tag{5.36}$$

$$E(1,\ p,\ U) = G(1,\ p,\ V) - b, \tag{5.37}$$

$$e_p(1,\ p,\ u) + E_p(1,\ p,\ U) = g_p(1,\ p,\ v) + G_p(1,\ p,\ V), \tag{5.38}$$

where the vector p now excludes the element with index zero.

We can write the general-equilibrium equations (5.36), (5.37), and (5.38) more compactly as

$$x(p,\ b,\ v) + X(p,\ -b,\ V) = 0, \tag{5.39}$$

where

$$x = e_p[p,\ \psi\{p,\ g(p,\ v) + b\}] - g_p(p,\ v)$$

and

$$X = E_p[p,\ \Psi\{p,\ G(p,\ V) - b\}] - G_p(p,\ V)$$

are the excess-demand functions; for economy of notation the numeraire price (1) has been excluded from the equations.

Assumptions

In the rest of this section, I shall apply the results of Section 5.2 on the elasticities of the excess-demand functions to the foreign excess-demand functions $X(p,\ b,\ V) = E_p - G_p$, if the home country is small. Because in equilibrium X is equal to net-exports by the home country, I shall refer to the foreign excess-demand functions as the net-export functions of the home country.

The home country is said to be small if its gross exports are a small fraction of foreign income, i.e. if the ratio Z/Y is small, where $Z = \sum_{X_i>0} p_i X_i = -\sum_{x_i<0} p_i x_i$ is the value of gross exports.

I suppose that the goods can be divided in two groups: domestic goods and foreign goods. Domestic goods are produced by the domestic producers, but not by the foreign producers; and foreign goods are produced by the foreign producers, but not by the domestic producers. The case where this division is not possible (when domestic and foreign products are identical) will be dealt with in Section 5.5. I shall write $j \in d$ if good j is a domestic good and thus is exported by the home country, and $j \in m$ if good j is a foreign good and thus is imported by the home country.

I shall look only at goods that are always in positive quantities supplied, demanded, exported, and imported; i.e. for $i \in d$

$$Q_{Hi} > 0, \;\; Q_{Fi} < 0,$$

$$X_i = Q_{Hi} - Q_{Fi} > 0,$$

and for $i \in m$

$$Q_{Hi} > 0, \;\; Q_{Fi} > 0,$$

$$X_i = Q_{Hi} - Q_{Fi} < 0.$$

I assume that if Z/Y approaches zero, the foreign income, substitution and primary-input elasticities of the foreign goods remain finite, and the foreign shares of foreign goods remain finite and non-zero:[4]

$$-\infty < \lim \mathrm{H}_{Hi} < \infty, \;\; i, \, j = 1, 2, \ldots, N, \tag{5.40a}$$

$$-\infty < \lim \Sigma_{Hij} < \infty, \;\; i, \, j = 1, 2, \ldots, N, \tag{5.40b}$$

$$-\infty < \lim \Sigma_{Fij} < \infty, \;\; i, \, j = 1, 2, \ldots, N, \tag{5.40c}$$

$$-\infty < \lim \Phi_{Fih} < \infty, \;\; i = 1, 2, \ldots, N, \;\; h = 1, 2, \ldots, M, \tag{5.40d}$$

$$0 < \lim W_{Hi} < 1, \;\; i \in m, \tag{5.40e}$$

$$0 < \lim W_{Fi} < \infty, \;\; i \in m, \tag{5.40f}$$

$$-\infty < \lim W_i < 0, \;\; i \in m, \tag{5.40g}$$

$$0 < \lim A_h < \infty, \;\; h = 1, 2, \ldots, M, \tag{5.40h}$$

$$-\infty < \lim \frac{B}{Z} < \infty. \tag{5.40i}$$

The definitions of the symbols are the same as those of the corresponding lowercase variables in Sections 5.1 and 5.2, except that the uppercase indicates the rest of the world: H_{Hi} is the income elasticity[5] of foreign consumer demand, Σ_{Hij} is the elasticity of substitution of foreign consumer demand, Σ_{Fij} is the elasticity of substitution of foreign producer behaviour, $\Phi_{Fih} = (V_h/Q_{Fi})\partial Q_{Fi}/\partial V_h$ is the elasticity of foreign net output of good i with respect to the quantity of foreign primary input h, W_{Hi} is the foreign budget share of good i, W_{Fi} is the foreign revenue share of good i, $W_i = p_i X_i/Z$ is the foreign share of good i in gross imports by the rest of the world, and $A_h = R_h V_h/G$ is the foreign revenue share of primary input h.

The assumptions about the elasticities, (5.40a)-(5.40d), can be justified as follows. Assumption (5.40a) about the income elasticities is plausible for empirical reasons. The case where the assumptions (5.40b) and (5.40c) about the elasticities of substitution do

[4] In this section, $\lim f$ for an expression f means $\lim_{(Z/Y)\to 0} f$, unless otherwise stated.

[5] The first H in H_{Hi} is capital η and not capital h.

not hold will be analysed in the next subsection. How the analysis changes if assumption (5.40d) about the primary-input elasticities does not hold, can be investigated with the theory of behaviour under rationing [see Neary and Roberts (1980)]; I shall not attempt such an analysis here.

The assumptions about the shares, (5.40e)-(5.40h), can be justified for empirical reasons: we can actually observe that if the home country is very small, the foreign budget and revenue shares (W_{Hi}, W_{Fi}, and A_h) and the shares (W_i) in gross imports are finite and non-zero.

The elasticities of the net-export functions

The income elasticities of net exports are [cf. equation (5.27)]

$$\mathrm{H}_i = \frac{Z}{X_i}\frac{\partial X_i}{\partial B} = \frac{W_{Hi}}{W_i}\mathrm{H}_{Hi}, \quad i = 1, 2, \ldots, N. \tag{5.41}$$

Note that H_i measures the effect of a change in transfers B and not the effect of a change in income Y.

The elasticity of substitution between net exports of goods i and j is [cf. equation (5.28)]

$$\Sigma_{ij} = \frac{W_{Hi}}{W_i}\frac{W_{Hj}}{W_j}\frac{Y}{Z}\Sigma_{Hij} - \frac{W_{Fi}}{W_i}\frac{W_{Fj}}{W_j}\frac{G}{Z}\Sigma_{Fij}, \quad i, j = 1, 2, \ldots, N. \tag{5.42}$$

The elasticity of net export of good i with respect to the quantity of foreign primary input h is [cf. equation (5.29)]

$$\Phi_{ih} = \frac{V_h}{X_i}\frac{\partial X_i}{\partial V_h} = \frac{W_{Hi}}{W_i}\frac{G}{Z}A_h\mathrm{H}_{Hi} - \frac{W_{Fi}}{W_i}\frac{G}{Z}\Phi_{Fih},$$

$$i = 1, 2, \ldots, N, \quad h = 1, 2, \ldots, M. \tag{5.43}$$

The foreign shares of net exports by a small open economy

I shall now determine the magnitudes of the income, substitution, and primary-input elasticities if Z/Y approaches zero. To do this I shall first determine the magnitudes of the ratios W_{Hj}/W_j and W_{Fj}/W_j if Z/Y approaches zero.

By definition there holds

$$W_j = W_{Hj}\frac{Y}{Z} - W_{Fj}\frac{G}{Z};$$

thus

$$\frac{W_{Hj}}{W_j}\frac{Y}{Z} - \frac{W_{Fj}}{W_j}\frac{G}{Z} = 1 \tag{5.44}$$

and

$$\left(\frac{W_{Hj}}{W_j} - \frac{W_{Fj}}{W_j}\frac{G}{Y}\right)\frac{Y}{Z} = 1. \tag{5.45}$$

If Y/Z approaches infinity then $W_{Hj}/W_j - (W_{Fj}/W_j)(G/Y)$ must approach zero in order to keep the left-hand side of (5.45) finite. Because

$$\lim \frac{G}{Y} = 1 - \left(\lim \frac{B}{Z}\right)\left(\lim \frac{Z}{Y}\right) = 1,$$

there holds

$$\lim \frac{W_{Hj}}{W_j} = \lim \frac{W_{Fj}}{W_j}\,. \tag{5.46}$$

To obtain further results we must distinguish between domestic and foreign goods. If good j is a domestic good then $W_{Hj} > 0$ and $W_{Fj} < 0$. It follows then from (5.46) that

$$\lim \frac{W_{Hj}}{W_j} = 0, \quad j \in d, \tag{5.47a}$$

$$\lim \frac{W_{Fj}}{W_j} = 0, \quad j \in d. \tag{5.47b}$$

Because for $j \in d$

$$\frac{W_{Hj}}{W_j}\frac{Y}{Z} > 0 \text{ and } \frac{W_{Fj}}{W_j}\frac{G}{Z} < 0,$$

it follows from (5.44) that

$$0 < \lim \frac{W_{Hj}}{W_j}\frac{Y}{Z} < \infty, \quad j \in d, \tag{5.48a}$$

$$-\infty < \lim \frac{W_{Fj}}{W_j}\frac{G}{Z} < 0, \quad j \in d. \tag{5.48b}$$

If good j is a foreign good then by assumptions (5.40) we have

$$-\infty < \lim \frac{W_{Hj}}{W_j} < 0, \quad j \in m, \tag{5.49a}$$

$$-\infty < \lim \frac{W_{Fj}}{W_j} < 0, \quad j \in m. \tag{5.49b}$$

The elasticities of net exports by a small open economy

We can now apply the results (5.46), (5.47), (5.48), and (5.49) to the elasticity formulae (5.41), (5.42), and (5.43). Using (5.47a) and (5.49a) we get from (5.41)

$$\lim \frac{\mathrm{H}_i}{\mathrm{H}_{Hi}} = 0, \ \ i \in d, \tag{5.50a}$$

$$-\infty < \lim \frac{\mathrm{H}_i}{\mathrm{H}_{Hi}} < 0, \ \ i \in m. \tag{5.50b}$$

Equations (5.50) say that the net-export income elasticities of domestic goods tend to zero, and that the net-export income elasticities of foreign goods are opposite in sign to the corresponding foreign income elasticities of foreign goods. Thus if a small country makes a transfer, then demand for its exports does not change, but the supply of its imports does change.

From (5.42) we have

$$\Sigma_{ij} = \frac{W_{Hi}}{W_i} \frac{W_{Hj}}{W_j} \frac{Y}{Z} \left(\Sigma_{Hij} - \frac{W_{Fi}}{W_{Hi}} \frac{W_{Fj}}{W_{Hj}} \frac{G}{Y} \Sigma_{Fij} \right).$$

Using this equation, (5.46), (5.47), (5.48), (5.49), and $\lim(G/Y) = 1$ we get

$$\lim \frac{\Sigma_{ij}}{\Sigma_{Hij} - \Sigma_{Fij}} = 0, \ \ i \in d, \ j \in d, \tag{5.51a}$$

$$-\infty < \lim \frac{\Sigma_{ij}}{\Sigma_{Hij} - \Sigma_{Fij}} < 0, \ \ i \in d, \ j \in m, \tag{5.51b}$$

$$-\infty < \lim \frac{\Sigma_{ij}}{\Sigma_{Hij} - \Sigma_{Fij}} < 0, \ \ i \in m, \ j \in d, \tag{5.51c}$$

$$\lim \frac{\Sigma_{ij}}{\Sigma_{Hij} - \Sigma_{Fij}} = \infty, \ \ i \in m, \ j \in m. \tag{5.51d}$$

Similarly

$$-\infty < \lim \frac{\Phi_{ih}}{A_h \mathrm{H}_{Hi} - \Phi_{Fih}} < 0, \ \ i \in d, \tag{5.52a}$$

$$\lim \frac{\Phi_{ih}}{A_h \mathrm{H}_{Hi} - \Phi_{Fih}} = -\infty, \ \ i \in m. \tag{5.52b}$$

We see that if the home country is small, then import goods are perfect substitutes [if $(\Sigma_{Hij} - \Sigma_{Fij}) > 0$] or perfect complements [if $(\Sigma_{Hij} - \Sigma_{Fij}) < 0$], whereas substitution effects and income effects of export goods are zero. This implies that, seen from the home country, the prices of foreign goods remain relatively constant to each other; in other words, a small open economy cannot influence the price of its imports.[6]

In the next section I shall formally show that (5.50), (5.51), and (5.52) imply that a small open economy cannot influence prices of foreign goods. This implication can also be illustrated for a partial-equilibrium analysis. The own price elasticity of net

[6] The results (5.50) and (5.51) have been obtained for an economy without production by Keller (1980, p. 226).

exports of good i is

$$\varepsilon_{ii} = (\Sigma_{ii} - \mathrm{H}_i)W_i.$$

It follows from (5.50) and (5.51) that

$$\lim \varepsilon_{ii} = 0, \quad i \in d,$$

$$\lim \varepsilon_{ii} = \infty, \quad i \in m.$$

Thus for a small open economy, export demand is perfectly price inelastic, and import supply is perfectly price elastic, i.e. a small open economy cannot influence the quantity of its exports or the price of its imports.

5.4. Price formation in a small open economy

In this section I shall show what the results of the previous section imply for price formation when the home country is small. It will appear that changes in the prices of foreign goods are determined by changes abroad and that changes in the home country do not effect foreign prices. For simplicity, I assume that transfers are zero: $b = 0$ and $\mathrm{d}b = 0$, so that total gross exports Z of the home country are equal to total gross imports z of the home country. In the more general case, where $b \neq 0$, the formulae become more complicated, but the results are the same.

Comparative statics of a change in factor supply

Suppose a change in domestic and foreign primary inputs occurs. Total differentiation of (5.39) gives

$$x_p \mathrm{d}p + x_v \mathrm{d}v + X_p \mathrm{d}p + X_v \mathrm{d}V = 0. \tag{5.53}$$

Using the Slutsky equation and the definitions of the income elasticities and the elasticities of substitution we can write the $(i,\, j)$-th element of x_p as

$$\frac{\partial x_i}{\partial p_j} = \frac{1}{z} x_i \sigma_{ij} x_j - \frac{1}{z} x_i \eta_i x_j,$$

where σ_{ij} is the excess-demand elasticity of substitution between goods i and j, and η_i is the excess-demand income elasticity of good i. In matrix notation this equation reads

$$x_p = \frac{1}{z} \hat{x} \sigma \hat{x} - \frac{1}{z} \hat{x} \eta \iota' \hat{x}, \tag{5.54}$$

where $\hat{x}$ is the diagonal matrix with elements x_i, $\sigma = (\sigma_{ij})$, $\eta = (\eta_i)$, and $\iota = (1, 1, \ldots, 1)'$. Similarly we have

$$X_p = \frac{1}{Z} \hat{X} \Sigma \hat{X} - \frac{1}{Z} \hat{X} \mathrm{H} \iota' \hat{X}. \tag{5.55}$$

By (5.39) we have $X = -x$ and thus

$$\hat{X} = -\, \hat{x}. \tag{5.56}$$

Because I have assumed $b = B = 0$, there holds

$$Z = z. \tag{5.57}$$

Substitution of (5.54), (5.55), (5.56) and (5.57) into (5.53) and rearrangement give

$$\frac{1}{z}\,\hat{x}(\sigma - \eta\iota' + \Sigma - \mathrm{H}\iota')\hat{x}\mathrm{d}p = -\,(x_v\mathrm{d}v + X_V\mathrm{d}V).$$

Now $x_v = \hat{x}\phi\hat{v}^{-1}$, where ϕ is the matrix with as elements $(v_h/x_i)/(\partial x_i/\partial v_h)$. Similarly, $X_V = \hat{X}\Phi\hat{V}^{-1} = -\hat{x}\Phi\hat{V}^{-1}$. Thus

$$(\sigma - \eta\iota' + \Sigma - \mathrm{H}\iota')\hat{w}\tilde{p} = -\,\phi\tilde{v} + \Phi\tilde{V}, \tag{5.58}$$

where $\hat{w}$ is the diagonal matrix with the domestic excess-demand shares $w_i = p_i x_i/z$.

The changes in domestic and foreign prices

Rearrange now p such that the domestic goods come first; thus, if there are N_d domestic goods, then the goods with index $1, 2, \ldots, N_d$ are domestic goods and those with index $N_d + 1, N_d + 2, \ldots, N$ are foreign goods. Write p as (p_d, p_m), where p_d contains the prices of the domestic goods and p_m the prices of the foreign goods. Partition (5.58) conformably:

$$\begin{bmatrix} S_{dd} & S_{dm} \\ S_{md} & S_{mm} \end{bmatrix}\begin{bmatrix} \hat{w}_d & 0 \\ 0 & \hat{w}_m \end{bmatrix}\begin{bmatrix} \tilde{p}_d \\ \tilde{p}_m \end{bmatrix} = \begin{bmatrix} -\phi_d & \Phi_d \\ -\phi_m & \Phi_m \end{bmatrix}\begin{bmatrix} \tilde{v} \\ \tilde{V} \end{bmatrix}, \tag{5.59}$$

where $S_{ab} = \sigma_{ab} - \eta_a\iota' + \Sigma_{ab} - \mathrm{H}_a\iota'$ $(a, b = d, m)$.

We can now apply the results (5.50), (5.51), and (5.52) to Σ, H, and Φ. Write (5.59) as

$$S_{dd}\hat{w}_d\tilde{p}_d + S_{dm}\hat{w}_m\tilde{p}_m = -\,\phi_d\tilde{v} + \Phi_d\tilde{V}, \tag{5.60a}$$

$$S_{md}\hat{w}_d\tilde{p}_d + S_{mm}\hat{w}_m\tilde{p}_m = -\,\phi_m\tilde{v} + \Phi_m\tilde{V}. \tag{5.60b}$$

From (5.50), (5.51), and (5.52) we have that $\lim\Sigma_{dd}$ and $\lim\mathrm{H}_d$ are zero and that $\lim\Sigma_{dm}$, $\lim\mathrm{H}_m$, and $\lim\Phi_d$ are finite and non-zero. Thus if Z/Y approaches zero, then we have from (5.60a)

$$\lim\tilde{p}_d = \lim\hat{w}_d^{-1}(\sigma_{dd} - \eta_d\iota')^{-1}$$
$$\times[-(\sigma_{dm} - \eta_d\iota' + \Sigma_{dm})\hat{w}_m\tilde{p}_m - \phi_d\tilde{v} + \Phi_d\tilde{V}]. \tag{5.61}$$

We see that changes in domestic prices are determined by domestic as well as foreign elasticities and by the changes in domestic as well as foreign primary inputs.

Multiply (5.60b) by $\hat{w}_m^{-1}S_{mm}^{-1}$:

$$\hat{w}_m^{-1}S_{mm}^{-1}S_{md}\hat{w}_d\tilde{p}_d + \tilde{p}_m = -\,\hat{w}_m^{-1}S_{mm}^{-1}\phi_m\tilde{v} + \hat{w}_m^{-1}S_{mm}^{-1}\Phi_m\tilde{V}.$$

I shall show in the next subsection that

$$\lim\hat{w}_m^{-1}S_{mm}^{-1}\Phi_m = \lim\hat{W}_{Hm}^{-1}(\Sigma_{Hmm} - \Sigma_{Fmm})^{-1}(\Phi_{Fm} - \mathrm{H}_{Hm}A'), \tag{5.62}$$

$$\lim S_{mm}^{-1} S_{md} = 0, \tag{5.63}$$

$$\lim S_{mm}^{-1} \phi_m = 0. \tag{5.64}$$

Before giving the proofs I shall discuss the implications of (5.62)-(5.64). It follows from (5.62)-(5.64) that

$$\lim \tilde{p}_m = \lim [\hat{W}_{Hm}^{-1}(\Sigma_{Hmm} - \Sigma_{Fmm})^{-1}(\Phi_{Fm} - \mathrm{H}_{Hm}A')]\tilde{V}. \tag{5.65}$$

We see that equation (5.65) is similar to equation (5.22), which describes price formation in a closed economy. Thus the rest of the world can be regarded as a closed economy: changes in prices of foreign goods are determined by foreign elasticities, foreign shares, and changes in foreign primary inputs. In other words, prices of foreign goods are exogenous to a small open economy, i.e. in equation (5.60a) the variable $\tilde{p}_m$ is exogenous.

If other exogenous variables, such as technical progress and tax rates, are introduced and analysed, the same result appears: foreign prices are determined by foreign conditions, and domestic prices are determined by both domestic and foreign conditions. Similarly, it can be shown that exports of a small open economy are exogenous: they depend only on foreign conditions.

Proofs of (5.62)-(5.64)

I shall now give the proofs of (5.62)-(5.64). The proofs rest on the fact that it is the factor Y/Z that makes Σ_{mm} and Φ_m infinite [the factor G/Z in Σ_{mm} and Φ_m can be written as $(G/Y)(Y/Z)$; note that $G = Y$, because I have assumed that $B = 0$]. Because Σ_{mm} is the dominant term in S_{mm} and $\lim S_{md}$ and $\lim \phi_m$ are finite, (5.63) and (5.64) hold; and because the factors Y/Z in Σ_{mm} and Φ_m tend to cancel each other, (5.62) holds. Readers who are satisfied with these heuristic arguments may omit the rest of this subsection and continue with the next section.

Formal proofs of (5.62)-(5.64) go as follows. Define

$$S_{mm}^d = \sigma_{mm} - \eta_m \iota'$$

and

$$S_{mm}^m = \Sigma_{mm} - \mathrm{H}_m \iota',$$

so that $S_{mm} = S_{mm}^d + S_{mm}^m$. Then

$$S_{mm}^{-1} = (S_{mm}^d + S_{mm}^m)^{-1} = (S_{mm}^d)^{-1}[(S_{mm}^d)^{-1} + (S_{mm}^m)^{-1}]^{-1}(S_{mm}^m)^{-1}. \tag{5.66}$$

Now[7]

$$(S_{mm}^m)^{-1} = (\Sigma_{mm} - \mathrm{H}_m \iota')^{-1} = \Sigma_{mm}^{-1} + \frac{1}{1 - \iota'\Sigma_{mm}^{-1}\mathrm{H}_m} \Sigma_{mm}^{-1}\mathrm{H}_m \iota' \Sigma_{mm}^{-1}. \tag{5.67}$$

[7] The second equality sign in (5.67) is based on the lemma $(A + BCD)^{-1} = A^{-1} - A^{-1}B(C^{-1} + DA^{-1}B)^{-1}DA^{-1}$.

From (5.42) we have

$$\Sigma_{mm} = \frac{Y}{Z}\left(\hat{W}_m^{-1}\hat{W}_{Hm}\Sigma_{Hmm}\hat{W}_{Hm}\hat{W}_m^{-1} - \frac{G}{Y}\hat{W}_m^{-1}\hat{W}_{Fm}\Sigma_{Fmm}\hat{W}_{Fm}\hat{W}_m^{-1}\right).$$

Because of (5.40b), (5.40c), and $G = Y$, it follows that

$$\lim \Sigma_{mm}^{-1} = 0.$$

Therefore we have from (5.67), using (5.40a) and (5.50b),

$$\lim (S_{mm}^m)^{-1} = 0,$$

and then, because $\lim(S_{mm}^d)^{-1}$ is finite, from (5.66)

$$\lim S_{mm}^{-1} = 0.$$

Because $\lim S_{md}$ and $\lim \phi_m$ are finite, equations (5.63) and (5.64) now follow.

To prove (5.62) I shall first show that $\lim \Sigma_{mm}^{-1}\Phi_m$ is finite. From (5.42) and (5.43) we have

$$\begin{aligned}
&\Sigma_{mm}^{-1}\Phi_m \\
&= \left(\frac{Y}{Z}\hat{W}_m^{-1}\hat{W}_{Hm}\Sigma_{Hmm}\hat{W}_{Hm}\hat{W}_m^{-1} - \frac{G}{Z}\hat{W}_m^{-1}\hat{W}_{Fm}\Sigma_{Fmm}\hat{W}_{Fm}\hat{W}_m^{-1}\right)^{-1} \\
&\quad \times \frac{G}{Z}\left(\hat{W}_m^{-1}\hat{W}_{Hm}\mathrm{H}_{Hm}A' - \hat{W}_m^{-1}\hat{W}_{Fm}\Phi_{Fm}\right) \\
&= \left(\frac{Y}{G}\hat{W}_m^{-1}\hat{W}_{Hm}\Sigma_{Hmm}\hat{W}_{Hm}\hat{W}_m^{-1} - \hat{W}_m^{-1}\hat{W}_{Fm}\Sigma_{Fmm}\hat{W}_{Fm}\hat{W}_m^{-1}\right)^{-1} \\
&\quad \times (\hat{W}_m^{-1}\hat{W}_{Hm}\mathrm{H}_{Hm}A' - \hat{W}_m^{-1}\hat{W}_{Fm}\Phi_{Fm}).
\end{aligned}$$

Using (5.46) and $G = Y$ we get

$$\lim \Sigma_{mm}^{-1}\Phi_m = \lim \hat{W}_m\hat{W}_{Hm}^{-1}(\Sigma_{Hmm} - \Sigma_{Fmm})^{-1}(\mathrm{H}_{Hm}A' - \Phi_{Fm}), \tag{5.68}$$

which is finite. From (5.66)-(5.68) we have

$$\begin{aligned}
&\lim \hat{w}_m^{-1}S_{mm}^{-1}\Phi_m = \lim \hat{w}_m^{-1}\Sigma_{mm}^{-1}\Phi_m \\
&= \lim \hat{w}_m^{-1}\hat{W}_m\hat{W}_{Hm}^{-1}(\Sigma_{Hmm} - \Sigma_{Fmm})^{-1}(\mathrm{H}_{Hm}A' - \Phi_{Fm}) \\
&= \lim \hat{W}_{Hm}^{-1}(\Sigma_{Hmm} - \Sigma_{Fmm})^{-1}(\Phi_{Fm} - \mathrm{H}_{Hm}A'),
\end{aligned}$$

which is equation (5.62); the last equality sign is based on (5.56), which implies that $W_{mi} = -w_{mi}$.

5.5. Price formation with perfect domestic and foreign substitutes

In this section, I shall show that if for a domestic product there exists a perfectly substitutable foreign product, then the price changes of these two products are equal. For simplicity, I assume that for *each* domestic good there exists a foreign good that is a perfect substitute in consumption or production. If goods $i \in d$ and $j \in m$ are perfect substitutes in consumption, then $\sigma_{Hij} = \infty$ and, because of (5.8), $\sigma_{Hii} = \sigma_{Hjj} = -\infty$. Thus σ_{dd} and σ_{dm} are square matrices of the same order, whose diagonal elements are infinite.

I shall model this perfect substitutability by letting the diagonal elements of σ_{Hdm} go to infinity and examining the behaviour of (5.60a) under this limit. Let the (i, i)-th element of σ_{Hdm} have value α. Because of (5.8) we have

$$\frac{(\sigma_{Hdd})_{ii}}{\alpha} = -\frac{w_{Hmi}}{w_{Hdi}} + \sum_{j \neq i} \frac{w_{Hdj}}{w_{Hdi}} \frac{(\sigma_{Hdd})_{ij}}{\alpha} + \sum_{j \neq i} \frac{w_{Hmj}}{w_{Hdi}} \frac{(\sigma_{Hdm})_{ij}}{\alpha}.$$

Thus

$$\lim_{\alpha \to \infty} \frac{(\sigma_{Hdd})_{ii}}{\alpha} = -\frac{w_{Hmi}}{w_{Hdi}}. \tag{5.69}$$

Similarly,

$$\lim_{\alpha \to \infty} \frac{(\sigma_{Hdm})_{ij}}{\alpha} = 0, \quad i \neq j. \tag{5.70}$$

Because each diagonal element of σ_{Hdm} goes to infinity, we can give them all the same value α.

From (5.60a) we have

$$\tilde{p}_d = \hat{w}_d^{-1} S_{dd}^{-1}(-S_{dm}\hat{w}_m \tilde{p}_m - \phi_d \tilde{v} + \Phi_d \tilde{V}).$$

Write S_{dd} as

$$S_{dd} = D_{dd} + S^*_{dd},$$

where D_{dd} is the diagonal matrix with the diagonal elements of S_{dd}; thus the diagonal of S^*_{dd} is zero. Similarly,

$$S_{dm} = D_{dm} + S^*_{dm}.$$

Now

$$S_{dd}^{-1} = (S^*_{dd})^{-1}[(S^*_{dd})^{-1} + D_{dd}^{-1}]^{-1} D_{dd}^{-1}.$$

Because $\lim_{\alpha \to \infty} D_{dd} = \infty$, there holds

$$\lim_{\alpha \to \infty} D_{dd}^{-1} = 0.$$

Thus

$$\lim_{\alpha \to \infty} S_{dd}^{-1} = 0.$$

Using (5.28), (5.42), (5.69), and (5.70), one can now show that

$$\lim_{\alpha\to\infty} S_{dd}^{-1} S_{dm} = \lim_{\alpha\to\infty} D_{dd}^{-1} D_{dm} = \lim_{\alpha\to\infty} (\alpha D_{dd})^{-1} = -\,\hat{w}_d \hat{w}_m^{-1}.$$

Therefore

$$\lim_{\alpha\to\infty} \tilde{p}_d = \tilde{p}_m,$$

i.e. the price change of a domestic good is equal to the price change of the foreign good that is its perfect substitute. The same conclusion is reached if for each domestic good there exists a foreign good that is its perfect substitute in production.

This equality of price changes holds whether the home country is small or not. If the home country is small, then we can combine the results of this section with those of the previous section. The equality of domestic and foreign price changes can then be interpreted as a causal relation: the foreign price change is equal to and *determines* the domestic price change. Thus for a small open economy, the law-of-one-price model of Chapter 4 is a limiting case of the general-equilibrium model of this chapter.

5.6. Specification of the price equation

In this section I shall specify the substitution matrices S_{dd} and S_{dm} in equation (5.60a); this equation will be referred to as the price equation. Equation (5.60a) gives only a restricted description of actual price behaviour, because it describes only the consequences of a change in the primary inputs; other explanatory variables, such as changes in tax rates, are not included. There are several reasons why (5.60a) may nevertheless give a reasonable description of actual price formation. Firstly, one may assume that the effects of the other foreign explanatory variables are partly reflected in $\tilde{p}_m$, so that their omission is partially remedied. Secondly, I think that relative changes in productivity are an important source of relative price changes. Thus if we measure primary-input quantities in efficiency units, then these relative productivity changes are reflected in the terms $\tilde{v}$ and $\tilde{V}$ in (5.60a). Anyway, specification of (5.60a) may serve to show that description of price formation by means of general-equilibrium methods is feasible.

One may wonder why I have chosen (5.60a) as the price equation and have not solved (5.59) for $\tilde{p}_d$ as a function of $\tilde{v}$ and $\tilde{V}$, thereby eliminating $\tilde{p}_m$. The reason is that solving of (5.59) would make it difficult to estimate the elasticities of substitution (which will be done in the next section), because there remain few explanatory variables: with the specifications that will be chosen, only two variables would remain, namely the changes in the Divisia index numbers of respectively domestic and foreign primary inputs.

I assume that the matrices S_{dd}, S_{md}, S_{dm}, and S_{mm} in (5.60a) are constant; i.e. (5.60a) is regarded as a first-order Taylor expansion around the values of p_d and p_m in a certain base year.

I suppose that for each domestic good there exists a competing foreign good that is a close substitute; thus in (5.60) S_{md} and S_{dm} are square matrices, and S_{dd}, S_{md}, S_{dm}, and S_{mm} have the same order. This implies that there is only one non-traded good, which serves as numeraire. A domestic good and the competing foreign good are in this section and the next one regarded as varieties of the same good, and they are therefore called domestic and foreign products; for example domestic cars and foreign cars are products of the good cars.

I assume that the consumer follows a two-stage budgeting procedure: he first decides how much will be spent on each good and then for each good he decides how much will be spent on the two products.

Producer behaviour is modelled by a different two-stage procedure. I assume that there exists an aggregate of the domestic products and an aggregate of the foreign products. In the first stage the primary inputs and the aggregate foreign input produce the aggregate domestic output; in the second stage the aggregate output and the aggregate input are distributed over the products.

The plan of the section is as follows. After an introduction to two-stage budgeting[8] I shall derive expressions for the substitution and income elasticities of consumer behaviour, using the theory of nested CES utility functions. Thereafter I shall derive the elasticities of substitution of producer behaviour, using the theory of nested CES transformation functions. Finally I shall use these results to derive from (5.60a) an equation, which will be estimated in the next section.

Consumer behaviour

For each domestic product there exists a foreign product; these products are varieties of the same good: for example, domestic clothing and foreign clothing are products that are varieties of the good clothing, cf. Armington (1969a, 1969b). In the first stage the consumer allocates his income to goods, using for each good a price index that is a function of the prices of the two products. In the second stage he allocates for each good the expenditure that has been determined in the first stage to the two products. This two-stage procedure is schematically represented in Figure 5.1.

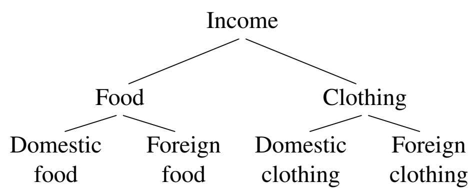

Figure 5.1 *Two-stage budgeting*

For this two-stage procedure to coincide with the one-stage procedure, it is necessary that preferences are separable: the consumer must have preferences over goods and within goods he must have preferences over products. Formally, it must be possible to write his utility function as

[8] A formal analysis of two-stage budgeting is given in Appendix A.

$$u(q_{Hd1}, q_{Hm1}, \ldots, q_{HdN}, q_{HmN}) =$$
$$= U[u_1(q_{Hd1}, q_{Hm1}), \ldots, u_N(q_{HdN}, q_{HmN})]. \tag{5.71}$$

The function U is called the macro-utility function and the functions u_i ($i = 1, 2, \ldots, N$) the sub-utility functions. Separability alone does not suffice for equality of one-stage and two-stage budgeting; additional constraints on preferences must hold. A condition that is sufficient (but not necessary) is:

For each product there are certain minimum quantities $\bar{q}_{Hai}$, the sub-utility function is homogeneous of degree one in the excess quantities $q^{+}_{Hai} = q_{Hai} - \bar{q}_{Hai}$,[9] and the macro-utility function is additive: $U = \sum_{i=1}^{N} u_i$.

I assume that this condition holds.

The elasticities of substitution under two-stage budgeting

I specify consumer preferences further by assuming that the sub-utility functions are CES functions of the excess quantities and that the macro-utility function is a CES function of the sub-utility functions. For the minimum quantities I take

$$\bar{q}_{Hai} = (1 - \eta^{0}_{Hai})q^{0}_{Hai}, \;\; a, b = d, m, \;\; i = 1, 2, \ldots, N,$$

where η_{Hai} is the income elasticity of product Hai, and a 0 indicates the value in the base year around which the Taylor expansion in (5.60a) is made.

The elasticities of substitution in the base year can then be written as [see Keller (1980), Chapter 4, in particular equations (4.44), (4.52), and (4.84)-(4.86)]

$$\sigma_{H,ai,ai} = \eta^{2}_{Hai}\left[\sigma^{+i}_{H}\left(\frac{1}{w^{+}_{Hi}} - \frac{1}{w^{+}_{Hai}}\right) + \sigma_H\left(1 - \frac{1}{w_{Hi}}\right)\right], \tag{5.72}$$

$$\sigma_{H,ai,bi} = \eta_{Hai}\eta_{Hbi}\left[\sigma^{+i}_{H}\,\frac{1}{w^{+}_{Hi}} + \sigma_H\left(1 - \frac{1}{w_{Hi}}\right)\right], \; a \neq b, \tag{5.73}$$

$$\sigma_{H,ai,bj} = \eta_{Hai}\eta_{Hbj}\sigma_H, \;\; i \neq j, \tag{5.74}$$

where $\sigma_{H,ai,bj}$ is the elasticity of substitution between products ai and bj, σ^{+i}_{H} is the elasticity of substitution between the excess quantities q^{+}_{Hdi} and q^{+}_{Hmi} with sub-utility u_i constant, σ_H is the elasticity of substitution between goods i and j ($j \neq i$), $w_{Hi} = w_{Hdi} + w_{Hmi}$ is the budget share of good i,

$$w^{+}_{Hai} = \eta_{Hai} w_{Hai} \tag{5.75}$$

is the marginal budget share of product ai, and $w^{+}_{Hi} = w^{+}_{Hdi} + w^{+}_{Hmi}$ is the marginal budget share of good i.

[9] Note that the excess quantities q^{+}_{Hai} are not equal to the quantities of excess demand ($x_{ai} = q_{Hai} - q_{Fai}$).

Producer behaviour

The aggregate production possibilities of the economy are represented by a nested CES transformation function. I assume that there exists an aggregate of the domestic products and an aggregate of the foreign products; thus here domestic and foreign products are aggregated separately, whereas with the consumer the domestic and the foreign products of the same good were aggregated.

In the first stage the aggregate output (i.e. the aggregate domestic product) is produced by the inputs (the aggregate foreign product and the, fixed, primary inputs) according to a production function with constant elasticity of substitution $\sigma_F > 0$; maximization of revenue (the difference between the value of the aggregate output and the value of the foreign aggregate input) then gives revenue of the domestic aggregate product and revenue of the foreign aggregate product.

In the second stage two separate revenue maximization problems are solved: the first problem is to maximize revenue of the domestic products subject to the constraint that the total revenue equals the amount determined in the first stage; and the second problem is to maximize revenue of the foreign products subject to the constraint that total revenue equals the amount determined in the first stage. Since quantities of inputs are negative, maximization of the revenue of the inputs amounts to minimization of their cost.

I assume that in the second stage the relations between an aggregate product and its components can be represented by CES functions; the domestic products have a common elasticity of substitution $\sigma_{Fd} < 0$ and the foreign products have a common elasticity of substitution $\sigma_{Fm} > 0$. The two-stage revenue maximization is illustrated in Figure 5.2.

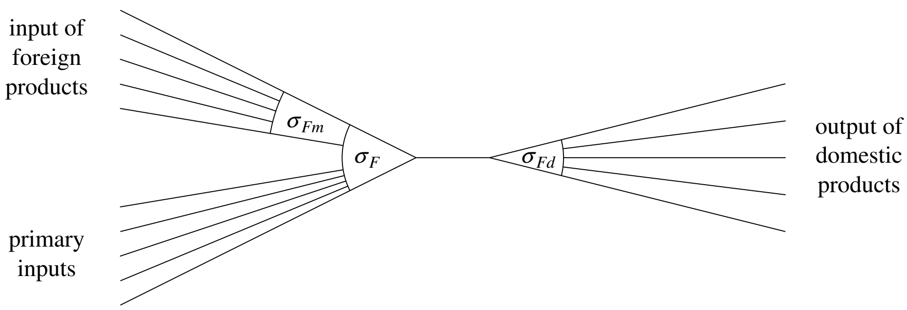

Figure 5.2 *Revenue maximization in two stages*

Using (5.12) and equation (A.19) of Appendix A.2, we get for the producer elasticities of substitution

$$\sigma_{F,ai,bj} = \sigma_F, \quad a \neq b, \tag{5.77}$$

$$\sigma_{F,ai,aj} = \sigma_F\left(1 - \frac{1}{w_{Fa}}\right) + \sigma_{Fa}\frac{1}{w_{Fa}}, \quad i \neq j, \tag{5.78}$$

$$\sigma_{F,ai,ai} = \sigma_F\left(1 - \frac{1}{w_{Fa}}\right) + \sigma_{Fa}\left(\frac{1}{w_{Fa}} - \frac{1}{w_{Fai}}\right), \tag{5.79}$$

$$i = 1, 2, \ldots, N, \;\; a, b = d, m,$$

where $\sigma_{F,ai,bj}$ is the producer elasticity of substitution between products ai and bj, $w_{Fai} = p_{ai}q_{Fai}/g$ is the revenue share of product ai, and $w_{Fa} = \sum_{i=1}^{N} w_{Fai}$ is the revenue share of the aggregate product a.

The primary-input elasticities can be obtained as follows. The CES transformation function that has been used above can be written as

$$N(q_F) - T(v) = 0,$$

where N is a linearly homogeneous function. It is easily shown [cf. Diewert (1982, p. 551)] that the revenue function has the form

$$g(p, v) = D(p)T(v).$$

Using this equation and equations (5.9) and (5.10), one can derive that

$$\phi_{F,di,h} = \frac{v_h}{q_{Fdi}} \frac{\partial q_{Fdi}}{\partial v_h} = a_h,$$

$$i = 1, 2, \ldots, N, \;\; h = 1, 2, \ldots, M, \tag{5.80}$$

where $a_h = r_h v_h/g$ is the revenue share of primary input h.

Foreign elasticities

For foreign consumer and producer behaviour there hold completely similar formulae; we only have to replace in (5.72)-(5.80) the variables by capitals. Because in foreign producer behaviour the domestic products are inputs and the foreign products are outputs, we have $\Sigma_{Fd} > 0$ and $\Sigma_{Fm} < 0$.

The domestic price equations

Using equations (5.27)-(5.29) and (5.72)-(5.80) we can express the domestic excess-demand elasticities in the elasticities σ_H, σ^{+}_{Hai}, η_{Hai}, σ_F, σ_{Fd}, and σ_{Fm}. Similarly we can express the foreign excess-demand elasticities in Σ_H, Σ^{+}_{Hai}, H_{Hai}, Σ_F, Σ_{Fd}, and Σ_{Fm}. Substitution of these expressions into equation (5.60a) then gives an equation that relates changes in domestic prices to changes in foreign prices, domestic primary inputs, and foreign primary inputs. It is straightforward to show that these operations result in

$$\sigma_H^{+i} p_{di} q_{Hdi} \eta_{Hdi} \left[\eta_{Hdi} w_{Hdi} \left(\frac{1}{w^{+}_{Hi}} - \frac{1}{w^{+}_{Hdi}} \right) \tilde{p}_{di} + \eta_{Hmi} w_{Hmi} \frac{1}{w^{+}_{Hi}} \tilde{p}_{mi} \right]$$

$$+ \Sigma_H^{+i} p_{di} Q_{Hdi} \mathrm{H}_{Hdi} \left[\mathrm{H}_{Hdi} W_{Hdi} \left(\frac{1}{W^{+}_{Hi}} - \frac{1}{W^{+}_{Hdi}} \right) \tilde{p}_{di} + \mathrm{H}_{Hmi} W_{Hmi} \frac{1}{W^{+}_{Hi}} \tilde{p}_{mi} \right]$$

$$+ \sigma_H p_{di} q_{Hdi} \eta_{Hdi} \left(\sum_{j=1}^{N} w_{Hdj} \eta_{Hdj} \tilde{p}_{dj} + \sum_{j=1}^{N} w_{Hmj} \eta_{Hmj} \tilde{p}_{mj} \right.$$

$$\left. - \eta_{Hdi} w_{Hdi} \frac{1}{w_{Hi}} \tilde{p}_{di} - \eta_{Hmi} w_{Hmi} \frac{1}{w_{Hi}} \tilde{p}_{mi} \right)$$

$$+ \Sigma_H p_{di} Q_{Hdi} \mathrm{H}_{Hdi} \left(\sum_{j=1}^{N} W_{Hdj} \mathrm{H}_{Hdj} \tilde{p}_{dj} + \sum_{j=1}^{N} W_{Hmj} \mathrm{H}_{Hmj} \tilde{p}_{mj} \right.$$

$$\left. - \mathrm{H}_{Hdi} W_{Hdi} \frac{1}{W_{Hi}} \tilde{p}_{di} - \mathrm{H}_{Hmi} W_{Hmi} \frac{1}{W_{Hi}} \tilde{p}_{mi} \right)$$

$$- \sigma_F p_{di} q_{Fdi} \left(1 - \frac{1}{w_{Fd}} \right) \sum_{j=1}^{N} (w_{Fdj} \tilde{p}_{dj} + w_{Fmj} \tilde{p}_{mj})$$

$$- \Sigma_F p_{di} Q_{Fdi} \left(1 - \frac{1}{W_{Fd}} \right) \sum_{j=1}^{N} (W_{Fdj} \tilde{p}_{dj} + W_{Fmj} \tilde{p}_{mj})$$

$$- \sigma_{Fd} p_{di} q_{Fdi} \left(\frac{1}{w_{Fd}} \sum_{j=1}^{N} w_{Fdj} \tilde{p}_{dj} - \tilde{p}_{di} \right) - \Sigma_{Fd} p_{di} Q_{Fdi} \left(\frac{1}{W_{Fd}} \sum_{j=1}^{N} W_{Fdj} \tilde{p}_{dj} - \tilde{p}_{di} \right)$$

$$+ (W_{Hdi} \mathrm{H}_{Hdi} - w_{Hdi} \eta_{Hdi}) \sum_{j=1}^{N} (p_{dj} x_{dj} \tilde{p}_{dj} + p_{mj} x_{mj} \tilde{p}_{mj})$$

$$+ p_{di} (q_{Hdi} \eta_{Hdi} - q_{Fdi}) \sum_{h=1}^{M} a_h \tilde{v}_h$$

$$+ p_{di} (Q_{Hdi} \mathrm{H}_{Hdi} - Q_{Fdi}) \sum_{h=1}^{M} A_h \tilde{V}_h = 0, \quad i = 1, 2, \ldots, N. \tag{5.81}$$

Equations (5.81) are a simultaneous model where the changes in the domestic prices are the endogenous variables, the changes in the foreign prices and in the domestic and foreign primary inputs are the exogenous variables, and the budget shares and the substitution and income elasticities determine the coefficients [note that the marginal budget shares w^{+}_{Hai} follow from (5.75)]. Because domestic and foreign products have been aggregated separately in the two-stage budgeting for the producer, σ_{Fm} and Σ_{Fm} do not appear in (5.81). Note that (5.80) has led to the disappearance of the individual primary inputs: only the changes in the Divisia index numbers of the primary inputs appear in (5.81).

5.7. Empirical analysis

In this section I shall report the estimation results for a restricted version of (5.81). First the restrictions and the data will be described, and thereafter the results will be presented.

Restrictions

In obvious notation (5.81) can be written as

$$\sum_{j=1}^{N} \alpha_{ij}\tilde{p}_{dj} + \sum_{j=1}^{N} \beta_{ij}\tilde{p}_{mj} + \gamma_i\tilde{v} + \Gamma_i\tilde{V} = 0, \;\; i = 1, 2, \ldots, N, \tag{5.82}$$

where $\tilde{v} = \sum_{h=1}^{M} a_h\tilde{v}_h$ and $\tilde{V} = \sum_{h=1}^{M} A_h\tilde{V}_h$ are the changes in the Divisia index numbers of primary inputs. I assume that the coefficients α_{ij}, β_{ij}, γ_i, and Γ_i in (5.82) are constant. Thus (5.82) is regarded as a first-order Taylor expansion, where the budget and revenue shares and the value data ($p_{di}q_{Hdi}$, etc.) are evaluated in a certain base year. The infinitesimal changes have been replaced in the empirical analysis by finite logarithmic changes (for example $\tilde{p}_{dj}$ is replaced by $\Delta \log p_{dj}$).

We can also write equation (5.81), in obvious notation, as

$$\sigma^{+}_{Hi}n_i + \Sigma^{+}_{Hi}N_i + \sigma_H f_i + \Sigma_H F_i + \sigma_F k_i + \Sigma_F K_i$$

$$+ \sigma_{Fd}d_i + \Sigma_{Fd}D_i + \gamma_i\tilde{v} + \Gamma_i\tilde{V} = 0, \;\; i = 1, 2, \ldots, N. \tag{5.83}$$

Whereas (5.82) emphasizes the endogenous and exogenous variables p_d and p_m, equation (5.83) emphasizes the unknown substitution elasticities. When the income elasticities are given, the time series of n_i and N_i will be almost collinear because they depend on the same price changes. Similarly, f_i and F_i, k_i and K_i, and d_i and D_i will be almost collinear. Therefore I assume

$$\sigma^{+}_{Hi} = \Sigma^{+}_{Hi}, \;\; i = 1, 2, \ldots, N, \tag{5.84a}$$

$$\sigma_H = \Sigma_H, \tag{5.84b}$$

$$\sigma_F = \Sigma_F, \tag{5.84c}$$

$$\sigma_{Fd} = -\Sigma_{Fd}. \tag{5.84d}$$

Finally, because attempts to estimate (5.81) with both elasticities of substitution and income elasticities as unknowns failed, I have fixed the income elasticities, assuming that

$$\eta_{Hdi} = \eta_{Hmi} = \mathrm{H}_{Hdi} = \mathrm{H}_{Hmi}. \tag{5.85}$$

The values of the income elasticities are computed from the detailed analysis of consumer expenditure by Keller and Van Driel (1982, Table 4); see Table 5.5 below.

Data[10]

Five commodity groups are distinguished, the same as in Chapter 4:

[10] Time series are given in Appendix C.2; the other data are given in Tables 5.1-5.4.

1. Agricultural and food products (SITC 0 + 1),
2. Fuels (SITC 3),
3. Chemical products (SITC 5),
4. Machinery and transport equipment (SITC 7),
5. Other manufactures (SITC 6 + 8).

As I have said in the introduction to Section 5.6, all non-traded goods are aggregated into one good, which serves as numeraire.

The price index numbers of domestic products have been aggregated from price index numbers of 24 industries;[11] most of these series are taken from publications of the Netherlands Central Bureau of Statistics (CBS). The price index numbers of foreign products are computed as the ratio of world-market unit values in US dollars and the US-dollar/guilder exchange rate; both are published in the UN Yearbook of International Trade Statistics.

For the Divisia index number of domestic primary inputs I have taken the index number of real national income, published in the National Accounts (CBS); for the Divisia index number of foreign primary inputs I have taken the quantity index number of gross domestic product of the OECD countries, published in the National Accounts (OECD).

The budget and revenue shares and the value data are computed from the input-output tables for 1970, published by Eurostat (European Community). In order to make consumer income equal to producer revenue I have made three adjustments to the tables. Firstly, I have treated the government as a firm, which sells its product (public consumption) to households. Thus consumption by households consists of private consumption and public consumption.

Secondly, I have introduced a fictitious firm that buys the output of the capital-goods producing firms and sells services of capital goods (i.e. capital consumption).[12] Both the government and the fictitious capital-goods firm are regarded as industries that produce non-traded goods.

Thirdly, the import surplus of the Netherlands is considered to be saving by the foreign consumer and is represented by a delivery of capital goods.[13] Because data on saving by foreign consumers were not readily available, I have not taken other savings into account. Because of these three transformations, final output consists now only of consumption and gross exports.

Computation of the domestic budget and revenue shares is now straightforward; the results are given in Tables 5.1 and 5.2. The sum of the first two column totals is equal to consumer income, and the sum of the last two column totals is equal to producer revenue; by construction income and revenue are equal. The second column less the last column is equal to imports of foreign products, and the third column less the first column is equal to exports of domestic products. Note that, contrary to what the term non-traded suggests, intermediate consumption of foreign non-traded products is not

[11] The exact correspondence is given in Appendix C.2.

[12] Cf. Keller (1980, p. 295-6).

[13] Cf. Keller (1980, p. 298).

Table 5.1 *Domestic consumption and output in 1970*

	Domestic consumption of		Domestic net output of	
	domestic products	foreign products	domestic products	foreign products
	(mln ECU)[a]			
1. Agricultural and food producs	3440.0	476.9	6397.2	−2006.8
2. Fuels	319.4	79.0	1548.7	−1690.9
3. Chemical products	213.8	205.8	2015.5	−1364.7
4. Machinery and transport equipment	365.9	737.0	3164.7	−3952.3
5. Other manufactures	1558.3	1073.5	3799.9	−3530.7
6. Non-traded goods	14668.9	6.9	20179.5	−1414.7
Total	20566.3	2579.1	37105.5	−13960.1

Source: Eurostat (1978).

[a] 1 ECU (European Currency Unit) was in 1970 equal to 1 US dollar and to 3.62 Dutch guilder.

Table 5.2 *Domestic budget and revenue shares in 1970*

	Domestic budget shares of		Domestic revenue shares of	
	domestic products	foreign products	domestic products	foreign products
	(pro mille)			
1. Agricultural and food producs	149	21	276	−87
2. Fuels	14	3	67	−73
3. Chemical products	9	9	87	−59
4. Machinery and transport equipment	16	32	137	−171
5. Other manufactures	67	46	164	−153
6. Non-traded goods	634	0	872	−61
Total	889	111	1603	−603

equal to zero; this occurs because imports of services are classified as competing with services industries.

To compute the foreign data two problems must be solved. In the first place, exports by the Netherlands to the rest of the world are not divided into exports of consumer goods and exports of producer goods. Secondly, foreign data that are available in a form comparable with the domestic data, refer to the European Community and not the rest of the world.

I have solved the first problem by dividing exports into exports to households and exports to firms in the proportion that domestic households and domestic firms respectively have in domestic sales; this division was made for each of the 44 industries in the input-output table, and the results have been aggregated to the 6-commodity level.

The second problem has been solved as follows. First the data for the other five member countries of the EC in 1970 (West Germany, France, Italy, Belgium, and Luxembourg; abbreviated as EUR5) have been derived in the same way as has been done for the Netherlands. Then the value of consumption of EUR5 has been multiplied by the ratio of gross domestic product of the OECD and gross domestic product of EUR5, so as to give consumption of the rest of the world. The value of foreign consumption of foreign products has been obtained by substracting Dutch exports of consumer goods from the value of foreign consumption. Finally, the value of foreign output of foreign products has been computed as the residual that makes world supply of foreign products equal to world demand for foreign products. The results are given in Tables 5.3 and 5.4. Note that in all tables 'domestic' refers to the Netherlands and 'foreign' to the rest of the world.

Table 5.3 *Foreign consumption and output in 1970*

	Foreign consumption of		Foreign net output of	
	domestic products	foreign products	domestic products	foreign products
	(mln ECU)[a]			
1. Agricultural and food producs	1682.5	255070.6	−1274.7	257554.3
2. Fuels	315.4	34772.1	−913.9	36542.0
3. Chemical products	329.6	31243.6	−1472.1	32814.1
4. Machinery and transport equipment	409.3	59606.9	−2389.5	64296.2
5. Other manufactures.	667.2	138259.7	−1574.4	142863.9
6. Non-traded goods	3617.4	861932.0	−1893.2	863353.6
Total	7021.4	1380884.9	−9517.8	1397424.1

Source: Eurostat (1978).

[a] 1 ECU (European Currency Unit) was in 1970 equal to 1 US dollar and to 3.62 Dutch guilder.

Table 5.4 *Foreign budget and revenue shares in 1970*

	Foreign budget shares of		Foreign revenue shares of	
	domestic products	foreign products	domestic products	foreign products
	(pro mille)			
1. Agricultural and food producs	1	184	−1	186
2. Fuels	0	25	−1	26
3. Chemical products	0	23	−1	24
4. Machinery and transport equipment	0	43	−2	46
5. Other manufactures	0	100	−1	103
6. Non-traded goods	3	621	−1	622
Total	5[a]	995[a]	−7	1007

[a] Not equal to column total because of rounding errors.

Estimation results

Equation (5.81) has been estimated under the restrictions (5.84) and (5.85), with the income elasticities given in the first column of Table 5.5, and with an additive disturbance. The estimation period is 1961-1979; the method of estimation is full-information-maximum-likelihood. The estimation results are given in Table 5.5; the actual values and the solved-reduced-form values of the changes in the absolute domestic prices[14] are shown in Figures 5.3-5.7.

When all elasticities of substitution were free to vary, the estimates of σ_F, σ_H, and σ_H^{+5} became negative. Therefore I have restricted the search over positive values of σ_H, σ_F, and σ_H^{+i} and over negative values of σ_{Fd}.

The convergence to the maximum was after the first steps very slow, which indicates that the likelihood surface around the maximum is flat. This slow convergence might be due to underidentification of the parameters; it is probably not due to the fact that the restrictions (5.50)-(5.52) have not been taken into account: estimation of (5.60a) without all foreign variables showed the same slow convergence.

The likelihood of the model is larger than the likelihood of the law-of-one-price model in Section 4.1 (see Table 4.2), which has a larger number of coefficients.

The elasticities of substitution have reasonable values, except the producer elasticity of substitution between domestic products (σ_{Fd}) and the consumer elasticity of substitution between domestic and foreign agricultural and food products (σ_H^{+1}). The relatively

[14] The absolute price change of good i is defined as $\tilde{p}_{di} + \tilde{p}_{d0}$, where $\tilde{p}_{d0}$ is the actual price change of the numeraire.

Table 5.5 *Results of FIML estimation of the price equation (5.81)*

Log likelihood		224.650	
Consumer elasticity of substitution (macro) (σ_H)		0.6	
		(0.7)	
Producer elasticity of substitution (σ_F)		0.6	
		(2.0)	
Producer elasticity of substitution between domestic products (σ_{Fd})		-2.9^a	
		(0.7)	
	Income elasticity[b] η_{Hi}	Consumer elasticity of substitution (within-good) σ_H^{+i}	R^{2c}
1. Agricultural and food products	0.4	290.7^a	0.27
		(87.0)	
2. Fuels	0.7	9.5	0.84
		(10.7)	
3. Chemical products	1.6	5.0^a	0.94
		(1.4)	
4. Machinery and transport equipment	2.0	1.4^a	0.76
		(0.5)	
5. Other manufactures	2.4	1.3	0.78
		(0.7)	

Asymptotic standard errors are in parentheses.
[a] Significantly different from zero at 5 % level.
[b] Computed from Table 4 of Keller and Van Driel (1982).
[c] Square of correlation coefficient between actual value and solved-reduced-form value of absolute domestic price change.

high absolute value of σ_{Fd} is perhaps caused by the restriction $\Sigma_{Fd} = -\sigma_{Fd}$; Σ_{Fd} measures substitution between domestic products as inputs, whereas σ_{Fd} measures substitution between domestic products as outputs, so that a large negative estimate of σ_{Fd} may be caused by great substitution possibilities of domestic products as inputs. Another explanation for the high value of σ_{Fd} may be the fact that I have not taken into account the restrictions (5.50)-(5.52) [i.e. I should have estimated equation (5.61) instead of equation (5.60a)]: it can be shown that if (5.61) is evaluated with (5.72)-(5.80), Σ_{Fd} drops out. A third possibility is that the specification of producer behaviour in Section 5.6 is incorrect; for example, it may be more appropriate to aggregate domestic and foreign products of the same good in the same way as in the specification of consumer preferences.

The correlation coefficient between actual and fitted value of the domestic price

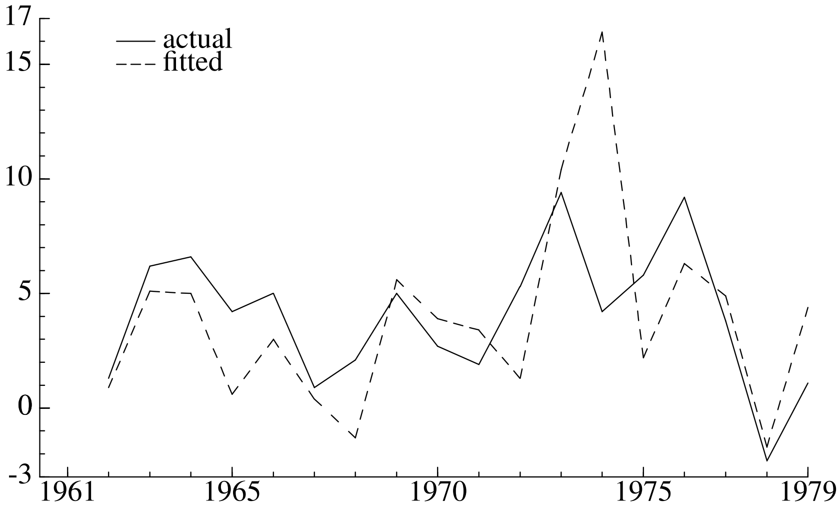

Figure 5.3 *Agricultural and food products: actual and fitted values (× 100)*

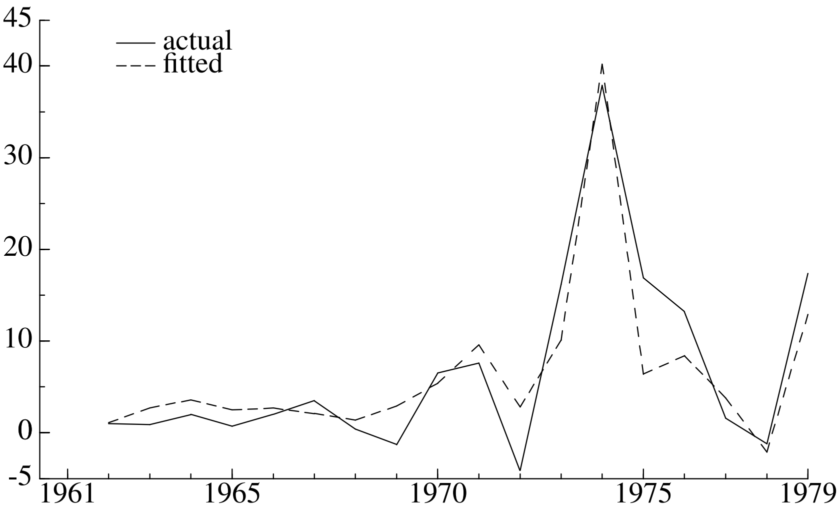

Figure 5.4 *Fuels: actual and fitted values (× 100)*

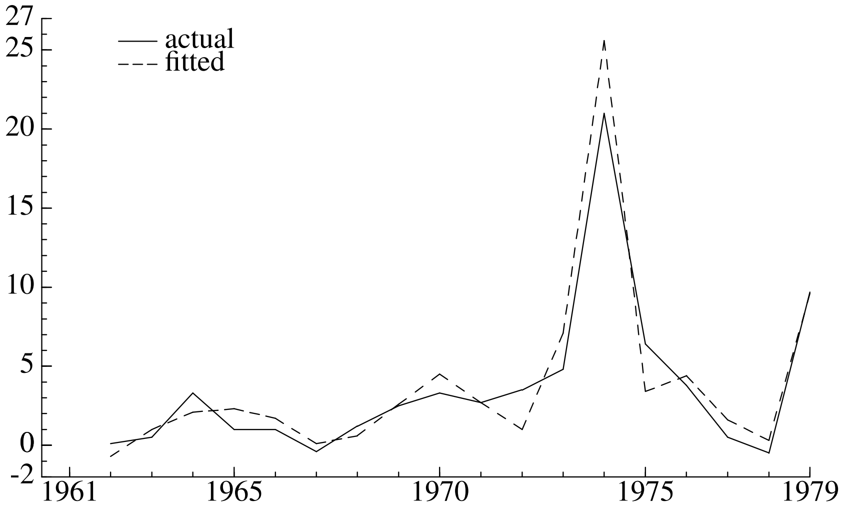

Figure 5.5 *Chemical products: actual and fitted values (× 100)*

Figure 5.6 *Machinery and transport equipment: actual and fitted values (× 100)*

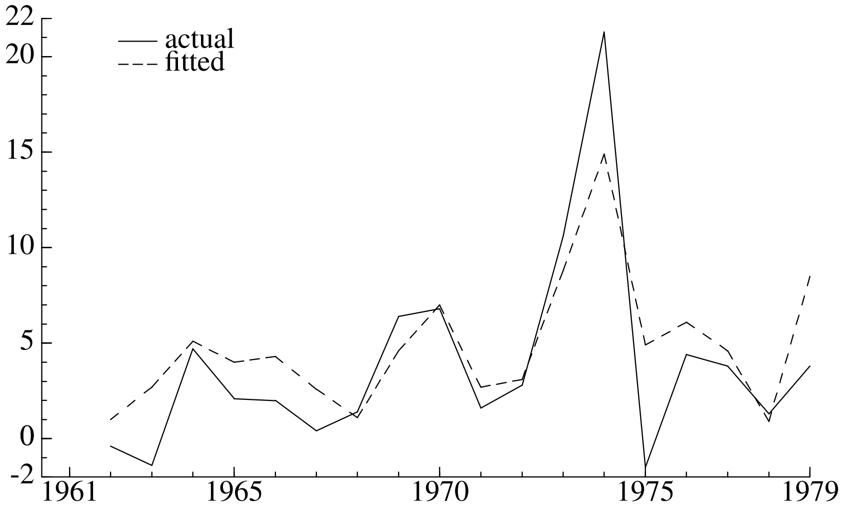

Figure 5.7 *Other manufactures: actual and fitted values (× 100)*

changes is for Machinery and transport equipment and Other manufactures much higher than those in Section 4.1, for Chemical products the model of this chapter gives a slightly better explanation, and for Agricultural and food products and Fuels both models are equally good. Comparing Figures 5.3-5.7 with Figures 4.1-4.5, we see that in particular the price changes in 1974 are better explained by the model of this chapter.

5.8. Summary

After an exposition of general-equilibrium methods, the properties of excess-demand functions have been studied. It has been shown that the excess-demand functions can be regarded as net-demand functions of a fictitious utility-maximizing consumer, and the income and substitution elasticities of excess-demand behaviour have been expressed in terms of the income and substitution elasticities of consumer and producer behaviour. Using these expressions I have shown that, if the home country is small, the income effects of domestic goods in the net-export demand functions tend to vanish, that the substitution effects between domestic goods in the net-export demand functions tend to vanish, and that substitution effects between foreign goods in the net-export demand functions tend to infinity. This implies that foreign prices are determined by foreign conditions and are not influenced by domestic conditions; therefore foreign prices are exogenous to a small open economy. Domestic prices, on the contrary, are determined by both domestic and foreign conditions; only when domestic and foreign goods are perfect substitutes, then domestic prices are completely determined by foreign conditions.

To derive an empirical model, I have represented consumer preferences and producer technology by nested CES functions. The elasticities of substitution of consumer and producer behaviour have been estimated under the restrictions that foreign substitution elasticities are equal to the corresponding domestic elasticities and that income elasticities are extraneously fixed. The estimation results show that the model gives a better explanation of domestic price formation than the law-of-one-price model, analysed in Chapter 4.

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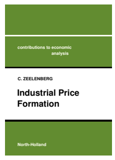


PART III

Price formation under imperfect competition

CHAPTER 6

Foreign competition and price formation

Part 3 (Chapters 6-9) deals with price formation under imperfect competition. In Chapters 6, 7, and 9 I assume that all producers in an industry act in collusion (i.e. they form a monopoly)[1] and that they produce one homogeneous product. These assumptions make it possible to concentrate on the effects that foreign competition (in Chapter 6) and competition between industries (in Chapters 7 and 9) have on price formation. Both assumptions will be relaxed in Section 8.4, where producers within an industry can react in an arbitrary way to each other and they can produce heterogeneous products (provided the relative prices of these products remain constant). The generalization to arbitrary reaction patterns does not change the form of the price equations derived in Chapters 6 and 7 if the reaction patterns remain constant over time; the generalization to heterogeneous products with constant relative prices has no effects on the form of the price equations.

Chapter 6 gives the basic model of price formation, where only competition between domestic and foreign products matters; Chapter 7 treats the general case, where also competition between industries plays a role; Chapter 8 deals with the consequences that non-collusive forms of industry structure have for price formation; and Chapter 9 deals with the comparative statics of the model of Chapter 7. Throughout this part, I assume that the prices of foreign products are exogenous.

This chapter is in line with work by Laden (1972), Nordhaus (1972), De Menil (1974), Bruno (1979), Nieuwenhuis (1980), Aspe and Giavazzi (1982), and Maccini (1982), who derive a price equation from micro-economic theory; unlike these authors, I model the price elasticity of demand explicitly and give special emphasis to the role of foreign competition. The main result of this chapter is a price equation that relates the mark-up of a monopolist to the domestic market share (i.e. the share of the domestic producer in total expenditure on both the domestic product and its competing foreign

[1] This assumption is strictly speaking only needed for the empirical analysis, where I use industry data. For the theoretical analysis it is sufficient to assume that the producer faces a downward-sloping demand curve and does not take into account the reactions of other producers.

product). The domestic market share often appears in cross-section studies of industrial price formation [see for example Esposito and Esposito (1971)]; this chapter will give a theoretical foundation to the inclusion of this variable.

Section 6.1 reviews the theory of price formation by a monopolist ('the ratio of output price to marginal cost depends on the price elasticity of demand'). Section 6.2 deals with the price elasticity of demand under two-stage budgeting, where the consumer allocates first his income to goods (such as cars) and then for each good its expenditure to the domestic and the foreign product of the good (thus for the good cars to domestic cars and foreign cars). In Section 6.3 I derive from the analysis in Sections 6.1 and 6.2 a price equation, where the ratio of price to marginal cost is a linear function of the ratio of domestic sales and competing imports; the coefficients in this equation are a function of the elasticity of substitution between the domestic and the foreign product. I also study the comparative statics of this price equation. In Section 6.4 the equation is estimated for 15 Dutch industries in the period 1961-1979.

6.1. The profit-maximizing price

Consider a producer who maximizes his profit while taking into account that the quantity he produces and offers for sale has consequences for the price he can get:

$$\max\ p(q)q - C(q),$$

where $p(q)$ is the output price, dependent on quantity; q is quantity; and $C(q)$ is total cost, dependent on quantity. The term $p(q)q$ is called total revenue [$R(q)$]. I assume that the demand curve is downward sloping and that marginal cost is positive, i.e. $\partial p/\partial q < 0$ and $\partial C/\partial q > 0$. The assumption $\partial p/\partial q < 0$ makes it possible to view the problem either as one of choosing quantity, as I have done, or as one of choosing price.

The first-order condition for the profit maximum is that marginal revenue equals marginal cost:

$$\frac{\partial R}{\partial q} = \frac{\partial C}{\partial q},$$

or

$$p + q\,\frac{\partial p}{\partial q} = \frac{\partial C}{\partial q}. \tag{6.1}$$

The left-hand side of this equation is marginal revenue: if output is increased by one small unit, revenue increases by p, but decreases with $-q(\partial p/\partial q)$ because a lower price for the whole of output must be accepted in order to sell the extra unit. The right-hand side is marginal cost: the extra cost that is incurred because of the extra unit of output.

It follows from (6.1) that

$$p\left(1 + \frac{q}{p}\,\frac{\partial p}{\partial q}\right) = \frac{\partial C}{\partial q},$$

or

$$p\left(1+\frac{1}{\varepsilon}\right)=\frac{\partial C}{\partial q},$$

where $\varepsilon = (p/q)(\partial q/\partial p)$ is the price elasticity of demand [note that as it has been assumed $\partial p/\partial q < 0$, there holds $\partial q/\partial p = (\partial p/\partial q)^{-1}$]. Therefore

$$p = \Delta\left(1+\frac{1}{\varepsilon}\right)^{-1}, \tag{6.2}$$

where $\Delta = \partial C/\partial q$ is marginal cost. Equation (6.2) says that the profit-maximizing price is equal to marginal cost times a mark-up factor that depends on the price elasticity of demand. Equation (6.2) is the basis of the price equation of this chapter. In the next section I shall further analyse the price elasticity of demand ε.

Because I have assumed that marginal cost is positive, a necessary and sufficient condition for a positive price is

$$\varepsilon < -1. \tag{6.3}$$

Indeed, if ε was larger than -1, it would be possible to increase revenue by lowering output, whereas costs would decrease; profit could thus be increased by reducing quantity and would therefore not be at a maximum. Note that (6.3) implies $(1+\varepsilon^{-1})^{-1} > 1$, and therefore $p > \Delta$.

The sufficient second-order condition for the profit maximum is

$$\frac{\partial^2[p(q)q - C(q)]}{\partial q^2} < 0,$$

or

$$\frac{\partial}{\partial q}\left(\frac{\partial R}{\partial q}\right) < \frac{\partial}{\partial q}\left(\frac{\partial C}{\partial q}\right), \tag{6.4}$$

in other words, marginal revenue increases at the optimum less than marginal cost. It is easily seen that a sufficient condition for (6.4) is that both marginal cost and the price elasticity of demand increase as quantity increases ($\partial^2 C/\partial q^2 > 0$ and $\partial\varepsilon/\partial q > 0$); the condition $\partial\varepsilon/\partial q > 0$ is, because $\partial p/\partial q < 0$, equivalent to $\partial\varepsilon/\partial p < 0$, i.e. the price elasticity of demand increases as price decreases.

The results of this section are illustrated in Figure 6.1, where MR is marginal revenue, AR (average revenue) is the inverse demand curve [$p = p(q)$], MC is marginal cost, and $AC(= C/q)$ is average cost. The equality of marginal revenue and marginal cost determines optimal output q^*; in order to sell this quantity the price must be set equal to p^*. Total profit is thus equal to $(p^* - c^*)q^*$. Because $MR = p(1+\varepsilon^{-1})$ we see that (6.3) is equivalent to $MR > 0$; therefore price cannot be less than $\bar{p}$ and output cannot exceed $\bar{q}$.

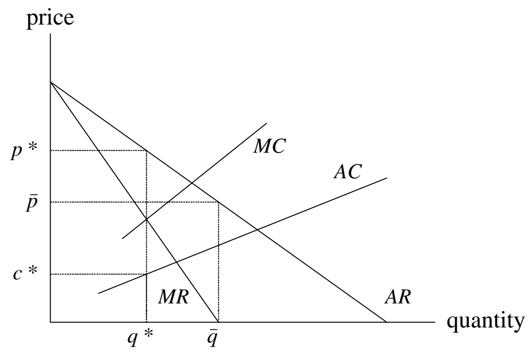


Figure 6.1 *Profit-maximization*

6.2. The price elasticity of demand

I shall first consider the structure of consumer preferences, with special emphasis on competition between foreign and domestic products. From these preferences I shall derive an expression for the price elasticity of demand, which gives, together with formula (6.2), a price equation.

The structure of preferences

I distinguish between goods,[2] (such as food and clothing) and products (such as domestic food, foreign food, domestic clothing, and foreign clothing): for each good there exist a foreign and a domestic product, which will be called the products that 'belong' to this good. I assume that demand for goods and products is generated by a representative consumer[3] who allocates his income in two stages: he determines first the quantities of the goods, and then for each good he determines which part is bought from the domestic producer and which part from foreign producers. For example, suppose that the consumer can buy only two goods, food and clothing; for each good there are two sources of supply: foreign and domestic. The consumer determines first how much food and clothing he will buy and then, given the amounts of food and clothing, he determines the part that is bought at home and the part that is bought abroad; see Figure 6.2.

[2] Services are considered to be goods.

[3] See Deaton and Muellbauer (1980, Section 6.2) for the restrictions on individual preferences that are necessary for the existence of a representative consumer. For the analysis in this chapter it is not necessary to assume that there exists a representative consumer; it is sufficient to assume that there exist aggregate demand functions that satisfy the Slutsky conditions; see Van Daal and Merkies (1984, Section 3.6). The assumption of a representative consumer simplifies the analysis somewhat.

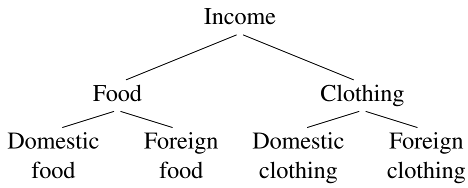


Figure 6.2 *Two-stage budgeting*

I require that the two-stage-budgeting procedure gives the same results as the one-stage-budgeting procedure where the quantities of the products are directly determined. This requirement may seem obvious, but in practice it need not be fulfilled. For example, consumers may follow a multi-stage procedure because the allocation would otherwise become intractable and impossible; the multi-stage procedure may then give results different from the one-stage procedure, but the consumer has to be satisfied with the approximate optimality. Nevertheless, I shall make this requirement, because it allows me to derive a simple expression for the price elasticity of demand. If in practice this requirement is not fulfilled, then the formulae that will be derived hold only approximately.

Gorman (1959) has shown that two conditions are necessary and sufficient for the equivalence of the one-stage and two-stage budgeting procedures.[4] Firstly, preferences of the consumer must be separable in the way that his utility function can be written as

$$u[q_{d1}, q_{m1}, q_{d2}, q_{m2}, \ldots, q_{dN}, q_{mN}] =$$

$$= U[u_1(q_{d1}, q_{m1}), u_2(q_{d2}, q_{m2}), \ldots, u_N(q_{dN}, q_{mN})],$$

where, for $i = 1, 2, \ldots, N$, q_{di} is the quantity of good i that is bought from domestic producers, q_{mi} is the quantity of good i that is bought from foreign producers, and u, U, and u_i are utility functions. The functions u_i are called the sub-utility functions and U is called the macro-utility function. This kind of separability with domestic and foreign products has originated with Armington (1969a, 1969b) in his study of international trade flows.

Secondly, either the sub-utility functions must be homogeneous of degree one, or the sub-utility functions must have a special form (see Appendix A.1) and the macro-utility function must be additive. Both specifications have disadvantages.

Under additivity income and price elasticities are functionally dependent: knowledge of all income elasticities and one price elasticity is sufficient to determine all other price elasticities [see Deaton and Muellbauer (1980, pp. 138-40)].

Homogeneity, on the other hand, implies that the income elasticities of the foreign and domestic products that belong to the same good are equal. The only evidence on this point is from Somermeijer and Hilhorst (1962). For seven commodity groups[5]

[4] See also Appendix A.

[5] Potatoes, vegetables, and fruit; Textiles and clothing; Fuels; Chemists' goods; Furniture and household equipment; Other household articles, flowers, and plants; and Bicycles, automobiles, and other durable goods.

they have estimated a one-level and a two-level indirect addilog model over the years 1949-1957. Whether the hypothesis of equal income elasticities for foreign and domestic products could be rejected depended on the level of the model (one or two), the inclusion of a trend variable, and the price series used (unit values or wholesale price index numbers). Only for the group Bicycles, automobiles, and other durable goods was the hypothesis rejected for all specifications and price series; this rejection was due to the difference in composition in the 1950's: the domestic products consisted mainly of bicycles (then a necessity) and the foreign products of automobiles (then a luxury). Thus, in general the assumption of equal income elasticities need not be unrealistic. Moreover, in the empirical section it will allow me to compute certain interesting parameters, such as the elasticity of substitution between foreign and domestic products and the price elasticity of demand. Therefore I assume that the sub-utility functions are homogeneous of degree one.

Gorman (1959) has shown that under separability and homogeneity, the consumer's allocation problem can be written as follows. Because of the homogeneity there exist functions q_i and p_i of the quantities and prices of the products belonging to good i such that the first stage is equivalent to maximizing the macro-utility function subject to a budget constraint:

$$\left.\begin{aligned} &\max U(q_1, q_2, \ldots, q_N) \\ &\text{s.t.} \sum_{i=1}^{N} p_i q_i = y, \end{aligned}\right\} \tag{6.5}$$

where $q_i = q_i(q_{di,}\ q_{mi})$ is a 'quantity index', $p_i = p_i(p_{di,}\ p_{mi})$ is a 'price index', p_{di} is the price of the domestic product, p_{mi} is the price of the foreign product, and y is given total expenditure. After solving (6.5) one knows the quantities q_i and thus the expenditures $p_i q_i$. It can be shown that the price and quantity indices are Divisia indices [see Appendix A.1, equations (A.10) and (A.11)]:

$$\tilde{p}_i = w_d^i \tilde{p}_{di} + (1 - w_d^i)\tilde{p}_{mi}, \tag{6.6}$$

$$\tilde{q}_i = w_d^i \tilde{q}_{di} + (1 - w_d^i)\tilde{q}_{mi},$$

where $w_d^i = p_{di}q_{di}/(p_{di}q_{di} + p_{mi}q_{mi})$ is the within-good budget share of the domestic product,[6] and a tilde denotes a relative differential change [for example $\tilde{p}_i = (\mathrm{d}p_i)/p_i$].

In the second stage the consumer maximizes for each good the sub-utility function subject to the budget constraint that total expenditure equals the expenditure on the good determined in the first stage:

$$\max u_i(q_{di}, q_{mi})$$

$$\text{s.t. } p_{di}q_{di} + p_{mi}q_{mi} = y_i,$$

where $y_i = p_i q_i$ with q_i the solution of (6.5).

[6] Within-good variables will be referred to by superscripts.

The price elasticity of demand

The price elasticity of demand for the domestic product is under the homogeneity and separability assumptions made [see Appendix A.1, equation (A.14)]

$$\varepsilon_{di,di} = \frac{\partial \log q_{di}}{\partial \log p_{di}} = \varepsilon^i_{dd} + (1 + \varepsilon_{ii})w^i_d,$$

$$i = 1, 2, \dots, N, \tag{6.7}$$

where ε^i_{dd} is the within-good price elasticity of demand for the domestic product,[7] and ε_{ii} is the price elasticity of demand for the good.[8]

It is shown in the next subsection that the within-good price elasticity of demand is

$$\varepsilon^i_{dd} = (\sigma^i - 1)w^i_d - \sigma^i. \tag{6.8}$$

where $\sigma^i = -\partial \log (q^i_d/q^i_m) \;/\; \partial \log (p_{di}/p_{mi})\rfloor_{u_i \text{ constant}}$ is the within-good elasticity of substitution between the domestic and foreign product. Substituting (6.8) into (6.7) we get for the price elasticity of demand

$$\varepsilon_{di,di} = (\sigma^i - 1)w^i_d - \sigma^i + (1 + \varepsilon_{ii})w^i_d. \tag{6.9}$$

For the moment I assume that $\varepsilon_{ii} = -1$ (a sufficient condition for $\varepsilon_{ii} = -1$ is that the macro-utility function is Cobb-Douglas).[9] It appears from Table 6.1 that this assumption is empirically justified for many industries. The assumption $\varepsilon_{ii} = -1$ implies that the budget share of the good remains constant if the price of its domestic product or its foreign product changes.

Dropping the subscript and superscript i we then get from (6.8)

$$\varepsilon_{dd} = (\sigma - 1)w_d - \sigma. \tag{6.10}$$

Thus the price elasticity of demand for the domestic product depends on the elasticity of substitution between the domestic and the foreign product and on the market share of the domestic producer.

It is easily shown that the condition $\varepsilon_{dd} < -1$, which is necessary for a profit maximum [see (6.3)], is equivalent to

$$\sigma > 1 \text{ and } w_d \neq 1. \tag{6.11}$$

It follows from (6.10) and (6.11) that the domestic and the foreign product belonging to the same good are gross substitutes, i.e. an increase in the price of one product leads to an increase in the demand for the other product.

[7] That is the price elasticity of demand in the demand function q^i_d obtained by maximizing $u_i(q^i_d, q^i_m)$ subject to $p_{di}q^i_d + p_{mi}q^i_m = y_i$, with y_i *given.*

[8] That is the price elasticity of demand in the demand function q_i obtained by maximizing $U(q_1, \dots, q_N)$ subject to $p_1q_1 + \dots + p_Nq_N = y$.

[9] The case $\varepsilon_{ii} \neq -1$ will be dealt with in the next chapter.

Table 6.1 *Own price elasticities of the demand for goods*

	Budget share (average 1953-1977)	Price elasticity	
1. Agriculture	0.051	−0.565[a]	(0.083)
2. Meat and dairy	0.113	−0.857	(0.120)
3. Other food	0.106	−0.537[a]	(0.128)
4. Drink and tobacco	0.063	−0.938	(0.143)
5. Textiles	0.061	−0.328[a]	(0.230)
6. Clothing and leather	0.086	−0.805	(0.149)
7. Paper and printing	0.021	−1.222	(0.435)
8. Timber and stone	0.031	−0.407	(0.567)
9. Chemical products	0.029	−1.037	(0.655)
10. Primary metal products	0		
11. Metal products and machinery	0.023	−0.498	(0.554)
12. Electrical products	0.050	−0.425	(0.476)
13. Transport equipment	0.023	−1.489	(0.867)
14. Mineral oil refining	0.017	−1.339	(0.257)
15. Mining	0.013	0.326[a]	(0.513)
16. Electricity, gas and water	0.029	−0.245[a]	(0.161)
17. Construction	0.008	−1.404	(0.552)
18. Housing services	0.065	−0.373[a]	(0.085)
19. Distribution[b]			
20. Sea and air transport services[c]			
21. Other transport and communication	0.026	−0.428[a]	(0.218)
22. Banking and insurance	0.020	−1.045	(0.682)
23. Health services	0.058	−0.423[a]	(0.172)
24. Other services	0.103	−0.581[a]	(0.209)

Standard errors are in parentheses.
[a] Significantly different from −1 at 5% level.
[b] Distribution margins are included in the other industries (only in this table).
[c] Included in industry 21.
Source: computed from Table 4 in Keller and Van Driel (1982).

The within-good price elasticity of demand

The within-good compensated elasticity of demand for the domestic product with respect to the price of the foreign product is

$$\varepsilon_{dm}^{i*} = \left.\frac{\partial \log q_d^i}{\partial \log p_{mi}}\right|_{u_i \text{ constant}} = \sigma^i w_m^i = \sigma^i (1 - w_d^i). \tag{6.12}$$

Because compensated demand functions are homogeneous of degree zero in the prices, it follows from Euler's Theorem that[10]

$$\varepsilon_{dd}^{*i} + \varepsilon_{dm}^{i*} = 0. \tag{6.13}$$

The within-good Slutsky equation for the domestic product is

$$\varepsilon_{dd}^{i} = \varepsilon_{dd}^{i*} + \eta_d^i w_d^i = \varepsilon_{dd}^{i*} + w_d^i, \tag{6.14}$$

where $\eta_d^i = \partial \log q_d^i / \partial \log y_i$ is the within-good income elasticity of the domestic product; the second equality sign is based on the homogeneity of the sub-utility functions (i.e. $\eta_d^i = \eta_m^i = 1$). Using (6.12), (6.13), and (6.14) we get (6.8):

$$\varepsilon_{dd}^{i} = (\sigma^i - 1)w_d^i - \sigma^i.$$

6.3. The price equation

It follows from equations (6.2) and (6.10) that

$$\frac{p_d}{\Delta} = \frac{\sigma}{\sigma - 1} + \frac{1}{\sigma - 1}\frac{w_d}{1 - w_d} = \frac{\sigma}{\sigma - 1} + \frac{1}{\sigma - 1}\frac{D}{M}, \tag{6.15}$$

where $D = p_d q_d$ is the value of domestic sales by the domestic producer and $M = p_m q_m$ is the value of competing imports. The coefficient of D/M is positive because of (6.11); and it is a monotonically strictly decreasing function of σ.

It is easily shown that $\partial(p_d/\Delta)/\partial w_d > 0$ and $\partial(p_d/\Delta)/\partial\sigma < 0$. Thus the higher the market share of the domestic producer is, the higher the mark-up of price over marginal cost is; and the greater the possibilities of substitution between domestic and foreign products are, the lower the mark-up is.

I assume from now on that the elasticity of substitution between domestic and foreign products is constant; then the sub-utility functions are CES (constant-elasticity-of-substitution) functions. Totally differentiating (6.15) we get

$$\tilde{p}_d = \tilde{\Delta} + \frac{w_d}{(w_d - 1)[(\sigma - 1)w_d - \sigma]}\,\tilde{w}_d =: \tilde{\Delta} + \gamma\tilde{w}_d. \tag{6.16}$$

It is easily shown that $\gamma > 0$ and $\partial\gamma/\partial\sigma > 0$; thus the more substitutable domestic and foreign products are, the more the mark-up reacts to a change in the domestic market share.

The market-share equation

Besides equation (6.15), which shows how the domestic price depends on marginal cost and the market share of the domestic producer, there exists a relationship between the market share on the one hand and the domestic and foreign prices on the other hand. For it follows from the equality of price ratio and marginal rate of substitution that

[10] Cf. Deaton and Muellbauer (1980, p. 46, Exercise 2.18).

$$\frac{p_{di}}{p_{mi}} = \frac{\partial u/\partial q_{di}}{\partial u/\partial q_{mi}} = \frac{(\partial U/\partial u_i)(\partial u_i/\partial q_{di})}{(\partial U/\partial u_i)(\partial u_i/\partial q_{mi})} = \frac{\partial u_i/\partial q_{di}}{\partial u_i/\partial q_{mi}}.$$

Because I have assumed that the sub-utility functions are CES functions, there holds [see equation (B.3) in Appendix B.1]:

$$\tilde{w}_d^i = (1-\sigma^i)(\tilde{p}_{di} - \tilde{p}_i) = (1-\sigma^i)(1-w_d^i)(\tilde{p}_{di} - \tilde{p}_{mi}),$$

where the second equality sign is based on (6.6). Dropping again the subscript and superscript i we get

$$\tilde{w}_d = (1-\sigma)(1-w_d)(\tilde{p}_d - \tilde{p}_m). \tag{6.17}$$

I shall refer to equation (6.17) as the *market-share equation* for the domestic product. Note that, since $\sigma > 1$ [see equation (6.11)], an increase in the price ratio p_d/p_m leads to a lower market share of the domestic product.

Actually, it can be shown that equation (6.17) holds for any homogeneous utility function, not only for the CES utility function. I have assumed that the sub-utility functions are CES functions because this assumption firstly simplifies the proof of (6.17), secondly makes it possible to derive definite results on comparative statics, and thirdly makes linear estimation of (6.15) possible.

Comparative statics

The domestic price depends directly on marginal cost and indirectly, through the market share, on the price of the competing foreign product. If marginal cost increases, then the domestic price increases initially with the same percentage; this induces a fall in the domestic market share, which, through a decrease in the price elasticity of demand, leads to a fall in the domestic price; and so forth. It will be shown below that the total effect of an increase in marginal cost is positive and less than the increase in marginal cost.

A similar reasoning applies to the effects of a change in the foreign price: an increase in the price of the competing foreign product leads to an increase in the domestic market share; this induces a rise in the domestic price through a rise in the price elasticity of demand; this lowers the domestic market share, which in turn leads to a lower domestic price; and so forth. It will be shown below that the total change in the domestic price due to an increase in the foreign price is positive, but less than the increase in the foreign price.

Substituting (6.17) into (6.16) and rearranging we get

$$\tilde{p}_d = \left(1 - \frac{\sigma-1}{\sigma} w_d\right)\tilde{\Delta} + \frac{\sigma-1}{\sigma} w_d \tilde{p}_m. \tag{6.18}$$

Therefore the elasticities of the domestic price with respect to marginal cost and the foreign price are

$$e_c = \frac{\partial \log p_d}{\partial \log \Delta} = 1 - \frac{\sigma-1}{\sigma} w_d$$

and

$$e_m = \frac{\partial \log p_d}{\partial \log p_m} = \frac{\sigma - 1}{\sigma} \, w_d. \tag{6.19}$$

Since $\sigma > 1$, there holds

$$0 < e_c < 1$$

and

$$0 < e_m < 1.$$

Note that

$$e_c + e_m = 1. \tag{6.20}$$

Thus an increase in marginal cost or the foreign price always leads to an increase in the domestic price, and the change in the domestic price is a linearly homogeneous function of the changes in marginal cost and the foreign price.

The signs of the partial derivatives of e_m with respect to σ and w_d are

$$\frac{\partial e_m}{\partial \sigma} = \frac{w_d}{\sigma^2} > 0, \qquad \frac{\partial e_m}{\partial w_d} = \frac{\sigma - 1}{\sigma} > 0,$$
$$\frac{\partial^2 e_m}{\partial \sigma^2} = -2\,\frac{w_d}{\sigma^3} < 0, \qquad \frac{\partial^2 e_m}{\partial w_d^2} = 0,$$
$$\frac{\partial^2 e_m}{\partial w_d \, \partial \sigma} = \frac{1}{\sigma^2} > 0.$$

Thus e_m is a monotonically increasing function of σ and w_d; and $e_c = 1 - e_m$ is a monotonically decreasing function of σ and w_d. Therefore, the greater the possibilities of substitution or the higher the market share of the domestic producer, the more the domestic price reacts to the foreign price and the less to marginal cost.

Some limits of e_c and e_m are given in Table 6.2. When σ approaches one, then the market share of the domestic producer reacts less and less to changes in the price ratio p_d/p_m [see (6.17)], and the elasticity with respect to marginal cost approaches one.

If the domestic producer supplies the whole domestic market ($w_d = 1$), then the foreign price still influences the domestic price ($e_m \neq 0$). Note that if $w_d = 1$ or $\sigma = 1$, then $\varepsilon_{dd} = -1$ [see (6.10)], so that the mark-up and the domestic price are infinitely high. When on the other hand the market share of the domestic producer tends to zero, then marginal cost becomes more and more important ($e_c \to 1$).

If $\sigma = \infty$, then the price elasticity of demand ε_{dd} is infinite [see (6.10)], so that pure competition rules and there must hold $p_d = \Delta$. On the other hand, if $\sigma = \infty$, then the two products are perfect substitutes; thus the only stable solution is $p_d = p_m$. Therefore if $\sigma = \infty$, there holds $p_d = \Delta = p_m$, so that $e_m = e_c = 1$. Note that the market share w_d is indefinite, if $\sigma = \infty$.

The results for the limits of w_d have only local significance, because w_d is not independent of σ, Δ, and p_m. For example, a zero domestic market share can only exist

Table 6.2 *The elasticities and the mark-up for some special cases*

	Elasticity of domestic price with respect to		Ratio of domestic price to marginal cost
	marginal cost (e_c)	foreign price (e_m)	(p_d/Δ)
Elasticity of substitution			
1	1	0	∞
∞	$1 - w_d$	w_d	1
Domestic market share			
0	1	0	$\sigma/(\sigma - 1)$
1	$1/\sigma$	$(\sigma - 1)/\sigma$	∞

if the domestic price is infinite or the foreign price is zero.

6.4. Empirical analysis

In Section 6.3 I have derived a relation between the ratio of output price and marginal cost on the one hand and the market share on the other hand [cf. equation (6.15)];

$$\frac{p_d}{\Delta} = \frac{\sigma}{\sigma - 1} + \frac{1}{\sigma - 1}\frac{w_d}{1 - w_d}, \tag{6.21}$$

where p_d is output price, Δ is marginal cost, w_d is the market share of the domestic producer, and σ is the elasticity of substitution between the domestic and the foreign product. If it is assumed that marginal cost is equal to short-run average cost or to average variable cost, then equation (6.21) can be estimated; if marginal cost is equal to short-run average cost, then equation (6.21) becomes

$$\frac{p_d}{c + f} = \frac{\sigma}{\sigma - 1} + \frac{1}{\sigma - 1}\frac{w_d}{1 - w_d}, \tag{6.22}$$

where c is average variable cost and f is average fixed cost; and if marginal cost is equal to average variable cost, then equation (6.21) becomes

$$\frac{p_d}{c} = \frac{\sigma}{\sigma - 1} + \frac{1}{\sigma - 1}\frac{w_d}{1 - w_d}. \tag{6.23}$$

The market-share variable is typical of cross-section analyses; see for example Esposito and Esposito (1971), Hart and Morgan (1977), Jones, Laudadio, and Percy (1977), Khalilzadeh-Shirazi (1974), Pagoulatos and Sorensen (1976a, 1976b), and De Wolf (1981, 1982). The analysis in this chapter has given a foundation to the inclusion of this variable and has given an interpretation to its coefficient.

Equation (6.22) has been estimated by ordinary least squares for fifteen industries covering agriculture and manufacturing; the estimation period is 1961-1979. The results for equation (6.23) are broadly similar. Note that ordinary least squares gives biased estimates, because the domestic market share depends on the domestic price [see (6.17)]; some instrumental-variable estimations indicate that the bias is not very large (see Section 7.6 and Appendix 7.1 for further discussion).

Data

The data and their sources are given in Appendix C.3. The price index numbers refer to domestic sales by domestic producers. Most price series have been taken from publications of the Netherlands Central Bureau of Statistics; some have been supplied by the Central Planning Bureau.

From the yearly input-output tables I have taken the data on the value of cost (intermediate consumption, indirect taxes less subsidies, compensation of employees, and capital consumption), domestic sales, and competing imports. The average cost series have been constructed as the ratio of the value of cost and the quantity index of output (a Törnqvist index of the quantity index numbers of domestic sales and exports). The price-cost ratio has been normalized such that it is equal to 1 in 1970.

There are two reasons why the domestic market share refers to total sales and not to consumer sales, as the theory would have required. Firstly, in 1969 there has occurred a break in the series of the input-output tables; this break could only be overcome for total domestic sales and total imports, and not for consumer and producer goods separately. Secondly, price index numbers for consumer and producer goods are published only since 1975; before 1975 only an aggregate was published.

Estimation results

The results of the estimation are presented in Table 6.3. The coefficient of the domestic-sales/competing-imports ratio is significantly different from zero in 9 industries. In Metal products and Machinery it is negative; and in the other 8 industries it is positive, as the theory requires. Most of these 8 industries produce consumer goods or intermediate goods. The mark-up in Other food, Textiles, and Clothing and leather has been in particular lowered by the increase in foreign competition that took place in the 1960's and 1970's.

Table 6.4 gives the implied estimates of the elasticity of substitution, the price elasticity of demand for the product, the mark-up, and the elasticity of the domestic price with respect to the foreign price.

Table 6.3 *Estimation results for the mark-up equation (6.22)*

	Domestic market share (average 1961-1979) (per mille)	Coefficient of		$\bar{R}^2$	*DW*
		constant	domestic-sales/competing-imports ratio		
1. Agriculture	791	0.678[a] (0.061)	0.082[a] (0.016)	0.59	1.27
2. Meat and dairy	859	0.973[a] (0.011)	0.0016 (0.0014)	0.01	1.07
3. Other food	828	0.827[a] (0.029)	0.033[a] (0.006)	0.66	0.95
4. Drink and tobacco	881	0.956[a] (0.018)	0.004[a] (0.002)	0.20	0.58
5. Textiles	460	0.978[a] (0.007)	0.044[a] (0.007)	0.69	1.37
6. Clothing and leather	555	0.994[a] (0.005)	0.019[a] (0.002)	0.80	1.96
7. Paper and printing	799	0.994[a] (0.011)	0.006[a] (0.003)	0.24	1.45
8. Timber and stone	637	0.885[a] (0.025)	0.052[a] (0.014)	0.42	1.10
9. Chemical products	483	0.883[a] (0.049)	0.085 (0.048)	0.10	0.59
10. Primary metal products	341	0.755[a] (0.118)	0.374 (0.224)	0.09	1.26
11. Metal products and machinery	519	1.035[a] (0.019)	–0.041[a] (0.017)	0.22	1.55
12. Electrical products	373	1.048[a] (0.065)	–0.144 (0.107)	0.04	1.48
13. Transport equipment	395	1.026[a] (0.020)	–0.001 (0.026)	–0.06	1.03
14. Mineral oil refining	732	0.717[a] (0.080)	0.066[a] (0.027)	0.22	1.16
15. Mining	289	–0.429 (1.767)	4.835 (4.257)	0.02	0.24

Standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

Because the price-cost ratio has been normalized to 1 in 1970, one can compute the elasticity of substitution as the ratio of the estimate of the constant term and the estimate of the domestic-sales/competing-imports ratio. The point estimate of the elasticity of substitution tends to be high, but the 95% confidence interval is so large, that it includes also relatively low values of σ. The mark-up is not significantly different from zero in the 8 industries with a significant positive coefficient of the domestic-sales/competing-imports ratio; this means that one cannot reject the hypothesis that price equals average cost. This is clearly in contradiction with the significance of the estimate of the domestic-sales/competing-imports ratio. It may be that the asymptotic standard errors are unreliable in small samples.

The estimate of the elasticity of the domestic price with respect to the foreign price has a low standard error. Industries in which the elasticity is larger than 0.75 are the four food industries (Agriculture and fisheries, Meat and dairy, Other food, and Drink and tobacco), and Paper and printing; Clothing and leather, Timber and stone, Primary metal products, and Mineral oil refining have an elasticity that lies between 0.50 and 0.75; and in the remaining industries the elasticity lies between 0.25 and 0.50. Thus non-durable-consumer-goods industries tend to be more sensitive to foreign competition than durable and intermediate goods industries.

The elasticities of the domestic price with respect to the foreign price are roughly proportional to the domestic market shares (compare the last column of Table 6.4 with the first column of Table 6.3).[11] The explanation can be found in Table 6.2, which shows that as the elasticity of substitution approaches infinity, the elasticity of the domestic price with respect to the foreign price approaches the domestic market share.

It is somewhat remarkable that the elasticity of the domestic price with respect to the foreign price is significant in industries where the coefficient of the domestic-sales/competing-imports ratio is insignificant. This occurs because the elasticity is proportional to the ratio of two terms in σ [see (6.19)]; even if σ has a large standard error, then $(\sigma - 1)/\sigma$ and thus e_m will have a low standard error. Thus for industries where the coefficient of $w/(1 - w)$ is insignificant or negative, one should not give much weight to the estimate of e_m.

6.5. Summary

The ratio of a monopolist's profit-maximizing price to his marginal cost depends on the price elasticity of demand. In this chapter the price elasticity of demand has been analysed for a producer of a consumer product for which there exists a foreign substitute; both products are variants of the same good.

I assume that the consumer follows a two-stage budgeting procedure: he determines first the quantities of the goods and then for each good the quantities of the domestic and foreign product. In this chapter I assume that the price elasticity of demand for the good is equal to −1; this implies that the budget share of the good (that is the sum of the budget shares of its two products) remains constant if there occurs a change in the price of the domestic or foreign product that belong to the good. The price elasticity of demand for the domestic product depends under this assumption only on the elasticity of substitution between the domestic and the foreign product and on the domestic market share. Then the ratio of output price and marginal cost is a linear

[11] This proportionality has also been found by Calmfors and Herin (1979, p. 291) for Sweden in the period 1950-1974. Using foreign prices, they estimate models that are comparable to (6.18).

Table 6.4 *Parameter values implied by the estimates of the mark-up equation*

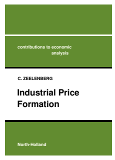
	Elasticity of substitution	Price elasticity of demand	Mark-up	Elasticity of domestic price with respect to foreign price
1. Agriculture	8.3[a]	−2.5[a]	0.66	0.70[a]
	(2.3)	(0.5)	(0.53)	(0.027)
2. Meat and dairy	628.0	−89.5	0.01	0.86[a]
	(566.1)	(79.9)	(0.91)	(0.001)
3. Other food	24.9[a]	−5.1[a]	0.24	0.79[a]
	(5.0)	(0.9)	(0.26)	(0.007)
4. Drink and tobacco	263.4[a]	−32.3[a]	0.03	0.88[a]
	(116.5)	(13.9)	(0.46)	(0.001)
5. Textiles	22.2[a]	−12.4[a]	0.09	0.44[a]
	(3.6)	(1.9)	(0.18)	(0.003)
6. Clothing and leather	52.3[a]	−23.9[a]	0.04	0.54[a]
	(6.3)	(2.8)	(0.13)	(0.001)
7. Paper and printing	153.0[a]	−31.6[a]	0.03	0.79[a]
	(61.2)	(12.3)	(0.42)	(0.002)
8. Timber and stone	17.1[a]	−6.9[a]	0.17	0.60[a]
	(5.1)	(1.8)	(0.37)	(0.011)
9. Chemical products	10.4	−5.9	0.21	0.44[a]
	(6.5)	(3.4)	(0.83)	(0.029)
10. Primary metal products	2.0	−1.7	1.49	0.17
	(1.5)	(1.0)	(3.71)	(0.127)
11. Metal products and machinery	−25.2[ab]	11.6[ac]	−0.08	0.54[a]
	(9.8)	(4.7)	(0.35)	(0.008)
12. Electrical products	−7.3	4.2	−0.19	0.42[a]
	(5.0)	(3.1)	(0.48)	(0.035)
13. Transport equipment	−1008.4	609.4	−0.002	0.40[a]
	(25690.9)	(15535.4)	(25.41)	(0.010)
14. Mineral oil refining	10.8	−3.6[a]	0.38	0.66[a]
	(5.5)	(1.5)	(0.78)	(0.035)
15. Mining	−0.1	−0.2	−1.29[a]	3.55
	(0.3)	(0.2)	(0.08)	(10.591)

Asymptotic standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.
[b] Significantly smaller than 1 at 5% level.
[c] Significantly larger than −1 at 5% level.

function of the ratio of competing imports and domestic sales; the coefficients are functions of the elasticity of substitution. I have shown that the higher the domestic market share is, the higher the mark-up is; and the smaller the possibilities of substitution between the domestic and the foreign product are, the higher the mark-up is and the less the domestic price reacts to the foreign price and the more to marginal cost.

This price equation has been estimated for 15 Dutch industries in the period 1961-1979. The domestic-sales/competing-imports ratio has a significant positive coefficient in 8 industries, which produce consumer goods or intermediate goods; in particular the mark-up in Other food, Textiles, and Clothing and leather has been strongly and negatively influenced by foreign competition.

Because the domestic market share depends on the ratio of domestic price to foreign price, the domestic price depends ultimately on the foreign price. It has been computed from the estimates that the elasticity of the domestic price with respect to the foreign price lies above 0.75 in non-durable-consumer goods industries; in most other industries it lies between 0.25 and 0.50.



CHAPTER 7

Price formation under imperfect competition: Extensions to the basic model

This chapter gives some extensions to the model of Chapter 6. In Section 7.1 a price equation is derived without the assumption that the price elasticity of demand for a good (which is the aggregate of a domestic product and the foreign product that competes with it) is equal to −1. This leads to the inclusion in the price equation of the budget share of the good. In Section 7.2 price equations will be derived for a producer of producer goods (i.e. intermediate and capital goods). The price equations are in form identical to those for consumer goods. Section 7.3 deals with the price equation for a multi-product firm. In Section 7.4 the relation between marginal cost, average cost, and capacity utilization is analysed. In Section 7.5 the specification of the price equation and some econometric problems are considered. Section 7.6 presents the empirical results. Some alternative estimation results are given in Appendix 7.1.

7.1. A general price equation for consumer goods

First I shall summarize results from Chapter 6 that are needed in this section.

The basis for the price equation is formula (6.2), which gives the profit-maximizing price of a monopolist:

$$p_{di} = \Delta_i \left(1 + \frac{1}{\varepsilon_{di,di}}\right)^{-1}, \quad i = 1, 2, \ldots, N, \tag{7.1}$$

where p_{di} is the output price of the producer of the domestic product of good i, Δ_i is his marginal cost, $\varepsilon_{di,di}$ is the own price elasticity of demand for his product, and N is the number of industries. A necessary condition for a profit maximum is [cf. (6.3)]

$$\varepsilon_{di,di} < -1 \tag{7.2}$$

Totally differentiating (7.1) we get

$$\tilde{p}_{di} = \tilde{\Delta}_i + \frac{1}{\varepsilon_{di,di}(\varepsilon_{di,di} + 1)} \mathrm{d}\varepsilon_{di,di}, \tag{7.3}$$

where a tilde (˜) denotes a relative differential [for example $\tilde{p}_{di} = (\mathrm{d}p_{di})/p_{di}$].

The price elasticity of demand is modelled as follows. I assume that the representative consumer follows a two-stage budgeting procedure: he determines first the quantities of the goods and then for each good how much he will buy at home and how much abroad. Under some assumptions that are necessary for this two-stage procedure we get for the price elasticity of demand [cf. (6.9)]:[1]

[1] A superscript refers to a within-good variable.

$$\varepsilon_{di,di} = (\sigma^i - 1)w_d^i - \sigma^i + (1 + \varepsilon_{ii})w_d^i, \tag{7.4}$$

where σ^i is the elasticity of substitution between the domestic and the foreign product with utility of the good constant, w_d^i is the share of the domestic producer in total expenditure on the good (the *domestic market share*), and ε_{ii} is the price elasticity of demand for the good. I assume that σ^i is constant.

Demand for goods

In Chapter 6 it has been assumed that ε_{ii} is constant and equal to -1, for example because the macro-utility function (that represents preferences for goods) is Cobb-Douglas. If the price elasticity of demand for the good is not equal to -1, then the term $(1 + \varepsilon_{ii})w_d^i$ in (7.4) does not vanish, and the demand for goods must be explicitly modelled. I assume that the demand for consumer goods can be represented by the global absolute version of the Rotterdam system [see Theil (1980, pp. 15 and 160)]. Demand for goods is then given by [see Appendix B.2, equation (B.4)]

$$w_i \tilde{q}_i = \mu_i(\tilde{y} - \tilde{P}) + \sum_{j=1}^{N} \pi_{ij} \tilde{p}_j, \quad i = 1, 2, \ldots, N, \tag{7.5}$$

where q_i is the quantity (index) of good i, p_j is the price (index) of good j, y is income, P is the Divisia-index of the prices p_j ($\tilde{P} = \sum_{j=1}^{N} w_j \tilde{p}_j$), $w_i = p_i q_i / y$ is the budget share of the good, and (π_{ij}) is a symmetric negative-definite matrix satisfying $\sum_{j=1}^{N} \pi_{ij} = 0$; the terms π_{ij} are called the Slutsky coefficients. Thus the change[2] in demand multiplied by the budget share is in the Rotterdam system a linear function of the changes in real income and all prices.

It follows from (7.5) that the income and price elasticities of the demand for goods are

$$\eta_i = \frac{\partial \log q_i}{\partial \log y} = \frac{\mu_i}{w_i}, \tag{7.6}$$

$$\varepsilon_{ij} = \frac{\partial \log q_i}{\partial \log p_j} = \frac{\pi_{ij}}{w_i} - \mu_i \frac{w_j}{w_i}, \tag{7.7}$$

$$i, j = 1, 2, \ldots, N.$$

Thus μ_i can be interpreted as the marginal budget share of good i. Using the Slutsky equation

$$\varepsilon_{ij}^* = \varepsilon_{ij} + w_j \eta_i,$$

where an asterisk denotes a compensated elasticity, one easily shows that the compensated elasticities are

$$\varepsilon_{ij}^* = \frac{\pi_{ij}}{w_i}.$$

[2] Change always means relative change.

It follows from (7.7) that the own price elasticity of demand for a good is

$$\varepsilon_{ii} = \frac{\pi_{ii}}{w_i} - \mu_i, \tag{7.8}$$

where $\pi_{ii} \leq 0$, because the compensated own price elasticities are non-positive.

Of course, other demand systems can be used, such as the constant-elasticity-of-substitution (CES) demand system, the Linear Expenditure System (LES) [see Deaton (1975) and Lluch, Powell, and Williams (1977)], the translog demand system [see Christensen, Jorgenson, and Lau (1975)], the Almost Ideal Demand System (AIDS) [see Deaton and Muellbauer (1981)], or the generalization of the CES and LES demand systems proposed by Keller (1976). The first two demand systems are too restrictive: the CES demand functions have an income elasticity of 1 and the LES demand functions have a functional dependence between price elasticities and income elasticities [see Deaton and Muellbauer (1980, p. 138)]. The last three systems are too flexible for my purpose: the price elasticities are functions of many parameters. Of all the flexible demand systems, the Rotterdam system gives the most simple expressions for price elasticities.

The price equation

Substituting (7.8) into (7.4) we get

$$\varepsilon_{di,di} = (\sigma^i - 1)w_d^i - \sigma^i + (1 + \frac{\pi_{ii}}{w_i} - \mu_i)w_d^i. \tag{7.9}$$

It is easily shown that a necessary and sufficient condition for $\varepsilon_{di,di} < -1$ is

$$\sigma^i > \frac{1 + \varepsilon_{ii} w_d^i}{1 - w_d^i}\,. \tag{7.10}$$

It follows from (7.3) and (7.9) that

$$\tilde{p}_{di} = \tilde{\Delta}_i + \frac{w_d^i(\sigma^i + \pi_{ii}/w_i - \mu_i)}{\varepsilon_{di,di}(\varepsilon_{di,di} + 1)}\,\tilde{w}_d^i - \frac{\pi_{ii} w_d^i / w_i}{\varepsilon_{di,di}(\varepsilon_{di,di} + 1)}\,\tilde{w}_i$$

$$=: \tilde{\Delta}_i + \gamma_i \tilde{w}_d^i + \delta_i \tilde{w}_i, \;\; i = 1, 2, \ldots, N. \tag{7.11}$$

The coefficient (δ_i) of $\tilde{w}_i$ is nonnegative, since $\varepsilon_{di,di} < -1$ and $\pi_{ii} \leq 0$. Using (7.10) one can easily show that $\varepsilon_{ii} \geq -1$ is a sufficient condition for the coefficient (γ_i) of $\tilde{w}_d^i$ to be positive, and that $\sigma^i > 1$ is a necessary condition. Because $\varepsilon_{ii} \geq -1$ is often found in empirical studies (see Table 6.1), one may expect that $\gamma_i > 0$. Assuming that $\gamma_i > 0$, we can show that the signs of the partial derivatives of γ_i and δ_i with respect to σ^i, π_{ii}, μ_i, w_d^i, and w_i are:

$$\frac{\partial\gamma_i}{\partial\sigma^i}\ \ ?,\qquad \frac{\partial\delta_i}{\partial\sigma^i} < 0,$$
$$\frac{\partial\gamma_i}{\partial\pi_{ii}} > 0,\qquad \frac{\partial\delta_i}{\partial\pi_{ii}}\ \ ?,$$
$$\frac{\partial\gamma_i}{\partial\mu_i} < 0,\qquad \frac{\partial\delta_i}{\partial\mu_i} < 0,$$
$$\frac{\partial\gamma_i}{\partial w_d^i} > 0,\qquad \frac{\partial\delta_i}{\partial w_d^i} > 0,$$
$$\frac{\partial\gamma_i}{\partial w_i} < 0,\qquad \frac{\partial\delta_i}{\partial w_i} < 0.$$

Unfortunately, the signs of $\partial\gamma_i/\partial\sigma^i$ and $\partial\delta_i/\partial\pi_{ii}$ cannot be determined.

Some special cases are:

— ε_{ii} is constant and equals -1: then $\delta_i = 0$;
— there is no competing foreign product: then $w_d^i = 1$, $\varepsilon_{di,di} = \varepsilon_{ii}$, and $\gamma_i = 0$;
— σ^i equals 1: then $\gamma_i = 1/\varepsilon_{di,di} < 0$.

The last special case shows that a negative γ_i is possible.

Market and budget share equations

As shown in Section 6.3, the domestic market share is independent of income and of the preferences for the goods; thus the change in the market share is given by (6.17):

$$\tilde{w}_d^i = (1 - \sigma^i)(1 - w_d^i)(\tilde{p}_{di} - \tilde{p}_{mi}), \tag{7.12}$$

where p_{mi} is the price of the competing foreign product.

It follows from (7.5) that the change in the budget share is equal to

$$\tilde{w}_i = \tilde{p}_i + \tilde{q}_i - \tilde{y} = \left(\frac{\mu_i}{w_i} - 1\right)\tilde{y} + \tilde{p}_i + \sum_{j=1}^{N}\left(\frac{\pi_{ij}}{w_i} - \frac{\mu_i}{w_i}\,w_j\right)\tilde{p}_j.$$

Using the fact that the prices of the goods are Divisia-indices of the prices of the products [$\tilde{p}_j = w_d^j\tilde{p}_{dj} + (1 - w_d^j)\tilde{p}_{mj}$; see (6.6) and Appendix A.1, equation (A.10)], we can express the change in the budget share in terms of the prices of the products:

$$\tilde{w}_i = \left(\frac{\mu_i}{w_i} - 1\right)\tilde{y} + w_d^i\tilde{p}_{di} + (1 - w_d^i)\tilde{p}_{mi} + \sum_{j=1}^{N}\left(\frac{\pi_{ij}}{w_i} - \frac{\mu_i}{w_i}\,w_j\right)[w_d^j\tilde{p}_{dj} + (1 - w_d^j)\tilde{p}_{mj}],\ \ i = 1, 2, \ldots, N. \tag{7.13}$$

Comparative statics

For each good we now have three equations, which represent supply and demand; equation (7.11) represents supply: it gives the change in price as a result of the changes in marginal cost, domestic market share, and budget share; equations (7.12) and (7.13) represent demand: they give the change in the budget shares as a result of the changes in income and prices. Because all prices appear in (7.13), we can analyse comparative statics not for each product separately, but only for all products together; this will be done in Chapter 9.

7.2. Price formation of producer goods

Price equations similar to (6.15) and (7.11) can be derived for a monopolist who produces a producer good (i.e. an intermediate or capital good), which is used as input by other producers. I assume that the demanders of the producer good base their decisions on given prices, i.e. the demand side of the output market is characterized by perfect competition.

The analysis in this section is so similar to that of Chapter 6 and the previous section that no derivations will be given, but only results.

The structure of production

I assume that the demand for the producer good can be considered to be generated by a cost-minimizing producer[3] whose production function is separable such that it can be written as

$$q(v_{d1}, v_{m1}, \ldots, v_{dN}, v_{mN}) = Q[q_1(v_{d1}, v_{m1}), \ldots, q_N(v_{dN}, v_{mN})],$$

where q is the production function, v_{di} and v_{mi} are the quantities of good i that are bought at home and abroad respectively, Q is the macro-production function and the q_i are the sub-production functions ($i = 1, 2, \ldots, N$). This assumption allows the producer to follow a two-stage procedure: he determines first the quantities of the goods and then for each good which part is bought from the domestic monopolist and which part from foreign suppliers. A sufficient condition for this procedure to be consistent is that the sub-production functions q_i are homogeneous of degree one; I assume that this condition holds.

[3] Note that throughout this section and the next one, 'producer' does not refer to the monopolist, but to the representative producer who demands the output of the monopolist.

The price elasticity of demand

The price elasticity of demand for the domestic product is[4] [see Appendix A, equation (A.18)]

$$\varepsilon_{di,di} = \frac{\partial \log v_{di}}{\partial \log p_{di}} = \varepsilon_d^i + w_d^i \varepsilon_{ii}, \tag{7.14}$$

where ε_d^i is the within-good elasticity of demand for the domestic product, w_d^i is the value share of the domestic product in total expenditure on good i, and ε_{ii} is the price elasticity of demand for the aggregate good i. For the moment I assume that ε_{ii} is constant and equal to -1. One can show analogously to the derivation of (6.8) in Section 6.2 that

$$\varepsilon_d^i = \sigma^i (w_d^i - 1),$$

where $\sigma^i = -\partial \log (v_{di}/v_{mi}) \;/\; \partial \log (p_{di}/p_{mi}) \rfloor_{q_i \text{ constant}}$ is the elasticity of substitution between the domestic and foreign products of good i, with the quantity of the good constant. Thus, equation (7.14) reduces to

$$\varepsilon_{di,di} = (\sigma^i - 1) w_d^i - \sigma^i. \tag{7.15}$$

Results

Because (7.15) is in form identical to (6.10), all results derived for the price of a consumer good also hold for the price of a producer good. Therefore, necessary and sufficient for $\varepsilon_{di,di} < -1$ is

$$\sigma^i > 1 \text{ and } w_d^i \neq 1;$$

the price equation in levels is

$$\frac{p_{di}}{\Delta_i} = \frac{\sigma^i}{\sigma^i - 1} + \frac{1}{\sigma^i - 1} \frac{w_d^i}{1 - w_d^i}\,, \quad i = 1, 2, \ldots, N;$$

and the market share equation is

$$\tilde{w}_d^i = (1 - \sigma^i)(1 - w_d^i)(\tilde{p}_{di} - \tilde{p}_{mi}). \tag{7.16}$$

If the elasticity of substitution σ^i is constant, then the following relations also hold: the price equation in relative changes is

$$\tilde{p}_{di} = \tilde{\Delta}_i + \frac{(\sigma^i - 1) w_d^i}{\varepsilon_{di,di}(\varepsilon_{di,di} + 1)} \tilde{w}_d^i;$$

the elasticity of the domestic price with respect to the foreign price is

[4] For economy of notation I use the same symbols as in the sections on price formation of consumer goods.

$$e_m^i = \frac{\partial \log p_{di}}{\partial \log p_{mi}} = \frac{\sigma^i - 1}{\sigma^i}\, w_d^i;$$

the elasticity of the domestic price with respect to marginal cost is

$$e_c^i = \frac{\partial \log p_{di}}{\partial \log \Delta_i} = 1 - \frac{\sigma^i - 1}{\sigma^i}\, w_d^i = 1 - e_m^i;$$

and the following inequalities hold:

$$0 < e_m^i < 1$$

and

$$0 < e_c^i < 1.$$

Also, e_m^i is a monotonically increasing function of σ^i and of w_d^i, whereas e_c^i is a monotonically decreasing function of σ^i and of w_d^i.

A general price equation for producer goods

I now drop the assumption that the price elasticity of demand for the good is equal to −1. I assume instead that the demand for producer goods can be represented by the global absolute version of the Rotterdam system [see Theil (1980, p. 36)]. The demand for good i is then given by [cf. Appendix B, equation (B.5)]:

$$w_i \tilde{v}_i = \phi \mu_i \tilde{q} + \sum_{j=1}^{N} \pi_{ij} \tilde{p}_j \tag{7.17}$$

where v_i is the quantity of good i, q is output, $\phi = \partial \log C / \partial \log q$ is the inverse of the elasticity of scale, C is total cost, $\mu_i = [\partial(p_i v_i)/\partial q]/(\partial C/\partial q)$ is the marginal cost share of good i, $\sum_{i=1}^{N} \mu_i = 1$, (π_{ij}) is a symmetric negative-definite matrix satisfying $\sum_{j=1}^{N} \pi_{ij} = 0$, and $w_i = p_i v_i / C$ is the cost share of the good. It follows that the price elasticity of demand for the good is

$$\varepsilon_{ii} = \frac{\pi_{ii}}{w_i}\,. \tag{7.18}$$

Because (π_{ij}) is negative definite, there holds $\pi_{ii} \le 0$ and thus $\varepsilon_{ii} \le 0$. I have used the Rotterdam system because other demand systems, such as those based on the translog cost function [see Christensen, Jorgenson, and Lau (1973)] or the generalized Leontief cost function [see Diewert (1971)] yield price elasticities that are too complicated.

Substitution of (7.15) and (7.18) into (7.14) gives

$$\varepsilon_{di,di} = \sigma^i (w_d^i - 1) + \pi_{ii} \frac{w_d^i}{w_i}\,. \tag{7.19}$$

It is easily shown that $\varepsilon_{di,di} < -1$ holds if and only if

$$\sigma^i > \frac{1 + \varepsilon_{ii} w_d^i}{1 - w_d^i}\,. \tag{7.20}$$

Using (7.19) we get from (7.3)

$$\tilde{p}_{di} = \tilde{\Delta}_i + \frac{w_d^i(\sigma^i + \pi_{ii}/w_i)}{\varepsilon_{di,di}(\varepsilon_{di,di}+1)}\,\tilde{w}_d^i - \frac{\pi_{ii}w_d^i/w_i}{\varepsilon_{di,di}(\varepsilon_{di,di}+1)}\,\tilde{w}_i$$

$$=: \tilde{\Delta}_i + \gamma_i \tilde{w}_d^i + \delta_i \tilde{w}_i, \;\; i = 1, 2, \ldots, N. \tag{7.21}$$

The coefficient of $\tilde{w}_i$ is nonnegative, because $\varepsilon_{di,di} < -1$ and $\pi_{ii} \leq 0$. Using (7.19) and (7.20) one easily shows that a sufficient condition for the coefficient of $\tilde{w}_d^i$ to be positive is $\varepsilon_{ii} \geq -1$. Note that the sum of the coefficients of $\tilde{w}_i$ and $\tilde{w}_d^i$ is $[\varepsilon_{di,di}(\varepsilon_{di,di}+1)]^{-1} w_d^i \sigma^i$, which is nonnegative.

The cost share equation

Total cost is a function of the input prices and output:

$$C = C(p, q).$$

Total differentiation gives

$$\tilde{C} = \phi\tilde{q} + \sum_{j=1}^{N} w_j \tilde{p}_j,$$

where $\partial \log C / \partial \log p_j = w_j$ because of Shephard's Lemma [see Varian (1978, p. 32)]. It follows that the change in the cost share of the i-th input is

$$\tilde{w}_i = \tilde{p}_i + \tilde{v}_i - \tilde{C} = \phi\left(\frac{\mu_i}{w_i} - 1\right)\tilde{q} + \tilde{p}_i + \sum_{j=1}^{N}\left(\frac{\pi_{ij}}{w_i} - w_j\right)\tilde{p}_j.$$

Because the price of a good is the Divisia price index of the prices of its products, we get

$$\tilde{w}_i = \phi\left(\frac{\mu_i}{w_i} - 1\right)\tilde{q} + w_d^i \tilde{p}_{di} + (1 - w_d^i)\tilde{p}_{mi}$$

$$+ \sum_{j=1}^{N}\left(\frac{\pi_{ij}}{w_i} - w_j\right)[w_d^j \tilde{p}_{dj} + (1 - w_d^j)\tilde{p}_{mj}], \;\; i = 1, 2, \ldots, N. \tag{7.22}$$

7.3. Price formation of a multi-product firm

I shall analyse a monopolist who produces two goods, a consumer good and a producer good. I assume first that price discrimination is possible and practised. Then the monopolist sets two prices according to (7.11) and (7.21). If price index numbers are available for consumer goods and for producer goods, then the two equations may be analysed separately. However, separate price index numbers for consumer and producer goods are often not available by industry; only the aggregate is published.[5] Using (7.11) and (7.21) and adding a subscript H and F respectively we get for the change in the Divisia price index

$$\begin{aligned}\tilde{p}_{di} &= s_{Hi}\tilde{p}_{Hdi} + s_{Fi}\tilde{p}_{Fdi} \\ &= \tilde{\Delta}_i + s_{Hi}\gamma'_{Hi}\tilde{w}^i_{Hd} + s_{Fi}\gamma'_{f_i}\tilde{w}^i_{Fd} + s_{Hi}\delta'_{hi}\tilde{w}_{Hi} + s_{Fi}\delta'_{Fi}\tilde{w}_{Fi} \\ &=: \tilde{\Delta}_i + \gamma_{Hi}\tilde{w}^i_{Hd} + \gamma_{Fi}\tilde{w}^i_{Fd} + \delta_{Hi}\tilde{w}_{Hi} + \delta_{Fi}\tilde{w}_{Fi},\end{aligned} \tag{7.23}$$

with

$$\gamma_{Hi} > 0\ ?,\ \gamma_{Fi} > 0\ ?,\ \delta_{Hi} > 0,\ \delta_{Fi} > 0,$$

where s_{Hi} is the value share of sales to consumers in total sales, s_{Fi} is the value share of sales to producers in total sales, and $s_{Hi} + s_{Fi} = 1$. Thus the change in output price is a linear function of the changes in marginal cost and the four shares w^i_{Hd}, w^i_{Fd}, w_{Hi}, and w_{Fi}.

If price discrimination is not possible, then the monopolist faces one demand curve that is the aggregate of the consumer and the producer demand curve. The observed price elasticity of demand is then a weighted average of the two elasticities:

$$\varepsilon_{di,di} = s_{Hi}\varepsilon_{H,di,di} + s_{Fi}\varepsilon_{F,di,di}. \tag{7.24}$$

Using (7.24), (7.9), and (7.19) and assuming s_{Hi} and s_{Fi} are constant, we get from (7.3)

$$\tilde{p}_{di} = \tilde{\Delta}_i + \overset{*}{\gamma}_{Hi}\tilde{w}^i_{Hd} + \overset{*}{\gamma}_{Fi}\tilde{w}^i_{Fd} + \overset{*}{\delta}_{Hi}\tilde{w}_{Hi} + \overset{*}{\delta}_{Fi}\tilde{w}_{Fi}, \tag{7.25}$$

with

$$\overset{*}{\gamma}_{Hi} > 0\ ?,\ \overset{*}{\gamma}_{Fi} > 0\ ?,\ \overset{*}{\delta}_{Hi} > 0,\ \overset{*}{\delta}_{Fi} > 0,$$

where the definitions of the coefficients are analogous to those of (7.11) and (7.21). Again, the change in price is a linear function of the changes in marginal cost and the four shares w^i_{Hd}, w^i_{Fd}, w_{Hi}, and w_{Fi}.

The equations (7.23) and (7.25) are easily extended to the case of more than two groups of buyers.

[5] In the Netherlands, price index numbers by industry for consumer and producer goods separately are published since 1975.

7.4. Marginal cost, average cost, and capacity utilization

This section deals with the consequences that fixed capital has for the difference between marginal and average cost. In the previous sections I have derived a relation between the change in output price and the changes in marginal cost, the market shares, and the budget and cost shares. Because marginal cost as such is not observable, I shall derive a relation between marginal cost on the one hand and average variable cost, average fixed cost, and capacity utilization on the other hand. I shall make this derivation using a specific cost function; a more general analysis has been given by Nieuwenhuis (1980), who uses the theory of behaviour under rationing developed by Neary and Roberts (1980).

One might of course assume that marginal cost is equal to average cost. For the long run this is a plausible assumption: many cross-section studies of cost differences between firms have found only a small influence of output on average cost.[6]

In the short run it are the fixedness of capital and the difference between actual (short run) and expected (long run) output[7] that cause a difference between marginal and average cost. The model of producer behaviour that underlies this difference is described in the textbooks: cost minimization on the basis of expected long-run output gives the long-run demand for capital services and the other inputs; the producer builds a plant that yields the required capital services; as soon as the plant is built, the producer minimizes the cost of the variable inputs on the basis of actual output. Because the amount of capital services is fixed and corresponds to expected output, a difference between actual and expected output leads to an excess of short-run (actual) cost over long-run cost; and a variation in output causes a change in cost that is larger when capital is fixed than when all inputs are variable. Therefore short-run cost is larger than long-run cost and short-run marginal cost increases faster than long-run marginal cost; since short-run cost and long-run cost are equal if short-run output equals long-run output, short-run and long-run marginal costs are in that case also equal. Figure 7.1 gives an illustration of the relation between the cost curves when long-run marginal and average cost are equal.

The figure shows that if the producer expects his long-run output to be q_1^*, he will build a plant that yields capital services k_1; when the plant is built, his short-run marginal cost is $SRMC(k_1)$. Similarly if his expected output is q_2^*.

In the figure we see that the larger the difference is between actual output and long-run output, the larger the differences are between short-run marginal cost and short-run average cost and those between short-run marginal cost and long-run marginal cost. A more formal analysis goes as follows.

I assume that the long-run production function of the producer is linearly homogeneous, which means that if all inputs increase with the same percentage, output increases also with the same percentage. The long-run cost function is then the product

[6] See for example Johnston (1960), Koutsoyiannis (1975, pp. 137-48), and Scherer (1970, pp. 91-8).

[7] A difference between actual and expected input prices may also be a cause of a difference between marginal and average cost; see Nieuwenhuis (1980) for an analysis.

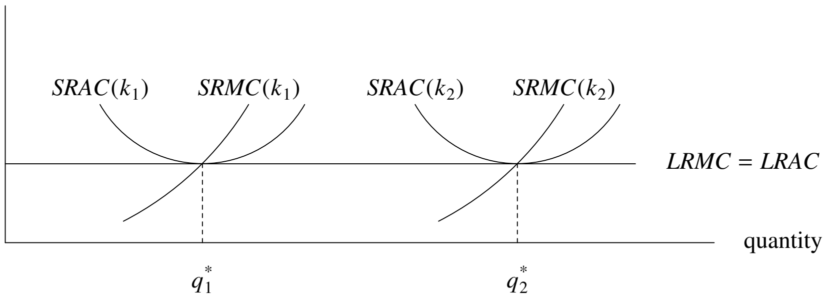


Figure 7.1 *Short and long run cost curves*

of long-run output and a unit-cost function that depends only on the input prices:

$$C^*(q^*, r) = q^* c^*(r),$$

where q^* is long-run output, r is the vector with input prices, and C^* and c^* are functions that are concave and linearly homogeneous in the prices r [see Varian (1978, Chapter 1)].

In the short-run the amount of capital services is fixed, because the size of the plant is fixed. Total short-run cost (C) is the sum of variable cost (C_v) and fixed cost; variable cost is a function of actual output (q), the amount of capital services (k), and the input prices except the price of capital services:

$$C = C_v(q, k, r^-) + r_1 k,$$

where r_1 is the price of capital services and r^- is the vector with the prices of the other inputs.

I assume that the short-run cost function can be approximated by the sum of a linear function in output and a power in output:

$$C = a + bq + dq^n,$$

where a, b, and d are functions of the input prices r^- and the fixed amount of capital services k, and n is a real scalar. Note that a is total fixed cost. Average variable cost is

$$c = \frac{C - a}{q} = b + dq^{n-1},$$

short-run marginal cost is

$$\Delta = \frac{\partial C}{\partial q} = b + ndq^{n-1},$$

and short-run average cost is

$$\frac{C}{q} = \frac{a}{q} + b + dq^{n-1} = f + c,$$

where $f = a/q$ is average fixed cost. Typical shapes of the average variable cost curves are shown in Figure 7.2.

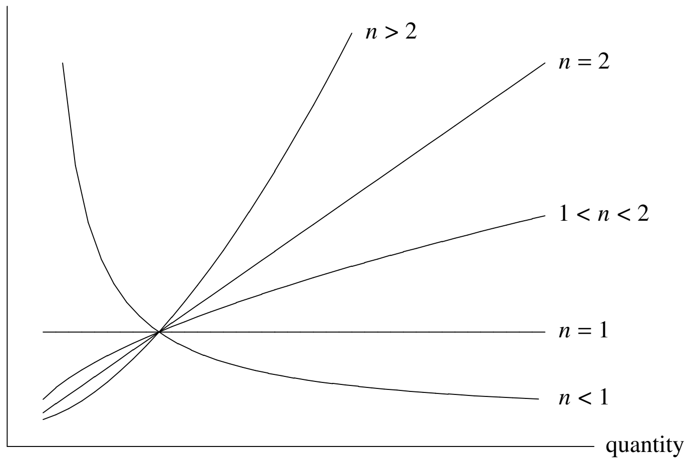


Figure 7.2 *Average variable cost curves*

Thus the average variable cost curve has the usual convex shape if $n \leq 1$ or $n \geq 2$.

Long-run output is equal to the minimum of the short-run average cost curve (see Figure 7.1). It is easily shown that for the above specification there holds

$$q^* = \left[\frac{a}{(n-1)d} \right]^{1/n}.$$

The difference between short-run marginal cost and average variable cost is therefore

$$\Delta - c = (n-1)dq^{n-1} = \frac{a}{q}\left(\frac{q}{q^*}\right)^n = fu^n, \tag{7.26}$$

where $u = q/q^*$ is capacity utilization. Thus short-run marginal cost is equal to average variable cost plus the product of average fixed cost and a power of capacity utilization. It follows from (7.26) that marginal cost is larger than average variable cost. Totally differentiating (7.26) we get

$$\tilde{\Delta} = \frac{c}{\Delta}\tilde{c} + \frac{\Delta - c}{\Delta}\tilde{f} + n\frac{\Delta - c}{\Delta}\tilde{u} =: \alpha_1\tilde{c} + \alpha_2\tilde{f} + \beta\tilde{u}, \tag{7.27}$$

where $\alpha_1 + \alpha_2 = 1$.

Because $\Delta \geq c$, there holds $0 \leq \alpha_1 \leq 1$ and $0 \leq \alpha_2 \leq 1$. If short-run marginal cost is equal to average variable cost, then $\alpha_1 = 1$, $\alpha_2 = 0$, and $\beta = 0$. If short-run marginal cost is equal to short-run average cost, then $u = 1$ and $\beta = 0$, whereas α_1 and α_2 are equal to the cost shares of respectively the variable and the fixed inputs.

7.5. Specification of the general price equation

In Section 7.3 I have shown that the change in the output price of a monopolist is a function of the changes in the monopolist's marginal cost, his market shares relative to foreign suppliers of a similar good, and the market shares he and his foreign competitors together hold in total expenditure [see equations (7.23) and (7.25)]:

$$\tilde{p}_{di} = \tilde{\Delta}_i + \gamma_{Hi}\tilde{w}^i_{Hd} + \gamma_{Fi}\tilde{w}^i_{Fd} + \delta_{Hi}\tilde{w}_{Hi} + \delta_{Fi}\tilde{w}_{Fi}, \;\; i = 1, 2, \ldots, N, \tag{7.28}$$

where p_{di} is output price, Δ_i is marginal cost, w^i_{Hd} is the market share of the monopolist on the consumer market for the good, w_{Hi} is the share of the good in total expenditure by consumers, w^i_{Fd} is the market share of the monopolist on the producer market for the good, and w_{Fi} is the share of the good in total cost of producers. The expected signs of the coefficients are

$$\gamma_{Hi} \geq 0 \text{ ?}, \;\; \gamma_{Fi} \geq 0 \text{ ?}, \;\; \delta_{Hi} \geq 0, \;\; \delta_{Fi} \geq 0. \tag{7.29}$$

In Section 7.4 I have shown how the difference between short-run marginal cost and average variable cost depends on capacity utilization and fixed cost [see equation (7.27)]:

$$\tilde{\Delta}_i = \alpha_{i0}\tilde{c}_i + \alpha_{i1}\tilde{f}_i + \beta_i\tilde{u}_i, \;\; i = 1, 2, \ldots, N, \tag{7.30}$$

where c_i is average variable cost, f_i is average fixed cost, and u_i is capacity utilization. The coefficients should obey the following restrictions:

$$\alpha_{i0} \geq 0, \;\; \alpha_{i1} \geq 0, \;\; \alpha_{i0} + \alpha_{i1} = 1, \;\; \beta_i \geq 0. \tag{7.31}$$

Substitution of (7.30) into (7.28) gives

$$\tilde{p}_{di} = \alpha_{i0}\tilde{c}_i + \alpha_{i1}\tilde{f}_i + \beta_i\tilde{u}_i + \gamma_{Hi}\tilde{w}^i_{Hd} + \gamma_{Fi}\tilde{w}^i_{Fd} + \delta_{Hi}\tilde{w}_{Hi} + \delta_{Fi}\tilde{w}_{Fi}. \tag{7.32}$$

This equation forms the basis of the empirical analysis in the next section. Some of the variables in (7.32) occur often in time-series analyses of price formation, other variables occur often in cross-section analyses. The first three variables, which represent cost and capacity utilization, are common in time-series analyses, although fixed cost is often omitted; see for example Coutts, Godley, and Nordhaus (1978), Driehuis, De Wolff, and Van Heeringen (1975), Eckstein and Fromm (1968), Eckstein and Wyss (1972), Gordon (1971, 1975), Neild (1963), Nordhaus and Godley (1972), Rushdy and Lund (1967), and Schultze and Tyron (1965); Nordhaus (1972) and Earl (1973, Chapters 1-4) give a survey. Many cross-section analyses[8] make the price-cost ratio a function of market-structure variables, the domestic market share, and a product-differentiation variable (often a dummy variable indicating whether a substantial part of output is sold to consumers). The market-structure variables will be treated in the next chapter. The

[8] See the references in Section 6.4.

analysis in Chapters 6 and 7 has given a foundation to the inclusion of the domestic market share, whereas the product-differentiation variable may be a proxy for the effect that separate inclusion of the shares for consumer and producer markets has.

Before we can proceed to estimation, some further assumptions and specifications have to be made. Firstly, I assume that the coefficients in (7.32) are constant, i.e. (7.32) is considered to be a first-order Taylor expansion. Thus the coefficients are equal to the average values in the sample period.

Secondly, I have integrated equation (7.32), so that a constant is added and the infinitesimal changes are replaced by logarithms. The alternative is to replace the infinitesimal changes by finite changes; then the equation must not include a constant term. The empirical differences between the two specifications are shown in Appendix 7.1.

Thirdly, some changes in the specification must be made because there exists a break in the time-series of the market, budget, and cost shares. This break in 1969 could only be overcome for the aggregate of consumer and producer products, but not for consumer and producer products separately. Therefore I have replaced the terms w^i_{Hd} and w^i_{Fd} by the value share of the domestic product in total expenditure on the good (i.e. by the weighted average of w^i_{Hd} and w^i_{Fd}) and w_{Hi} and w_{Fi} by the value share of the good in total supply in the domestic market (i.e. by the weighted average of w_{Hi} and w_{Fi}).

Fourthly, I have added a dummy variable to represent price controls that have been in force in 1969 and since 1973. Under these controls, the price change since the introduction of the controls may not be larger than the change of cost since the introduction. Only in Mining has the price change in the period since 1972 exceeded the cost change; this is caused by the link between the price of natural gas and the price of crude oil. For the other industries we cannot expect therefore that this dummy variable will have a significant coefficient; if it has, it must represent the influence of some left-out variables.

We have now arrived at the following specification:

$$\log p_{dit} = \text{constant} + \alpha_{i0} \log c_{it} + \alpha_{i1} \log f_{it} + \beta_i \log u_{it} + \gamma_i \log w^i_{dt}$$
$$+ \delta_i \log w_{dt} + \xi_i DP_t + \varepsilon_{t,} \qquad (7.33)$$

where t indicates the time-period, DP_t is the price-controls dummy (1 in years with price controls and 0 in other years), and ε_t is a disturbance representing left-out variables and the error that arises because the coefficients are assumed to be constant. I assume that ε_t is distributed with mean zero and constant variance[9] (see the next subsection for a discussion of this assumption). The coefficients should satisfy the following restrictions:

[9] To account for structural changes that may occur because the true coefficients are not constant (these changes are now included in the disturbance), the constant and the disturbance might have been jointly specified as a random walk [cf. Maddala (1977, pp. 396-9)].

$$0 \le \alpha_{i0} \le 1,\ \ 0 \le \alpha_{i1} \le 1,\ \ \alpha_{i0} + \alpha_{i1} = 1,$$

$$\beta_i \ge 0,\ \ \gamma_i \ge 0?,\ \ \delta_i \ge 0,\ \ \xi_i \le 0. \tag{7.34}$$

We can determine as follows whether marginal cost is proportional to average variable cost or to average cost: if $\alpha_0 = 1$, $\alpha_1 = 0$, and $\beta = 0$, then marginal cost is proportional to average variable cost; and if $\beta = 0$ and α_0 and α_1 are equal to the cost shares of the variable and fixed inputs respectively, then marginal cost is proportional to average cost.

For several industries one may question the plausibility of (7.33) as a description of price formation. For example, the prices of many agricultural and food products are fixed by the European Community; the price of natural gas, in the 1970's the most important product of Mining, is linked to the price of crude mineral oil, which is partly fixed by the oil-producing countries; and the prices of Electricity, gas, and water, Housing services, Other transport and communication services, and Health services are partly fixed by the government. Nevertheless, the price-fixing agents cannot for long disregard economic considerations. And at least estimation of (7.33) gives an indication whether prices in these industries have behaved in the way that my model describes.

Some econometric problems

There are two sources of simultaneity in the price equations (7.32) and (7.33). Firstly, the changes in the market, budget, and cost shares are functions of, amongst others, the left-hand variable [see equations (7.12), (7.13), (7.16), and (7.22)]. Secondly, average variable cost of an industry is a function of the output prices of the other industries which depend in turn on the price of that industry; this simultaneity works through the input-output relations (see Chapter 2).

Full-information-maximum-likelihood (FIML) estimation is not possible for three reasons. Firstly, as said above, there are no consistent time-series of market shares for consumer products and producer products and of separate budget and cost shares. Secondly, competing import price index numbers are not published at the level of aggregation used in this chapter. Thirdly, there are no input-output tables for the years 1961-1968 at a comparable level of aggregation, so that the dependence of variable cost on output prices cannot be modelled. The first problem can be overcome by using the average of the shares on producer and consumer markets and by aggregating equations (7.12) and (7.16) into an equation that explains the combined budget/cost share. The second problem can only be overcome by constructing unit-value index numbers from the External Trade Statistics, which appeared to be not practicable. The third problem may be approximately solved by using one input-output-matrix (for example that of 1969) for all years. However, the average-variable-cost series created with such a table appear to differ so much from the true series (described in Appendix C.3), that the estimates of the coefficients would change very much.

Therefore I have taken a different solution. The estimates to be presented below are computed by ordinary least squares; in Appendix 7.1 some instrumental-variables-estimates are presented for comparison. It appears that an estimate obtained by one technique lies always within the confidence interval of the corresponding estimate obtained by the other technique.

More important than the correlation between the error term and some of the explanatory variables appears to be autocorrelation of the error term. If this autocorrelation is taken into account, the estimates for some industries change appreciably; this is shown in Appendix 7.1.

The OLS-estimates are computed on the assumption that the error term is distributed with mean zero and a constant variance. In an analysis of price formation by industry it may be appropriate to assume that the errors of different industries are correlated. Since the number of industries (24) is larger than the number of observation periods (19), this alternative is not practical:[10] it would lead to a singular estimate of the covariance matrix.

7.6. Empirical analysis

I have estimated equation (7.33) by ordinary least squares for 24 industries, which cover the whole private sector in the Netherlands.

Data

The data and their sources are given in Appendix C.3. The price index numbers refer to domestic sales by domestic producers. Most price series have been taken from publications of the Netherlands Central Bureau of Statistics (CBS); some have been supplied by the Central Planning Bureau.

From the yearly input-output tables I have taken the data on the value of variable cost (intermediate consumption, indirect taxes less subsidies, and compensation of employees), fixed cost (capital consumption), domestic sales, and competing imports. The average-cost series have been constructed as the ratio of the value of cost and the quantity index of output (a Törnqvist index of the quantity index numbers of domestic sales and exports).

Data on capacity utilization in the years 1972-1979 have for most manufacturing industries been supplied by the CBS; for Primary metal products, a measure of physical capacity utilization has been taken from Eurostat (EC) publications; for the other industries and for the years 1961-1972 I have constructed a Wharton index [see Klein and Preston (1967)], which has been linked to the CBS data, where available.

Estimation results

Table 7.1 presents the OLS estimates of equation (7.33); the first two columns give the average value of the domestic market share w_d^i and the budget/cost share w_i. Average variable cost is clearly the most important determinant of output price: its coefficient is

[10] It may be made practical by setting some correlations a priori equal to zero, but I have not tried this.

Table 7.1 *Estimation results for the price equation (7.33)*

	Domestic market share	Budget/ cost share	Cost share of		Coefficient of							$\bar{R}^2$/ *DW*
			variable inputs	fixed inputs	con- stant	average variable cost	average fixed cost	capacity utili- zation × 100	price controls dummy	domestic market share	budget/ cost share	
	average 1961-1979, per mille											
1. Agriculture and fishing	791	73	929	71	0.640	1.014[a]	0.034	0.198	0.017	1.041	0.234	0.98
					(0.373)	(0.203)	(0.179)	(0.307)	(2.282)	(0.545)	(0.284)	1.66
2. Meat and dairy	859	35	986	14	0.411	1.031[a]	–0.107	0.050	–0.933	–0.382	0.034	0.99
					(0.399)	(0.109)	(0.059)	(0.207)	(1.397)	(0.359)	(0.098)	1.40
3. Other food	828	68	974	26	0.168	0.821[a]	–0.053	0.087	0.542	0.051	–0.342	0.99
					(0.460)	(0.115)	(0.104)	(0.215)	(1.302)	(0.463)	(0.200)	1.47
4. Drink and tobacco	881	18	953	47	1.869[a]	0.714[a]	0.326[a]	0.039	0.352	0.893[a]	0.478[a]	0.99
					(0.349)	(0.072)	(0.091)	(0.165)	(1.116)	(0.431)	(0.065)	2.32
5. Textiles	460	30	964	36	0.426	0.884[a]	0.120[a]	0.092	0.374	0.020	0.112	1.00
					(0.385)	(0.082)	(0.059)	(0.200)	(0.839)	(0.127)	(0.119)	1.56
6. Clothing and leather	555	19	974	26	1.182[a]	0.817[a]	0.067	0.078	–0.266	–0.081	0.164[a]	1.00
					(0.293)	(0.105)	(0.088)	(0.121)	(0.780)	(0.059)	(0.043)	2.33
7. Paper and printing	799	38	961	39	–0.254	0.943[a]	0.092	0.121	–0.013	0.531[a]	–0.074	1.00
					(0.374)	(0.066)	(0.063)	(0.072)	(0.634)	(0.149)	(0.126)	1.93
8. Timber and stone	637	33	949	51	1.554[a]	0.687[a]	0.203[a]	0.032	0.012	–0.032	0.317[a]	1.00
					(0.258)	(0.064)	(0.048)	(0.102)	(0.526)	(0.097)	(0.082)	1.39
9. Chemical products	483	50	932	68	2.731[a]	0.364[a]	0.364[a]	–0.021	0.059	0.142	0.448[a]	0.99
					(0.593)	(0.148)	(0.148)	(0.094)	(1.609)	(0.109)	(0.173)	1.82
10. Primary metal products	341	23	929	71	1.165[a]	0.844[a]	0.227	0.563[a]	0.622	0.471	0.251	0.95
					(0.518)	(0.148)	(0.146)	(0.220)	(3.510)	(0.264)	(0.151)	2.13
11. Metal products and machinery	519	71	970	30	–0.128	0.956[a]	0.010	0.208[a]	–0.135	–0.203	–0.074	1.00
					(0.202)	(0.072)	(0.063)	(0.093)	(0.819)	(0.161)	(0.095)	1.51
12. Electrical products	373	35	966	34	0.566	0.739[a]	–0.043	0.297	6.006[a]	–0.142	–0.208	0.92
					(0.735)	(0.246)	(0.212)	(0.164)	(2.343)	(0.196)	(0.248)	1.56

Table 7.1 *Estimation results for the price equation (7.33) (continued)*

	Domestic market share	Budget/ cost share	Cost share of variable inputs	Cost share of fixed inputs	Coefficient of con- stant	average variable cost	average fixed cost	capacity utili- zation × 100	price controls dummy	domestic market share	budget/ cost share	$\bar{R}^2$/ DW
	average 1961-1979, per mille											
13. Transport equipment	395	34	969	31	−0.006	0.711[a]	0.253[a]	0.253	0.659	−0.065	−0.053	0.99
					(0.556)	(0.118)	(0.089)	(0.166)	(1.910)	(0.093)	(0.120)	1.60
14. Mineral oil refining	732	25	966	34	2.905[a]	0.540[a]	0.345	0.042	0.348	0.301[a]	0.620[a]	0.99
					(1.034)	(0.076)	(0.264)	(0.250)	(2.343)	(0.141)	(0.063)	2.12
15. Mining	289	39	813	187	5.959[a]	−0.053	0.793[a]	−0.954[a]	3.172	0.702[a]	1.198[a]	0.98
					(0.523)	(0.085)	(0.088)	(0.287)	(5.001)	(0.176)	(0.112)	1.80
16. Electricity, gas	1000	24	779	221	1.744[a]	0.521[a]	0.342[a]	−0.062	−0.892		0.296[a]	1.00
and water					(0.406)	(0.102)	(0.120)	(0.063)	(0.910)		(0.106)	1.12
17. Construction	1000	94	981	19	0.624[a]	0.721[a]	0.181[a]	0.216	−0.264		0.056	1.00
					(0.208)	(0.123)	(0.092)	(0.144)	(1.223)		(0.062)	0.91
18. Housing services	1000	25	381	619	1.053	0.134	0.879[a]	−0.937	−0.077		0.313	1.00
					(1.685)	(0.090)	(0.096)	(1.342)	(2.526)		(0.327)	0.71
19. Distribution	1000	99	937	63	0.589[a]	0.647[a]	0.170[a]	0.377[a]	−1.014		−0.111	1.00
					(0.260)	(0.066)	(0.059)	(0.118)	(0.737)		(0.106)	2.01
20. Sea and air	1000	2	857	143	0.285	1.103[a]	−0.194	0.085	−2.783		−0.020	0.96
transport services					(0.912)	(0.223)	(0.173)	(0.239)	(2.568)		(0.063)	1.47
21. Other transport and	1000	38	854	146	1.662[a]	0.512[a]	0.497[a]	0.268	−1.472		0.536[a]	0.99
communication services					(0.724)	(0.207)	(0.157)	(0.337)	(1.717)		(0.194)	1.04
22. Banking and insurance	1000	32	988	12	−0.293	1.004[a]	0.012	0.538[a]	0.339		−0.094	0.99
services					(1.311)	(0.264)	(0.184)	(0.231)	(2.148)		(0.235)	0.44
23. Health services	1000	29	918	82	−0.108	0.791[a]	0.178[a]	−0.038	0.349		−0.073	1.00
					(0.401)	(0.080)	(0.062)	(0.093)	(0.598)		(0.071)	1.73
24. Other services	1000	63	969	31	0.963[a]	0.854[a]	0.052	0.275[a]	0.036		0.188[a]	1.00
					(0.298)	(0.042)	(0.034)	(0.125)	(0.425)		(0.076)	2.26

Standard errors are in parentheses.

[a] Significantly different from 0 at 5% level.

significantly different from zero in all industries except Mining and Housing services. The coefficient of average fixed cost is significantly different from zero in twelve industries; most of these industries are rather capital intensive. The restriction that the sum of the coefficients of average variable cost and average fixed cost is one [see (7.34)] is rejected in eight industries (see Table 7.2); these are also industries in which the coefficient of average variable cost or that of average fixed cost is significantly different from the cost share of respectively the variable and fixed inputs. It is possible that the restriction $\alpha_{i0} + \alpha_{i1} = 1$ is rejected because in these industries equation (7.27) is not a good approximation of marginal cost.

As said in Section 7.5 there are two interesting hypotheses on the coefficients of average variable cost, average fixed cost, and capacity utilization (respectively α_{i0}, α_{i1}, and β_i):

— $\alpha_{i0} = 1$, $\alpha_{i1} = 0$, and $\beta_i = 0$: marginal cost is proportional to average variable cost;
— $\beta_i = 0$ and α_{i0} and α_{i1} are equal to the cost shares of respectively the variable and the fixed inputs: marginal cost is proportional to average cost.

The first hypothesis is rejected in eleven industries: five manufacturing industries (Other food, Drink and tobacco, Timber and Stone, Chemical products, and Mineral oil refining) and six non-manufacturing industries (Mining, Electricity, gas, and water, Housing services, Distribution, Other transport and communication services, and Other services). The second hypothesis is rejected in twelve industries; except Construction these are also industries for which the first hypothesis is rejected. In the twelve remaining industries neither the first nor the second hypothesis can be rejected; apparently marginal cost, variable cost, and average cost are proportional in these industries.

Capacity utilization has a significant coefficient in six industries; one of these is negative, which contradicts the sign requirement (7.31). Curious are the significant coefficients in three services industries (Distribution, Banking and insurance, and Other services); for in many services industries capacity is a rather vague concept. The two manufacturing industries with significant coefficients of capacity utilization are Primary metal products and Metal products and machinery, the first of which is known for its very low rate of capacity utilization in the second half of the 1970's. Note that Mineral oil refining, an industry with large variations in capacity utilization, does not have a significant coefficient.

As has been expected, the price-controls dummy has an insignificant coefficient in almost all industries; the only exception is Electrical products, where the significance may be due to neglect of autocorrelation (see Appendix 7.1).

The competition variables, the domestic market share and the budget/cost share, have a significant coefficient in ten industries. The domestic market share has a significant coefficient in four industries: Drink and tobacco, Paper and printing, Mineral oil refining, and Mining. Remarkable is that in Textiles and Clothing and leather, where international competition is fierce, the domestic market share has an insignificant coefficient. Apparently these industries have been unable to follow their foreign competitors, because their cost levels were much higher than those of foreign producers; this has manifested itself in the disappearance of a very large part of

Table 7.2 *Tests on the coefficients of the price equation*

	Sum of the cost coefficients ($\alpha_0 + \alpha_1$)		Value of F-statistic for test that coefficient of variable cost = / fixed cost = / capacity utilization =	1 / 0 / 0	cost share / cost share / 0
1. Agriculture	1.048	(0.127)		0.22	0.17
2. Meat and dairy	0.925	(0.092)		1.38	1.74
3. Other food	0.769[a]	(0.076)		5.92[b]	5.42[b]
4. Drink and tobacco	1.040	(0.067)		6.06[b]	4.31[b]
5. Textiles	1.004	(0.056)		1.41	0.70
6. Clothing, leather	0.884	(0.087)		1.33	1.20
7. Paper and printing	1.035	(0.022)		1.53	1.28
8. Timber and stone	0.889[a]	(0.031)		10.76[b]	6.55[b]
9. Chemical products	0.726[a]	(0.030)		36.19[b]	35.08[b]
10. Primary metal products	1.072	(0.102)		2.69	2.36
11. Metal products and machinery	0.966	(0.040)		2.39	2.01
12. Electrical products	0.697	(0.172)		1.56	1.53
13. Transport equipment	0.964	(0.086)		2.86	2.22
14. Mineral oil refining	0.885	(0.201)		41.72[b]	35.75[b]
15. Mining	0.740[a]	(0.079)		82.58[b]	60.47[b]
16. Electricity, gas and water	0.862[a]	(0.035)		25.60[b]	12.46[b]
17. Construction	0.902[a]	(0.034)		3.33	3.88[b]
18. Housing services	1.013	(0.110)		60.81[b]	4.17[b]
19. Distribution	0.817[a]	(0.013)		79.40[b]	81.14[b]
20. Sea and air transport services	0.909	(0.120)		0.76	1.56
21. Other transport and communication	1.009	(0.057)		10.60[b]	5.63[b]
22. Banking and insurance	1.016	(0.133)		3.09	3.21
23. Health services	0.969	(0.033)		2.54	0.80
24. Other services	0.905[a]	(0.019)		7.92[b]	7.73[b]

Standard errors are in parentheses.
[a] Significantly different from 1 at 5% level.
[b] Hypothesis is rejected at 5% level (here the F-statistic is distributed with (3, 12) degrees of freedom; the 95th percentile is 3.49).

domestic production out of the market (employment in Textiles and in Clothing and leather was in 1979 only a third of that in 1961).[11]

[11] There exists a contradiction with the empirical results in Chapter 6, where I have found a significant influence of the domestic market share on the mark-up of these two industries. This contradiction may disappear if a numeraire is chosen, or (which is equivalent) p_i, c_i and f_i are deflated by a general price index; this will tend to reduce the importance of the cost variables.

Table 7.3 *Parameter values implied by the estimates of the price equation*

	Income elasticity[c]	Elasticity of sub-stitution	Price elasticity of demand	Mark-up
1. Agriculture	0.42	7.7 (9.3)	−2.7 (10.6)	0.58 (9.64)
2. Meat and dairy	0.66	−716.1 (11931.7)	41.5 (10939.8)	−0.02 (251.15)
3. Other food	0.20	−1.3 (1.6)	1.5 (3.3)	−0.40 (0.78)
4. Drink and tobacco	0.43	5.9 (3.8)	−2.5 (4.9)	0.67 (5.48)
5. Textiles	3.39	5.0 (7.0)	−4.7 (9.7)	0.27 (3.35)
6. Clothing, leather	2.45	3.5[a] (1.4)	−5.3 (2.9)	0.23 (0.83)
7. Paper and printing	0.96	357.9 (1965.2)	−25.5 (1710.0)	0.04 (72.58)
8. Timber and stone	2.61	2.8[a] (0.8)	−3.0[a] (1.4)	0.49 (1.06)
9. Chemical products	1.79	2.1[a] (0.6)	−1.9[a] (0.8)	1.13 (1.88)
10. Primary metal products	3.87	2.0[a] (0.6)	−1.6[a] (0.6)	1.75 (3.00)
11. Metal products and machinery	2.86	−3.8 (2.5)	2.3 (2.8)	−0.30 (0.59)
12. Electrical products	2.33	−0.6 (0.5)	0.5[b] (0.6)	−0.68[a] (0.14)
13. Transport equipment	1.97	−4.3 (6.5)	3.4 (7.6)	−0.23 (1.35)
14. Mineral oil	0.20	2.7[a] (0.5)	−2.0[a] (0.7)	0.96 (1.29)
15. Mining	1.58	1.3[a] (0.1)	−1.2[a] (0.1)	6.20 (4.23)

	Income elasticity[c]	Elasticity of substitution	Price elasticity of demand	Mark-up
16. Electricity, gas and water	0.45		−4.4[a]	0.30
			(0.6)	(0.23)
17. Construction	1.98		−18.7	0.06
			(9.9)	(0.59)
18. Housing services	0.08		−4.2[a]	0.31
			(1.7)	(0.69)
19. Distribution	1.17		8.2[b]	−0.11
			(4.3)	(0.42)
20. Sea and air transport services	−0.14		50.2	−0.02
			(83.1)	(1.59)
21. Other transport and communication	−0.14		−2.9[a]	0.53
			(0.3)	(0.28)
22. Banking and insurance	0.38		9.7	−0.09
			(13.4)	(1.14)
23. Health services	0.77		12.7[b]	−0.07
			(6.7)	(0.45)
24. Other services	0.53		−6.3[a]	0.19
			(1.1)	(0.24)

[a] Significantly different from 0 at 5% level.
[b] Significantly larger than −1 at 5% level.
[c] Computed from Table 4 in Keller and Van Driel (1982). The income elasticities have been normalized such that the sum of the marginal budget shares is equal to 1.

The budget/cost share has a significant coefficient in nine industries: Drink and tobacco, Clothing and leather, Timber and stone, Chemical products, Mineral oil refining, Mining, Electricity, gas, and water, Other transport and communication services, and Other services. In all these industries the sign is positive, as it should be [see (7.34)].

Some more information about the role of the two competition variables is given in Table 7.3, where the implied values of the elasticity of substitution between the domestic and foreign product, the price elasticity of demand, and the mark-up are given. I have computed them from the definitions of the coefficients of the two competition variables for the case of consumer goods [see (7.11)], using an extraneous estimate of the income elasticity (see the first column of Table 7.3); the results for producer goods are very similar to the results in Table 7.3.

The elasticity of substitution has in most industries a plausible[12] value; when it is negative, its standard error is so large that plausible values are included in the confidence interval. The price elasticity of demand is significantly larger than -1 in Electrical products, Distribution, and Health services; thus for these three industries the model of monopolistic price formation must be rejected.

The mark-up is only in Electrical products significantly different from zero; thus for the other 23 industries we cannot reject the hypothesis that the mark-up is zero.

7.7. Summary

For both consumer goods and producer goods, an equation has been derived that relates the output price of a monopolist to his marginal cost, his market share, and the share that he and his foreign competitors have in the total budget of the representative consumer, respectively in total cost of the representative producer. For a monopolist who produces both consumer and producer goods a mixture of these two equations holds: his output price is related to his marginal cost, his two market shares, the budget share, and the cost share (the last two shares refer to the combined sales of domestic and foreign producers).

I assume that in the long run marginal cost and average cost are equal; in the short run they may differ because of fixed capital. For a specific cost function I have shown that marginal cost is equal to average variable cost plus the product of average fixed (capital) cost and a term in capacity utilization.

From the two relations mentioned at the end of the two previous paragraphs I have derived a price equation that relates the change in output price to the changes in average variable cost, average fixed cost, capacity utilization, the shares of the domestic producer in total sales on respectively the consumer and the producer market for his product, the budget share of the consumer good, and the cost share of the producer good.

[12] I think that a value larger than one is a plausible value; then an increase in the ratio of foreign price to domestic price leads to an increase in the domestic market share.

This equation contains both variables that are common in time-series studies (the cost and capacity utilization variables) and variables that are common in cross-section studies (the four shares). According to the theory the coefficients should satisfy several restrictions: all coefficients must be positive, and the sum of the coefficients of the two cost variables must be one.

Because of data problems, the separate shares for consumer and producer goods have been aggregated, so that a domestic market share of the domestic producer and a combined budget/cost share remain. The resulting equation has been estimated for 24 industries in the Netherlands over the years 1961-1979. Average variable cost appeared to be the most important determinant of domestic prices; average fixed cost, capacity utilization, the domestic market share, and the budget/cost share were less important.

Appendix 7.1. Some alternative estimates

This appendix gives estimates of equation (7.33) with autoregressive errors, instrumental variable estimates (with autoregressive errors), and estimates of equation (7.33) in first differences.

The estimate of the autocorrelation coefficient is in most manufacturing industries not significantly different from zero, but in most non-manufacturing industries it is significantly different from zero. The OLS estimates lie in almost all industries within the confidence intervals of the autoregressive estimates.

The use of instrumental variables[13] does not cause an appreciable change in the coefficient estimates: the OLS estimates lie within the confidence intervals of the instrumental-variable estimates. This similarity is probably caused by the trending character of the time series. Estimation in first differences, too, does not cause significant changes in the estimates of the coefficients.

[13] The following instruments have been used: a constant term, average labour cost, average capital cost, capacity utilization, the price-controls dummy, the aggregate wage rate, and the aggregate import price index.

Table 7.4 *Estimation results with AR(1) errors*

	con-stant	average variable cost	average fixed cost	capacity utili-zation	price controls dummy × 100	domestic market share	budget/ cost share	$\hat{\rho}^b$
1.	0.790[a]	0.923[a]	0.107	0.214	0.212	1.143[a]	0.252	0.246
	(0.392)	(0.207)	(0.189)	(0.297)	(1.895)	(0.540)	(0.293)	(0.277)
2.	0.432	0.996[a]	–0.086	–0.040	–1.359	–0.414	0.023	0.327
	(0.409)	(0.114)	(0.073)	(0.220)	(1.134)	(0.360)	(0.092)	(0.319)
3.	0.451	0.803[a]	0.017	0.240	–0.083	0.087	–0.155	0.566[a]
	(0.424)	(0.104)	(0.088)	(0.175)	(0.905)	(0.451)	(0.203)	(0.233)
4.	1.926[a]	0.684[a]	0.378[a]	0.119	–0.432	1.049[a]	0.509[a]	–0.343
	(0.271)	(0.061)	(0.084)	(0.175)	(1.248)	(0.384)	(0.053)	(0.260)
5.	0.502	0.873[a]	0.130[a]	0.081	0.343	–0.001	0.137	0.226
	(0.362)	(0.079)	(0.060)	(0.201)	(0.772)	(0.124)	(0.115)	(0.284)
6.	1.191[a]	0.813[a]	0.053	0.003	–1.451	–0.100[a]	0.149[a]	–0.693[a]
	(0.202)	(0.074)	(0.068)	(0.104)	(0.834)	(0.042)	(0.026)	(0.203)
7.	–0.268	0.946[a]	0.090	0.118	–0.007	0.536[a]	–0.078	–0.032
	(0.374)	(0.066)	(0.063)	(0.071)	(0.649)	(0.146)	(0.126)	(0.290)
8.	1.582[a]	0.702[a]	0.196[a]	0.032	0.240	0.004	0.333[a]	0.387
	(0.262)	(0.065)	(0.047)	(0.111)	(0.397)	(0.093)	(0.085)	(0.263)
9.	2.726[a]	0.363[a]	0.363[a]	–0.018	0.035	0.142	0.446[a]	0.555
	(0.588)	(0.146)	(0.147)	(0.095)	(1.548)	(0.109)	(0.172)	(0.287)
10.	1.177[a]	0.823[a]	0.265	0.665[a]	1.470	0.616[a]	0.230	–0.210
	(0.494)	(0.144)	(0.144)	(0.211)	(3.986)	(0.266)	(0.141)	(0.274)
11.	–0.156	0.950[a]	0.010	0.226[a]	–0.190	–0.201	–0.098	0.218
	(0.208)	(0.073)	(0.065)	(0.093)	(0.715)	(0.168)	(0.092)	(0.304)
12.	1.602[a]	0.394[a]	0.217[a]	0.411[a]	1.379	0.082	–0.075	0.966[a]
	(0.524)	(0.112)	(0.108)	(0.106)	(0.968)	(0.107)	(0.099)	(0.045)
13.	0.155	0.746[a]	0.210[a]	0.178	0.576	–0.071	–0.011	0.265
	(0.506)	(0.113)	(0.093)	(0.152)	(1.625)	(0.084)	(0.107)	(0.267)
14.	2.837[a]	0.514[a]	0.404	0.112	0.695	0.336[a]	0.640[a]	–0.213
	(0.999)	(0.073)	(0.257)	(0.241)	(2.606)	(0.138)	(0.061)	(0.274)
15.	6.008[a]	–0.058	0.787[a]	–0.928[a]	2.878	0.703[a]	1.196[a]	0.063
	(0.542)	(0.088)	(0.090)	(0.295)	(4.802)	(0.176)	(0.117)	(0.299)

	con-stant	average variable cost	average fixed cost	capacity utili-zation	price controls dummy × 100	domestic market share	budget/ cost share	$\hat{\rho}^b$
16.	1.524[a]	0.597[a]	0.242[a]	−0.001	−0.177		0.208[a]	0.598[a]
	(0.363)	(0.071)	(0.098)	(0.059)	(0.010)		(0.073)	(0.204)
17.	0.825[a]	0.780[a]	0.138[a]	0.172	−0.092		0.171[a]	0.773[a]
	(0.214)	(0.079)	(0.060)	(0.115)	(0.588)		(0.076)	(0.156)
18.	0.959	0.024	0.936[a]	−0.337	−1.062		0.226	0.857[a]
	(0.888)	(0.073)	(0.080)	(1.087)	(1.003)		(0.171)	(0.112)
19.	−0.134	0.772[a]	0.060	0.409[a]	−3.000[a]		−0.399[a]	−0.748[a]
	(0.253)	(0.054)	(0.048)	(0.079)	(0.929)		(0.099)	(0.178)
20.	0.675	0.951	−0.080	0.164	−3.136		0.014	0.426
	(1.001)	(0.203)	(0.174)	(0.225)	(0.019)		(0.070)	(0.253)
21.	1.494[a]	0.687[a]	0.356[a]	0.581[a]	−0.845		0.524[a]	0.623[a]
	(0.646)	(0.177)	(0.139)	(0.276)	(0.982)		(0.200)	(0.208)
22.	1.028	0.812[a]	0.074	0.506[a]	0.077		0.112	0.836[a]
	(0.819)	(0.135)	(0.082)	(0.174)	(0.754)		(0.139)	(0.123)
23.	0.020	0.782[a]	0.176[a]	−0.060	0.466		−0.052	0.172
	(0.387)	(0.075)	(0.060)	(0.095)	(0.529)		(0.068)	(0.279)
24.	0.955[a]	0.865[a]	0.040	0.312[a]	0.256		0.185[a]	−0.280
	(0.301)	(0.040)	(0.030)	(0.112)	(0.503)		(0.077)	(0.264)

[a] Significantly different from 0 at 5% level.

[b] $\hat{\rho}$: estimated autocorrelation coefficient.

Table 7.5 *Instrumental-variable-estimation results with AR(1) errors*

	con-stant	average variable cost	average fixed cost	capacity utili-zation	price controls dummy × 100	domestic market share	budget/ cost share	$\hat{\rho}^b$
1.	0.266	1.171[a]	–0.162	0.435	0.035	1.517[a]	–0.028	0.132
	(0.459)	(0.254)	(0.222)	(0.365)	(0.023)	(0.685)	(0.393)	(0.280)
2.	0.544	0.966[a]	–0.091	–0.044	–1.400	–0.545	0.014	0.359
	(0.432)	(0.119)	(0.076)	(0.224)	(1.121)	(0.381)	(0.095)	(0.323)
3.	0.131	0.862[a]	–0.047	0.250	0.139	0.138	–0.285	0.412
	(0.471)	(0.116)	(0.097)	(0.193)	(1.002)	(0.477)	(0.223)	(0.269)
4.	1.395[a]	0.857[a]	0.233	0.066	0.962	0.846	0.420[a]	0.18
	(0.670)	(0.103)	(0.174)	(0.264)	(1.290)	(0.994)	(0.085)	(0.274)
5.	0.724	0.834[a]	0.135[a]	0.011	0.542	–0.053	0.170	0.276
	(0.421)	(0.091)	(0.063)	(0.228)	(0.808)	(0.143)	(0.132)	(0.284)
6.	1.248[a]	0.830[a]	0.026	–0.020	–1.315	–0.117[a]	0.155[a]	–0.683[a]
	(0.223)	(0.077)	(0.073)	(0.109)	(0.861)	(0.047)	(0.027)	(0.206)
7.	–0.441	0.957[a]	0.079	0.113	0.085	0.582[a]	–0.133	–0.112
	(0.491)	(0.071)	(0.069)	(0.072)	(0.712)	(0.150)	(0.167)	(0.287)
8.	1.506[a]	0.740[a]	0.173[a]	0.047	0.266	0.029	0.328[a]	0.434
	(0.385)	(0.094)	(0.063)	(0.143)	(0.392)	(0.120)	(0.108)	(0.257)
9.	2.742[a]	0.373	0.356	–0.017	–0.034	0.141	0.455	0.048
	(0.832)	(0.201)	(0.203)	(0.097)	(1.566)	(0.146)	(0.246)	(0.286)
10.	0.742	0.950[a]	0.093	0.544[a]	0.309	0.292	0.155	–0.006
	(0.593)	(0.173)	(0.173)	(0.231)	(3.672)	(0.299)	(0.169)	(0.279)
11.	–0.164	0.951[a]	–0.002	0.229[a]	–0.260	–2.257	–0.106	0.212
	(0.230)	(0.103)	(0.077)	(0.102)	(0.743)	(0.201)	(0.147)	(0.303)
12.	1.630[a]	0.402[a]	0.207	0.403[a]	1.408	0.073	–0.065	0.969[a]
	(0.764)	(0.136)	(0.111)	(0.116)	(1.012)	(0.148)	(0.120)	(0.042)
13.	–0.157	0.835[a]	0.188	0.183	1.011	0.006	–0.031	0.257
	(0.628)	(0.152)	(0.107)	(0.187)	(0.174)	(0.109)	(0.147)	(0.267)
14.	3.368[a]	0.671[a]	0.083	–0.209	–1.415	0.387[a]	0.576[a]	0.187
	(1.300)	(0.116)	(0.352)	(0.333)	(2.581)	(0.195)	(0.075)	(0.283)
15.	6.029[a]	–0.049	0.784[a]	–0.951[a]	3.008	0.714[a]	1.207[a]	0.052
	(0.546)	(0.088)	(0.090)	(0.302)	(4.841)	(0.190)	(0.117)	(0.300)

	con-stant	average variable cost	average fixed cost	capacity utili-zation	price controls dummy × 100	domestic market share	budget/ cost share	$\hat{\rho}^b$
16.	1.299[a]	0.605[a]	0.254[a]	0.017	–0.199		0.173[a]	0.595[a]
	(0.390)	(0.072)	(0.100)	(0.061)	(0.622)		(0.077)	(0.202)
17.	0.793[a]	0.759[a]	0.153[a]	0.203	–0.077		0.146	0.728[a]
	(0.217)	(0.083)	(0.062)	(0.119)	(0.061)		(0.079)	(0.171)
18.	0.938	0.120	0.870[a]	–0.033	–1.122		0.250	0.791[a]
	(1.067)	(0.102)	(0.105)	(1.182)	(1.113)		(2.209)	(0.147)
19.	–0.297	0.807[a]	0.029	0.438[a]	–3.404[a]		–0.460[a]	–0.797[a]
	(0.274)	(0.059)	(0.052)	(0.081)	(0.963)		(0.107)	(0.158)
20.	1.807	0.837[a]	–0.086	0.121	–3.451		0.107	0.548[a]
	(1.569)	(0.227)	(0.194)	(0.251)	(1.883)		(0.114)	(0.226)
21.	1.227	0.774[a]	0.289	0.622[a]	–0.914		0.470[a]	0.629[a]
	(0.729)	(0.188)	(0.148)	(0.287)	(0.997)		(0.226)	(0.204)
22.	0.526	0.867[a]	0.070	0.529[a]	0.129		0.034	0.826[a]
	(0.894)	(0.141)	(0.085)	(0.179)	(0.771)		(0.151)	(0.127)
23.	–0.269	0.791[a]	0.192[a]	–0.003	0.352		–0.100	0.011
	(0.425)	(0.083)	(0.064)	(0.097)	(0.602)		(0.751)	(0.274)
24.	1.032[a]	0.859[a]	0.041	0.329[a]	0.302		0.204[a]	–0.280
	(0.405)	(0.050)	(0.032)	(0.118)	(0.536)		(0.103)	(0.263)

[a] Significantly different from 0 at 5% level.

[b] $\hat{\rho}$: estimated autocorrelation coefficient.

Table 7.6 *Results of OLS estimation in first differences*

	average variable	average fixed	capacity utili-zation	price controls dummy × 100	domestic market share	budget/ cost share	*DW*
1.	0.568[a]	0.345	0.244	0.283	0.917	0.526	
	(0.210)	(0.219)	(0.296)	(1.332)	(0.527)	(0.325)	1.72
2.	0.747[a]	0.044	–0.148	–1.412	–0.592	0.072	
	(0.143)	(0.100)	(0.236)	(0.815)	(0.338)	(0.077)	1.16
3.	0.784[a]	0.032	0.270	–0.371	0.210	–0.008	
	(0.099)	(0.082)	(0.167)	(0.763)	(0.423)	(0.191)	1.41
4.	0.798[a]	0.231[a]	0.097	1.003	0.992	0.320[a]	
	(0.113)	(0.111)	(0.180)	(0.963)	(0.574)	(0.112)	2.33
5.	0.845[a]	0.111	0.053	0.278	–0.056	0.161	
	(0.075)	(0.070)	(0.204)	(0.681)	(0.123)	(0.113)	1.70
6.	0.866[a]	0.080	0.108	–0.104	–0.026	0.207[a]	
	(0.148)	(0.103)	(0.122)	(0.741)	(0.075)	(0.098)	2.24
7.	0.876[a]	0.118[a]	0.241[a]	–0.150	0.433[a]	–0.06	
	(0.060)	(0.057)	(0.090)	(0.389)	(0.197)	(0.132)	1.69
8.	0.717[a]	0.185[a]	0.029	0.332	0.092	0.377[a]	
	(0.059)	(0.047)	(0.113)	(0.313)	(0.093)	(0.088)	1.32
9.	0.365[a]	0.240	0.032	–0.173	0.257	0.281	
	(0.124)	(0.138)	(0.128)	(1.048)	(0.144)	(0.161)	2.28
10.	0.633	0.120	0.091	–0.676	0.225	0.487[a]	
	(0.200)	(0.275)	(0.277)	(0.241)	(0.241)	(0.213)	2.03
11.	0.929[a]	–0.005	0.272[a]	–0.487	–0.156	–0.145	
	(0.082)	(0.073)	(0.106)	(0.547)	(0.165)	(0.087)	1.59
12.	0.383[a]	0.204[a]	0.394[a]	1.322	0.091	–0.079	
	(0.107)	(0.104)	(0.104)	(0.925)	(0.102)	(0.094)	1.69
13.	0.728[a]	0.111	–0.072	0.478	–0.064	0.007	
	(0.161)	(0.121)	(0.149)	(1.369)	(0.073)	(0.094)	1.73
14.	0.487[a]	0.123	–0.182	–1.102	–0.031	0.525[a]	
	(0.078)	(0.253)	(0.278)	(1.478)	(0.164)	(0.061)	2.06
15.	0.160	0.422[a]	–0.411	0.199	0.613[a]	1.276[a]	
	(0.172)	(0.135)	(0.314)	(2.670)	(0.158)	(0.203)	1.39

	average variable	average fixed	capacity utili-zation	price controls dummy × 100	domestic market share	budget/ cost share	*DW*
16.	0.618[a]	0.191	0.009	0.064		0.206[a]	
	(0.072)	(0.106)	(0.069)	(0.605)		(0.067)	1.32
17.	0.802[a]	0.131[a]	0.124	−0.020		0.224[a]	
	(0.077)	(0.055)	(0.113)	(0.534)		(0.079)	1.52
18.	0.013	0.903[a]	−0.073	−1.007		0.219	
	(0.070)	(0.088)	(1.083)	(0.937)		(0.160)	1.01
19.	0.626[a]	0.155[a]	0.522[a]	−0.533		0.055	
	(0.074)	(0.072)	(0.132)	(0.480)		(0.079)	1.74
20.	0.794[a]	0.050	0.302	−3.117[a]		0.029	
	(0.246)	(0.170)	(0.213)	(1.529)		(0.712)	2.21
21.	0.743[a]	0.257	0.599[a]	−0.645		0.581[a]	
	(0.187)	(0.151)	(0.281)	(0.855)		(0.225)	1.50
22.	0.800[a]	0.073	0.472[a]	0.090		0.120	
	(0.131)	(0.078)	(0.179)	(0.711)		(0.133)	0.98
23.	0.772[a]	0.135[a]	−0.102	0.588		0.043	
	(0.060)	(0.052)	(0.112)	(0.375)		(0.062)	2.61
24.	0.820[a]	0.089	0.185	−0.093		0.183[a]	
	(0.065)	(0.063)	(0.174)	(0.352)		(0.085)	2.93

[a] Significantly different from 0 at 5% level.

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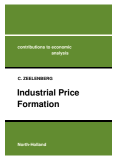

CHAPTER 8

Market structure and price formation

In Chapters 4 and 5 I have assumed that each industry is characterized by pure competition, and in Chapters 6 and 7 that each industry is characterized by monopoly. Since most industries have a structure between these extremes, I shall study in this chapter the relation between market structure and price formation; except in the last subsection of Section 8.4, I retain, however, the assumption that an industry produces only one good. The purpose of this chapter is to provide a link between the analysis of the price elasticity of demand in Chapters 6 and 7 and some existing models of the relationship between industry structure and price formation.

In Section 8.1 some well-known measures of concentration are briefly discussed. Sections 8.2-8.4 consider three models of price formation with several producers; it will appear that the ratio of price to marginal cost is related to the price elasticity of demand and to market-structure variables. The first model is Saving's (1970) model of price leadership, where the ratio of price to marginal cost depends among others on the market share of the leading firms. In the second model a single monopolist is threatened by entry of a potential producer [Bain (1951), Sylos-Labini (1957), and Modigliani (1958)]; the ratio of price to marginal cost now depends on the minimum scale at which production must take place. The third model is Cowling and Waterson's (1976) model, where the ratio of price to marginal cost depends on the Herfindahl index of concentration. In Section 8.5 the models are combined with the model for the price elasticity of demand that has been developed in Chapters 6 and 7; the resulting model is tested on cross-section data for 1963 and 1971. In Section 8.6 I show how a relationship between price, demand, and concentration can be derived from the models of Sections 8.2-8.4; the hypothesis is tested on pooled cross-section and time-series data.

8.1. Measurement of concentration

Concentration measures

A large number of concentration measures have been proposed in the literature; see Marfels (1972) and Hause (1977) for surveys. The measures that have been used most often are:

— the k-firm concentration ratio (the joint market share of the k largest firms):

$$CR_k = \sum_{i=1}^{k} \frac{q_i}{q}\,, \tag{8.1}$$

— the Herfindahl index (the sum of the squares of the market shares of all firms):

$$H = \sum_{i=1}^{K} \left(\frac{q_i}{q} \right)^2 , \tag{8.2}$$

— the Theil coefficient (minus the entropy of the market shares):

$$E = - \sum_{i=1}^{K} \frac{q_i}{q} \log \frac{q_i}{q} , \tag{8.3}$$

where q_i is output of firm i, $q = \sum_{i=1}^{K} q_i$ is industry output, and K is the number of firms in the industy. The Theil coefficient is an inverse measure of concentration: the higher E is, the lower concentration is. Both the Herfindahl index and the Theil coefficient are special transformations of the following inverse measure of concentration [cf. Hannah and Kay (1976, pp. 55-7)]:

$$C = \frac{1}{1-\alpha} \left\{ \left[\sum_{i=1}^{K} \left(\frac{q_i}{q} \right)^{\alpha} \right] - 1 \right\}, \ \alpha > 0. \tag{8.4}$$

If $\alpha = 2$ then C equals $1 - H$, and if $\alpha \to 1$ then C tends to E. If $\alpha = 0$, then C equals $K - 1$; i.e. concentration is measured by the number of firms. If $\alpha \to \infty$, then C tends to 0; i.e. C is insensitive to changes in concentration.

The measures (8.1)-(8.4) can be transformed into the 'equivalent number of equal-sized firms', which is defined as the number of equal-sized firms that yields a value of the concentration measure equal to the actual value. Equivalent numbers allow an easy comparison between concentration measures. It is easily seen that the equivalent numbers are

$$K_{CR_k} = \frac{k}{CR_k} = \frac{q}{(\sum_{i=1}^{k} q_i)/k} ,$$

$$K_H = \frac{1}{H} = \frac{q^2}{\sum_{i=1}^{K} q_i^2} ,$$

$$K_E = e^E = \prod_{i=1}^{K} \left(\frac{q_i}{q} \right)^{-\frac{q_i}{q}} ,$$

$$K_C = [(1-\alpha)C + 1]^{\frac{1}{1-\alpha}} = \left[\sum_{i=1}^{K} \left(\frac{q_i}{q} \right)^{\alpha} \right]^{\frac{1}{1-\alpha}} .$$

If $\alpha = 2$, then $K_C = K_H$; if $\alpha \to 1$, then K_C tends to K_E; if $\alpha = 0$, then $K_C = K$; and if $\alpha \to \infty$, then K_C tends to the inverse of the market share of the largest firm.

In general there holds $K_{CR_k} < K_H < K_E$. This occurs because the Theil coefficient gives often a relatively larger weight to small firms than the Herfindahl index, and the concentration ratio gives small firms a weight of zero.

Concentration in the Netherlands

Janus (1972, 1975) has computed Theil coefficients for 1950, 1963, and 1971, and Phlips (1971, Statistical Appendix) has computed four-firm concentration ratios for 1963. Their computations are based on the distribution of employment over size classes. I have adjusted their industrial classification to mine. For the Theil coefficient this adjustment was made by means of the decomposition formula

$$-\sum_{g=1}^{G}\sum_{i=1}^{n_g} x_{\gamma_i}\log x_{\gamma_i} = -\sum_{g=1}^{G} x_g \log x_g + \sum_{g=1}^{G} x_g E_g,$$

where G is the number of groups, n_g is the number of firms in group g, $\sum_{g=1}^{G} n_g = K$, x_{γ_i} is the market share of firm i in group g, $\sum_{g=1}^{G}\sum_{i=1}^{n_g} x_{\gamma_i} = 1$, $x_g = \sum_{i=1}^{n_g} x_{\gamma_i}$, and $E_g = -\sum_{i=1}^{n_g} x_{\gamma_i}\log x_{\gamma_i}$. Thus the Theil coefficient for an aggregate of industry groups is the sum of the Theil coefficient between the groups and the weighted average of the Theil coefficients of the groups. I have computed the four-firm concentration ratio of an industry as the weighted average of the four-firm concentration ratios of the industry groups; as weights I have used gross output. Further details are given in Appendix C.3.

The various concentration measures are in general highly correlated; see Table 8.1 and Figures 8.1 and 8.2.

Table 8.1 *Correlation between concentration measures, 1963 (14 industries)*

	CR_4	E	CR_4 (est.)
CR_4 (firms)	1.00	–0.93	0.93
E (firms)	–0.93	1.00	–0.86
CR_4 (establishments)	0.93	–0.86	1.00

A high correlation between different concentration measures has also been found by Van Lommel, De Brabander, and Liebaers (1977) and Jacquemin and De Jong (1977, pp. 49-50). Because of the high correlation and the fact that the Theil coefficient is the only measure available for both 1963 and 1971, I have used the Theil coefficient in the empirical analysis of Sections 8.5 and 8.6.

An impression of the changes in concentration over time[1] can be obtained from Figures 8.3 and 8.4. From 1950 to 1963 concentration rose in 10 industries (Drink and tobacco, Textiles, Clothing and leather, Paper and printing, Timber and stone, Primary metal products, Metal products and machinery, Electricity, gas, and water,

[1] The number of industries for which concentration measures are available differs between the years.

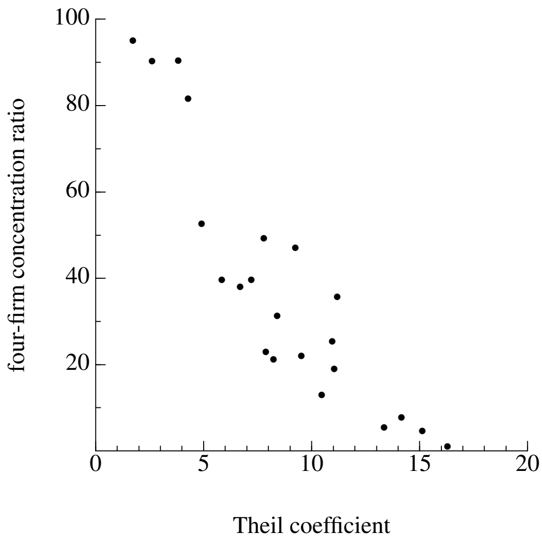

Figure 8.1 *Theil coefficient and four-firm concentration ratio, 1963 (24 industries)*

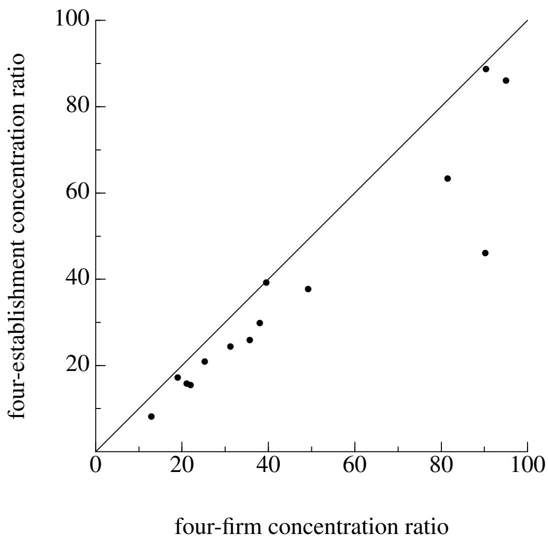

Figure 8.2 *Four-firm concentration ratio and four-establishment concentration ratio, 1963 (14 industries)*

Construction, and Distribution) and fell in 6 industries (Chemical products, Electrical products, Mineral oil refining, Mining, Sea and air transport services, and Other

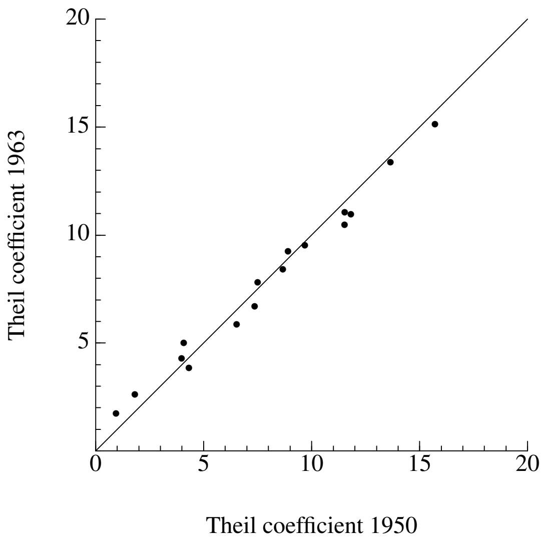

Figure 8.3 *Theil coefficient in 1950 and 1963 (16 industries)*

transport services). From 1963 to 1971 concentration rose in 10 industries (Meat and dairy products, Other food, Drink and tobacco, Textiles, Clothing and leather, Paper and printing, Timber and stone, Chemical products, Primary and fabricated metal products and machinery, and Electrical products) and fell in 2 industries (Mineral oil refining and Mining).

8.2. Price leadership

In this section I shall consider Saving's (1970) model of price leadership. In this model, the largest firms, acting in collusion, dominate the market and set the price, whereas the producers outside the cartel take the price as given.

Let the market supply function of the producers outside the cartel be given by $q_R(p)$ and the market demand function by $q(p)$, where p is the market price. The demand function for the cartel is then $q_D(p) = q(p) - q_R(p)$. Profit maximization by the cartel gives the first-order condition

$$p = \Delta_D \left(1 + \frac{1}{\varepsilon_D}\right)^{-1}, \tag{8.5}$$

where Δ_D is marginal cost of the cartel and $\varepsilon_D = \partial \log (q - q_R) \,/\, \partial \log p$ is the price elasticity of demand for the cartel. Now,

$$\varepsilon_D = \frac{q}{q_D} \frac{\partial B \log q}{\partial \log p} - \frac{q_R}{q_D} \frac{\partial \log q_R}{\partial \log p} = \frac{q}{q_D} \varepsilon - \frac{q_R}{q_D} \eta_R, \tag{8.6}$$

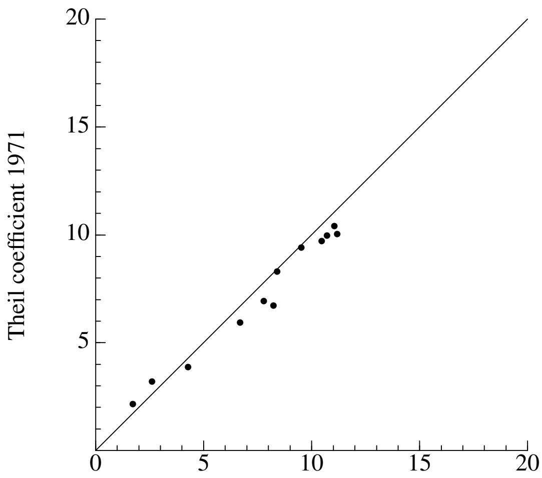

Figure 8.4 *Theil coefficient in 1963 and 1971 (12 industries)*

where ε is the price elasticity of market demand and η_R is the price elasticity of supply by the outside producers. By definition we have

$$\frac{q_D}{q} = C_k \tag{8.7}$$

and

$$\frac{q_R}{q_D} = \frac{1 - C_k}{C_k}, \tag{8.8}$$

where k is the number of cartel members, and C_k is the market share of the cartel (i.e. the k-firm concentration ratio). It follows then from (8.5)-(8.8) that

$$p = \Delta_D \left[1 + \left(\frac{1}{C_k}\, \varepsilon - \frac{1 - C_k}{C_k}\, \eta_R \right)^{-1} \right]^{-1}. \tag{8.9}$$

Thus, in a market where a cartel determines the price, the market price is a function of the cartel's marginal cost, its market share, and the elasticity of supply by the outside producers. Note that if the elasticity of supply by outsiders is infinite, then $p = \Delta_D$, i.e. price is equal to marginal cost of the cartel.

Totally differentiating (8.9) we obtain

$$\tilde{p} = \tilde{\Delta}_D + \frac{1}{\varepsilon_D(\varepsilon_D + 1)} \left(\frac{1}{C_k}\, \mathrm{d}\varepsilon - \frac{1 - C_k}{C_k}\, \mathrm{d}\eta_R + \frac{\eta_R - \varepsilon}{C_k^2}\, \mathrm{d}C_k \right), \tag{8.10}$$

where a tilde denotes a relative differential (for example $\tilde{p} = (\mathrm{d}p) \,/\, p]$. Note that the coefficient of the concentration ratio is positive if $\eta_R > 0$ and $\varepsilon < 0$; then an increase in concentration leads to a higher price. If the industry becomes more competitive by a rise in the price elasticity of supply by outsiders ($d\eta_R > 0$), then the market price will fall. The price elasticity of supply by outsiders can increase for example if entry occurs and the entrants try to capture a share of the market by price cutting.

8.3. Barriers to entry

The relation between barriers to entry and price formation has been investigated first by Bain (1951) and Sylos-Labini (1957). Their static models have been generalized by Modigliani (1958); dynamic extensions have been given by Gaskins (1971), Ireland (1972), and Kamien and Schwartz (1971, 1972). I shall follow here Modigliani's exposition, which deals with scale as a barrier to entry; other entry barriers are product differentiation[2] and excess capacity.[3]

It is assumed that there is one actual producer and one potential entrant. Entry must occur with an optimal plant size (or minimum efficient scale), which is defined as the lowest level of output at which long-run average cost is minimal. The actual producer is supposed to be large relative to the minimal efficient scale; moreover it is assumed that average cost is constant for output levels larger than the minimum efficient scale. The cost function, which holds for both the actual and the potential producer, is shown in Figure 8.5, where $\bar{q}$ is the minimum efficient scale. If the actual producer is a pure monopolist, he will charge the price p_{mon} where marginal cost MC and marginal revenue MR are equal. If entry is possible at an infinitesimal scale, then perfect competition rules and price is equal to long-run average cost c. If the actual producer wishes to prevent entry, he must charge a price such that if entry occurs the entrant would make a loss. Thus he must set his output at $q_l = q_c - \bar{q}$ and charge a price p_l; this price is called the *limit price*.

Alternatively, the actual producer can charge the monopoly price p_{mon} and have an excess capacity of $q_l - q_{mon}$ available, which he threatens to use if entry occurs. Which of the possibilities he will choose depends of course on the costs and profits under each scheme. Modigliani analyzes only the first scheme; he proceeds as follows: the price elasticity of demand at p_l is approximately equal to

$$\varepsilon \approx \frac{q_c - q_l}{q_l} \frac{p_l}{p_c - p_l} = \frac{\bar{q}}{q_l} \frac{p_l}{p_c - p_l} .$$

Solving for p_l we get

$$p_l = p_c \left(1 + \frac{s}{\varepsilon}\right)^{-1} = c \left(1 + \frac{s}{\varepsilon}\right)^{-1}, \tag{8.11}$$

where $s = \bar{q}/q_l$ is minimum efficient scale relative to actual output. Thus the ratio of

[2] See Bain (1951, Chapter 3).

[3] See Spence (1977) and Dixit (1980) for theoretical analyses and Esposito and Esposito (1974) for an empirical analysis.

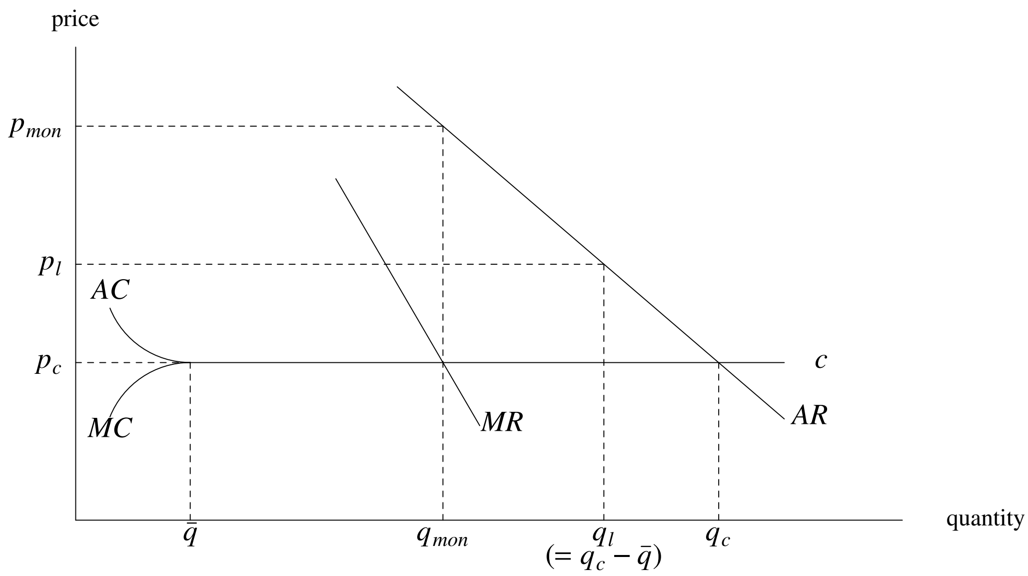

Figure 8.5 *Pricing under threat of entry*

the limit price to average cost is a function of the price elasticity of demand and minimum efficient scale relative to actual output. Totally differentiating (8.11) we obtain

$$\tilde{p}_l = \tilde{c} - \frac{1}{1 + \varepsilon/s}(\tilde{s} - \tilde{\varepsilon}). \tag{8.12}$$

Because $s < 1$ we have $(1 + \varepsilon/s) < 0$ if $\varepsilon < -1$. Therefore, if $\varepsilon < -1$, then an increase in minimum efficient scale relative to output leads to an increase in price.

8.4. Price formation under oligopoly

Consider an industry with K firms each of which maximizes its profits taking into account the reactions of its rivals. The first-order condition for a maximum of profits $pq_i - C_i(q_i)$ is

$$p\left(1 + \frac{q}{p}\frac{\partial p}{\partial q}\frac{q_i}{q}\frac{\partial q}{\partial q_i}\right) - \frac{\partial C_i}{\partial q_i} = 0, \quad i = 1, 2, \ldots, K, \tag{8.13}$$

where $q = \sum_{i=1}^{K} q_i$ is industry output. The term $\partial q/\partial q_i$ measures the expected change in industry output if the i-th firm changes its output. It is equal to

$$\frac{\partial q}{\partial q_i} = 1 + \sum_{j \neq i} \frac{\partial q_j}{\partial q_i} = 1 + \phi_i.$$

The terms $\partial q_j/\partial q_i$ are called the conjectural variations; they represent expected behaviour.

Equating expected and actual quantities, solving from the first-order condition (8.13) for q_i, and using the inverse demand function $p = f(\sum_{i=1}^{K} q_i)$, we can express the output of firm i as a function of the output of the other firms:

$$q_i = q_i^a(q_1, q_2, \ldots, q_{i-1}, q_{i+1}, \ldots, q_K), \quad i = 1, 2, \ldots, K. \tag{8.14}$$

The functions q_i^a are called the reaction functions; they represent actual behaviour of the firms if one of the other firms changes its output.

Cowling and Waterson (1976) proceeed now as follows. Multiply (8.13) by q_i/q and sum over i:

$$p\left(1 + \frac{1}{\varepsilon}\sum_{i=1}^{K}\frac{q_i^2}{q^2}\frac{\partial q}{\partial q_i}\right) - \sum_{i=1}^{K}\frac{q_i}{q}\frac{\partial C_i}{\partial q_i} = 0.$$

The term $\sum_{i=1}^{K}(q_i^2/q^2)(\partial q/\partial q_i)$ can be written as

$$\sum_{i=1}^{K}\frac{q_i^2}{q^2}\frac{\partial q}{\partial q_i} = \sum_{i=1}^{K}\frac{q_i^2}{q^2}(1 + \sum_{j\neq i}\frac{\partial q_j}{\partial q_i}) = \left(\sum_{i=1}^{K}\frac{q_i^2}{q^2}\right)\left(1 + \sum_{i=1}^{K}\frac{q_i^2}{\sum q_j^2}\sum_{j\neq i}\frac{\partial q_j}{\partial q_i}\right) = H(1 + \phi),$$

where $H = \sum_{i=1}^{K}(q_i/q)^2$ is the Herfindahl index and $\phi = (\sum_{i=1}^{K} q_i^2\phi_i)\ /\ (\sum_{i=1}^{K} q_i^2)$ is a weighted average of the conjectural variations; ϕ is called the degree of collusion, because it is zero for a Cournot oligopoly and positive for complete collusion. Thus

$$p = \Delta\left(1 + \frac{H}{\varepsilon}(1 + \phi)\right)^{-1}, \tag{8.15}$$

where $\Delta = \sum_{i=1}^{K}(q_i/q)(\partial C_i/\partial q_i)$ is a weighted average of marginal cost. Thus price depends on a weighted average of marginal cost, the price elasticity of demand, the Herfindahl index, and the degree of collusion (a weighted average of the conjectural variations).

Totally differentiating (8.15) we get

$$\tilde{p} = \tilde{\Delta} - \frac{\varepsilon^{-1}H(1 + \phi)}{\psi}\tilde{H} - \frac{\phi\varepsilon^{-1}H}{\psi}\tilde{\phi} + \frac{\varepsilon^{-1}H(1 + \phi)}{\psi}\tilde{\varepsilon}, \tag{8.16}$$

where $\psi = 1 + \varepsilon^{-1}H(1 + \phi)$.

A necessary condition for a profit maximum of the i-th firm is [cf. (6.3)],

$$\varepsilon^{-1}\frac{q_i}{q}\frac{\partial q}{\partial q_i} > -1.$$

Multiply this by q_i/q and sum over i; it then follows that

$$\frac{H}{\varepsilon}(1+\phi) > -1.$$

Therefore $\psi > 0$ and $\varepsilon < 0$. The coefficients of $\tilde{H}$ and $\tilde{\phi}$ in (8.16) are thus positive; the coefficient of $\tilde{\varepsilon}$ is negative and equal to minus the coefficient of $\tilde{H}$. An increase in the level of concentration or in the degree of collusion leads therefore to a higher price.

Note that in the Cowling-Waterson model the only differences between firms are differences in marginal cost; differences in output levels are therefore caused by differences in marginal cost. Thus actually the Herfindahl index is endogenous and a function of ε, ϕ, and the distribution of marginal cost; see Clarke and Davies (1982).

Special cases

If the reaction patterns are those of a Cournot oligopoly, then the conjectural variations are zero, i.e. $\partial q_j/\partial q_i = 0$ ($j \neq i$). Thus $\phi_i = 0$ and $\phi = 0$, and (8.15) reduces to

$$p = \Delta\left(1 + \frac{H}{\varepsilon}\right)^{-1}. \tag{8.17}$$

If on the other hand the conjectural variations are proportional to the ratio of the market shares, i.e. $\partial q_j/\partial q_i = q_j/q_i$, then

$$\phi_i = \frac{q}{q_i} - 1$$

and

$$\phi = \frac{1}{H} - 1.$$

Then (8.15) reduces to

$$p = \Delta\left(1 + \frac{1}{\varepsilon}\right)^{-1}.$$

Thus $\partial q_j/\partial q_i = q_j/q_i$ is equivalent to complete collusion.

If the Herfindahl index H and the degree of collusion ϕ remain constant over time, then $\tilde{H} = 0$ and $\tilde{\phi} = 0$, and (8.16) reduces to

$$\tilde{p} = \tilde{\Delta} + \frac{\varepsilon^{-1} H(1+\phi)}{\psi}\,\tilde{\varepsilon}.$$

Therefore the form of the price equations (6.15), (6.18), (7.3), and (7.11) does not change if we incorporate arbitrary reaction patterns in the model, provided the reaction patterns (represented by the Herfindahl index and the degree of collusion) remain constant.

Consistent conjectural variations

The conjectural variations (which represent expected behaviour) in the model of the previous two subsections are not necessarily consistent with actual behaviour. For example, in a Cournot oligopoly each firm expects that the output of the other firms remains constant, when it changes its own output; yet, the firm can observe that in the new equilibrium the output of the other firms has *not* remained constant [cf. Fellner (1949, pp. 73-4)]. Therefore Bresnahan (1981) and Kamien and Schwartz (1983) restrict the conjectural variations to be consistent with the reaction functions (8.14), which represent actual behaviour. Formally, the conjectural variations are consistent if at equilibrium

$$\left(\frac{\partial q_j}{\partial q_i}\right)^e = \frac{\partial q_j^a}{\partial q_i}, \quad i = 1, 2, \ldots, K, \quad j \neq i,$$

where $(\partial q_j/\partial q_i)^e$ is the conjectural variation of firm i and q_j^a is the reaction function of firm j.

Heterogeneous products

The model of this section presumes that all firms in an industry produce the same product. If we allow for heterogeneous products, then in general the analysis becomes more complicated, and it is no longer possible to derive a simple price equation like (8.15); see Waterson (1984, pp. 26-8). Note that with heterogeneous products, the analysis must be carried out in terms of prices instead of quantities.

A special case that allows a tractable analysis arises if we assume that price differences within the industry remain constant; thus

$$p_i = pp_i^0, \quad i = 1, 2, \ldots, K,$$

where p_i is the price of firm i, p_i^0 is the price of firm i in a base year, and p is the factor of proportionality. With Hicks' aggregation theorem [Deaton and Muellbauer (1980, p. 121)], we can aggregate the products to a single good and then carry out an analysis similar to that of the previous subsections. It is easily shown that in this case (8.15) also holds. Particularly in this special case it is appropriate to require that the conjectural variations are consistent. Then ϕ in (8.15) has a special form.

8.5. Empirical analysis

Specification

In the previous three sections we have seen how market structure affects price formation: under price leadership, the market price is a function of the market share of the leading firms; under limit pricing, the market price is a function of the scale barrier; and under oligopoly, the market price is a function of the Herfindahl index and the conjectural variations. Because it is difficult to measure the conjectural variations, they will be left out from the empirical analysis.

The results of these sections can be summarized in the following equation:

$$\tilde{p}_i = \tilde{c}_i + \alpha^* \tilde{C}_i + \beta \tilde{s}_i + \gamma \tilde{\varepsilon}_i, \ \ i = 1, 2, \ldots, N, \tag{8.18}$$

where p_i is the price of industry i, c_i is a function of marginal cost of the firms in industry i, C_i is a concentration measure, s_i is a scale barrier, ε_i is the price elasticity of demand, and N is the number of industries; there holds $\alpha^* > 0$, $\beta > 0$, and $\gamma < 0$.

In the two previous chapters the price elasticity of demand has been analysed; special attention has been given to the role of foreign competition. The analysis can be summarized in the following expression for $\tilde{\varepsilon}_i$ [cf. equations (7.9) and (7.19)]:[4]

$$\tilde{\varepsilon}_i = \delta \tilde{w}_d^i + \chi \tilde{w}_i, \ \ i = 1, 2, \ldots, N, \tag{8.19}$$

where $w_d^i = p_i q_i / (p_i q_i + V_{mi)}$ with V_{mi} the expenditure on the competing import product and $w_i = (p_i q_i + V_{mi}) \,/\, \sum_{i=1}^N (p_i q_i + V_{mi})$; there holds $\delta < 0$ and $\chi < 0$. Thus w_d^i is the market share of the domestic producers in total sales of good i, and w_i is the budget/cost share of good i (i.e. the share that domestic and foreign producers of the good together have in total expenditure). The term $\tilde{w}_d^i$ represents competition between domestic and foreign producers for the same good, and the term $\tilde{w}_i$ represents competition between goods for total expenditure. Thus the change in the price elasticity of demand for a domestic industry is a decreasing function of the changes in the domestic market share and the budget/cost share.

Combining equations (8.18) and (8.19) we obtain

$$\tilde{p}_i = \tilde{c}_i + \alpha^* \tilde{C}_i + \beta \tilde{s}_i + \lambda \tilde{w}_d^i + \mu \tilde{w}_i, \tag{8.20}$$

where $\lambda = \gamma\delta > 0$ and $\mu = \gamma\chi > 0$.

I assume that marginal cost is equal to average cost. Because the model will be applied to a cross-section sample of industries, this seems the only reasonable assumption possible; moreover for many industries this equality could not be rejected in the empirical analysis of Chapter 7. I also assume that the coefficients in (8.20), which are first-order derivatives of a nonlinear function, are constant. As said in Section 8.1, concentration will be represented by the Theil coefficient (E), which is an inverse measure of concentration. Integrating (8.20) and replacing C by E, we arrive at the following specification[5]

$$\log \frac{p_i}{c_i} = \text{constant} + \alpha \log E_i + \beta \log s_i + \lambda \log w_d^i + \mu \log w_i. \tag{8.21}$$

[4] I assume here that all goods are alike in the sense that the elasticities of substitution between domestic and foreign products are equal ($\sigma^i = \sigma^j$), the own Slutsky coefficients are equal ($\pi_{ii} = \pi_{jj}$), and the marginal budget shares are equal ($\mu_i = \mu_j$).

[5] In the empirical analysis I have also tried a linear specification; the results were very similar to those of the loglinear specification.

The expected signs of the coefficients are[6]:

$$\alpha < 0, \quad \beta > 0, \quad \lambda > 0, \quad \mu > 0.$$

Thus the ratio of gross output to cost depends negatively on the Theil coefficient and positively on the scale barrier, the domestic market share, and the aggregate market share of domestic and foreign producers together in total expenditure.

Equation (8.21) is characteristic of many studies on the relation between market structure and profits. An equation like (8.21) is often posed without theory and with only heuristic arguments. The analysis in this and the two previous chapters has given some foundation to it.

Data[7]

Equation (8.21) has been estimated for the years 1963 and 1971. These two years are the only ones for which Theil coefficients have been computed. Janus (1972) has computed Theil coefficients for 1963 from the employment distribution by size classes as given in the Census [CBS (1968-70)]. Janus (1975) has computed Theil coefficients for 1971 from the employment distribution by size classes as given in the Algemeen Bedrijfsregister (ABR); see CBS (1981). In 1963 employment includes self-employed; in 1971 self-employed are excluded from the data.

The industrial classification used in this chapter is the same as in the previous chapter; the total number of industries is 24.[8] For 1963 two industries (Housing services and Health services) have to be excluded, because they are not included in the Census. The data for 1971 refer only to manufacturing industries (no. 2-15); moreover industries 10 and 11 (Primary metal products and Metal products and machinery) are combined and industry 13 (Transport equipment) is excluded, so that the sample consists of 12 industries. For both years it was necessary to aggregate or disaggregate some of the Theil coefficients given in Janus (1972, 1975). This was done by the decomposition formula for the Theil coefficient (see Section 8.1) and the data given in CBS (1968-70) and CBS (1973).

Although in theory the scale variable is the ratio of minimum efficient scale to industry output, data on this variable are hard to come by. As the scale variable I have therefore taken capital consumption per establishment in 1963. This variable is computed as the product of capital consumption per employee and the number of employees per establishment; the number of employees per establishment is a weighted average of the number of employees per establishment at the lowest level of aggregation permitted by the Census data. The correlation coefficient between the Theil coefficient and capital consumption per establishment is −0.66. This correlation is also shown in Figures 8.6 and 8.7. Figure 8.6 shows the relation between the Theil coefficient and capital

[6] The Theil coefficient is an inverse measure of concentration; therefore E_i in (8.21) and C_i in (8.18) are opposite in sign.

[7] All data are given in Appendix C.3

[8] See Appendix C.3.

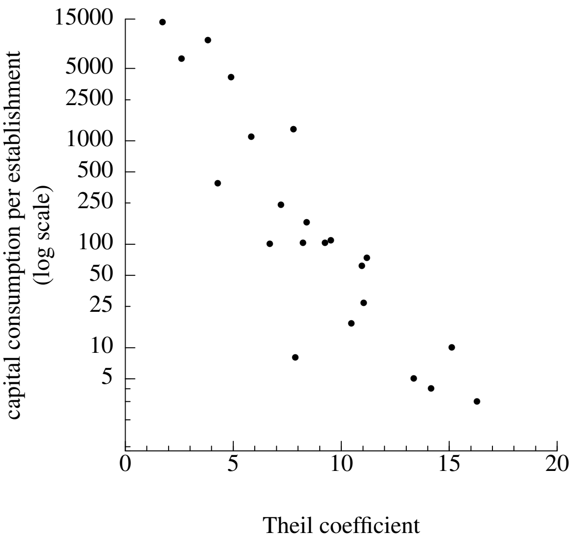

Figure 8.6 *Theil coefficient and capital consumption per establishment, 1963 (22 industries)*

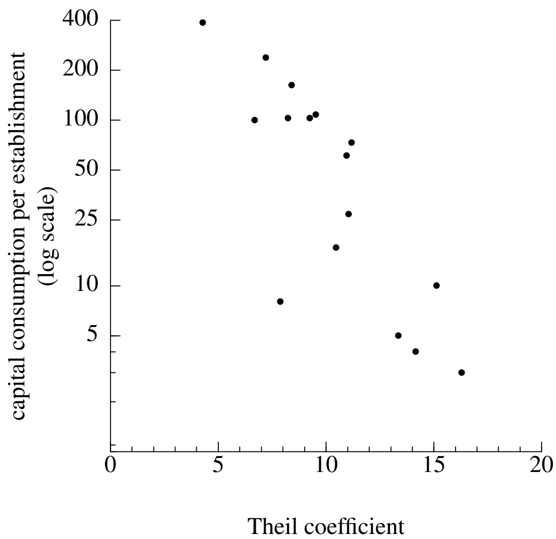

Figure 8.7 *Theil coefficient and capital consumption per establishment, 1963 (16 industries)*

consumption for all 22 industries, and Figure 8.7 shows the relation for the 16 industries with the lowest capital consumption per establishment. Thus a low value of the

Theil coefficient (that is a high level of concentration) tends to be associated with a high level of capital consumption per establishment.

The source of the other data is the same as those in Chapters 6 and 7; see also Appendix C.3. Cost is the sum of intermediate consumption, capital consumption, compensation of employees, indirect taxes less subsidies, and imputed labour cost of self-employed. The price-cost ratio *p*/*c* includes export sales; this is in contrast with Chapters 6 and 7, where only domestic price formation has been analysed.

Estimation results

The estimation results of (8.21) for 1963 and 1971 are, together with 6 variants, presented in Tables 8.2-8.5.

Table 8.2 *Estimation results for the price-cost equation (8.21), 1963 (22 industries)*

Variant no.	con-stant	Theil coeff. E	Capital cons.per establ. s	Domestic market share w_d	1 − Export share	Budget/ cost share w	$\bar{R}^2$
1.	−0.178 (0.265)	0.060 (0.068)	0.005 (0.015)	−0.060 (0.062)	0.051 (0.044)	−0.039 (0.038)	−0.16
2.	0.002 (0.218)	0.031 (0.064)	0.0004 (0.015)	−0.042 (0.060)		−0.006 (0.026)	−0.19
3.	0.026 (0.186)	0.028 (0.061)	0.001 (0.014)	−0.034 (0.050)			−0.13
4.	0.044 (0.181)	0.022 (0.059)	0.003 (0.013)				−0.09
5.	0.080 (0.056)	0.010 (0.027)					−0.04
6.	0.044 (0.075)	0.023 (0.032)		−0.035 (0.048)			−0.07
7.	0.006 (0.168)	0.030 (0.043)		−0.042 (0.056)		−0.006 (0.024)	−0.12

Standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

Since the price-cost ratio *p*/*c* includes export sales, I have estimated also equation (8.21) with 1 minus the export share added as explanatory variable: industries that sell a large fraction of their output at home are expected to be less influenced by foreign competition and to have larger profits; its coefficient should therefore be positive.

It appears from Table 8.2 that equation (8.21) cannot explain the price-cost ratios of the 22 industries: the adjusted coefficients of determination are negative and all coefficients except that of the scale variable have the wrong sign.

Table 8.3 gives the results for manufacturing industries (the 12 industries that constitute the sample in 1971). Now the $\bar{R}^2$ are positive, but the coefficients of most variables have again the wrong sign.

Table 8.3 *Estimation results for the price-cost equation (8.21), 1963 (12 industries)*

Variant no.	con- stant	Theil coeff. E	Capital cons.per establ. s	Domestic market share w_d	1 − Export share	Budget/ cost share w	$\bar{R}^2$
1.	−0.578	0.122	0.010	−0.165	−0.042	−0.084	0.25
	(0.608)	(0.123)	(0.019)	(0.127)	(0.183)	(0.079)	
2.	−0.486	0.100	0.008	−0.189[a]		−0.075	0.37
	(0.420)	(0.071)	(0.016)	(0.064)		(0.063)	
3.	−0.006	0.029	−0.006	−0.168[a]			0.33
	(0.124)	(0.039)	(0.011)	(0.064)			
4.	−0.028	0.039	0.006				−0.16
	(0.164)	(0.051)	(0.014)				
5.	0.034	0.025					−0.06
	(0.077)	(0.037)					
6.	−0.056	0.041		−0.156[a]			0.40
	(0.066)	(0.029)		(0.056)			
7.	−0.296	0.069		−0.191[a]		−0.051	0.44
	(0.202)	(0.036)		(0.061)		(0.041)	

Standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

The results for 1971 (12 industries), presented in Table 8.4, seem to be more satisfactory: the $\bar{R}^2$ are positive, the Theil coefficient and 1 − export share have the correct sign; but the domestic market share has the wrong sign. Because Mining consists after 1970 mainly of Natural gas production, which has a special production structure and price formation,[9] I have also estimated the equation without the data on Mining; the

[9] There is one large producer; prices are determined by the government and are linked to the price of crude mineral oil.

results are presented in Table 8.5. It appears that the results of Table 8.4 are entirely due to Mining: without Mining the $\bar{R}^2$ become negative and no coefficient is significantly different from 0.

Table 8.4 *Estimation results for the price-cost equation (8.21), 1971 (12 industries)*

Variant no.	con-stant	Theil coeff. E	Capital cons.per establ. s	Domestic market share w_d	1 – Export share	Budget/ cost share w	$\bar{R}^2$
1.	1.578	–0.408[a]	–0.021	–0.561[a]	0.653[a]	0.150	0.78
	(0.856)	(0.150)	(0.033)	(0.112)	(0.141)	(0.123)	
2.	0.476	–0.189	–0.009	–0.342	0.033		0.14
	(1.628)	(0.281)	(0.065)	(0.200)	(0.239)		
3.	0.265	–0.160	–0.003	–0.343			0.25
	(0.490)	(0.167)	(0.041)	(0.187)			
4.	0.281	–0.148	0.024				0.05
	(0.550)	(0.188)	(0.043)				
5.	0.552[a]	–0.217					0.11
	(0.271)	(0.140)					
6.	0.238	–0.153		–0.339[a]			0.33
	(0.281)	(0.125)		(0.165)			
7.	0.270	–0.156		–0.336		0.007	0.25
	(0.741)	(0.146)		(0.184)		(0.150)	

Standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

The result of this section is that equation (8.21) cannot explain differences in price-cost ratios of industries. Similar conclusions have been reached in other studies, for example Pagoulatos and Sorensen (1976a) and De Wolf (1981, 1982).[10] A possible explanation for this failure is that the assumption that all goods are alike (see footnote 4) may be too strong for the level of aggregation I have used. If this explanation is correct, then one can test the market-structure models of this chapter only with data on closely related industries or firms; also, one should doubt the results of any empirical analysis of the relation between market structure and prices or profits.

[10] Their samples are larger than mine; so it does not seem that my results are due to the sample's being too small.

Table 8.5 *Estimation results for the price-cost equation (8.21), 1971 (excluding Mining)*

Variant no.	con-stant	Theil coeff. E	Capital cons.per establ. s	Domestic market share w_d	1 – Export share	Budget/cost share w	$\bar{R}^2$
1.	0.547	–0.117	–0.009	–0.155	0.163	0.054	–0.41
	(0.512)	(0.105)	(0.017)	(0.115)	(0.140)	(0.068)	
2.	0.224	–0.032	–0.005	–0.042		0.023	–0.50
	(0.442)	(0.078)	(0.018)	(0.063)		(0.065)	
3.	0.076	–0.011	–0.0006	–0.043			–0.31
	(0.134)	(0.048)	(0.011)	(0.059)			
4.	0.071	–0.005	0.002				–0.23
	(0.130)	(0.045)	(0.010)				
5.	0.092	–0.010					–0.10
	(0.071)	(0.035)					
6.	0.071	–0.010		–0.042			–0.15
	(0.077)	(0.036)		(0.052)			
7.	0.111	–0.014		–0.039		0.009	–0.30
	(0.201)	(0.042)		(0.058)		(0.040)	

Standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

8.6. Prices, demand, and concentration

The administered-price hypothesis says that prices react less to demand changes, the more concentrated an industry is; see Weiss (1966), Phlips (1971, Chapter 2; 1983, Chapters 5 and 6), Qualls (1972, 1975), Dalton (1973), Ripley and Segal (1973), and Shinjo (1977).

In model (8.20) there exists a similar relation between price, demand, and concentration: the coefficients in (8.20) are derivatives of a nonlinear function and are therefore functions of the levels of the variables that occur on the right-hand side, cf. equations (8.10) and (8.16). As an example I shall analyse the model of Cowling and Waterson; I assume that the degree of collusion is constant and equal to zero, so that (8.16) becomes

$$\tilde{p} = \tilde{\Delta} - \frac{H/\varepsilon}{1 + H/\varepsilon}(\tilde{H} - \tilde{\varepsilon}) = \tilde{\Delta} - \alpha^* \tilde{H} + \alpha^* \tilde{\varepsilon}, \tag{8.22}$$

where $\alpha^* = (\varepsilon/p)/(\partial p/\partial\varepsilon) = (H/\varepsilon)/(1 + H/\varepsilon) < 0$. It is easily seen that α^* is an increasing function of the Herfindahl index H. A way to model this is to approximate (8.20) by an equation in logarithms that contains also the cross products of $\log H_i$ with $\log w_d^i$ and $\log w_i$ (thus to take the Taylor expansion, as far as the cross terms are concerned, one order further):

$$\log \frac{p_i}{c_i} = \text{constant} + \alpha^* \log H_i + \beta \log s_i + \lambda \log w_d^i$$
$$+ \mu \log w_i + \xi^* (\log H_i)(\log w_d^i) + \zeta^* (\log H_i)(\log w_i). \tag{8.23}$$

It has already been established in Section 8.5 that $\alpha^* > 0$, $\beta > 0$, $\lambda > 0$, and $\mu > 0$. One easily shows that the coefficients of the cross products are

$$\xi^* = ½ \frac{\partial^2 \log p}{\partial(\log H)\partial(\log w_d)} = ½\, \delta \frac{\partial\alpha^*}{\partial \log H} = ½\, \delta \frac{H/\varepsilon}{(1 + H/\varepsilon)^2} > 0$$

and

$$\zeta = ½ \frac{\partial^2 \log p}{\partial(\log H)\partial(\log w)} = ½\, \chi \frac{\partial\alpha^*}{\partial \log H} = ½\, \chi \frac{H/\varepsilon}{(1 + H/\varepsilon)^2} > 0,$$

where the subscripts and superscripts i are omitted, and $\delta = (w_d/\varepsilon)(\partial\varepsilon/\partial w_d) < 0$, and $\chi = (w/\varepsilon)(\partial\varepsilon/\partial w) < 0$ [cf. (8.19)]. Thus the more concentrated an industry is, the larger is the change in price as a result of a demand change (i.e. a change in the domestic market share or the budget/cost share). Note that this result is inconsistent with the administered-price hypothesis, but agrees with results of Phlips (1983, pp. 102-5).

Replacing $\log H_i$ in (8.23) by $\log E_i$ and noting that $\partial \log H_i/\partial \log E_i < 0$, we get

$$\log \frac{p_i}{c_i} = \text{constant} + \alpha \log E_i + \beta \log s_i + \lambda \log w_d^i$$
$$+ \mu \log w_i + \xi (\log E_i)(\log w_d^i) + \zeta (\log E_i)(\log w_i), \tag{8.24}$$

where the expected signs of the coefficients are

$$\alpha < 0,\ \beta > 0,\ \lambda > 0,\ \mu > 0,\ \xi < 0, \text{ and } \zeta < 0. \tag{8.25}$$

I have estimated equation (8.24) and several variants of it on the cross-section data that have been used in the previous section. The results were again disappointing: negative $\bar{R}^2$ or coefficients with wrong signs occurred; therefore, the results are not reported.

I have also estimated the following mixture of equations (7.33) and (8.24):

$$\log p_{it} = \text{constant}_i + (\gamma_1 + \delta_1 \log E_i) \log c_{it} + (\gamma_2 + \delta_2 \log E_i) \log f_{it}$$

$$+ (\gamma_3 + \delta_3 \log E_i) \log u_{it} + (\gamma_4 + \delta_4 \log E_i) DP_t$$

$$+ (\gamma_5 + \delta_5 \log E_i) \log w^i_{dt} + (\gamma_6 + \delta_6 \log E_i) \log w_{it}, \quad (8.26)$$

where i denotes the industry and t the time period, c_{it} is now average variable cost, f_{it} is average capital cost, u_{it} is capacity utilization, and DP_t is a price-controls dummy. Because yearly data on the Theil coefficient are not available, it does not have a time subscript in (8.26); I have taken for E_i its value in 1963. Thus not only the coefficients of the demand variables are a function of concentration, but also those of the cost, capacity utilization, and price controls variables.

Table 8.6 *Estimation results for the price equation (8.26), 1961-1979 (20 industries)*

Variable	Coefficient of	
	variable (γ_i)	product of variable and Theil coefficient (δ_i)
average variable cost	0.847[a]	–0.025
	(0.139)	(0.069)
average capital cost	–0.094	0.088
	(0.120)	(0.059)
capacity utilization	0.583[a]	–0.232[a]
	(0.175)	(0.090)
price-controls dummy	0.030	–0.012
	(0.027)	(0.012)
domestic market share	–0.197	0.070
	(0.152)	(0.068)
budget/cost share	–0.252[a]	0.153[a]
	(0.080)	(0.041)
$\bar{R}^2$	0.99	

Standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

I have estimated equation (8.26) for 22 industries (those for which Theil coefficients are available) in the years 1961-1979. The method of estimation is ordinary least squares with dummy variables for the industries.[11]

[11] Alternatively, an error-components model may be constructed and estimated; see Maddala (1977, Section 14.3).

Table 8.6 (cont.)
Coefficients of industry dummies

Industry		Industry	
1. Agriculture	0.776[a] (0.141)	11. Metal products and machinery	0.737[a] (0.092)
2. Meat and dairy	0.736[a] (0.086)	12. Electrical products	0.517[a] (0.129)
3. Other food	0.754[a] (0.099)	13. Transport equipment	0.737[a] (0.077)
4. Drink and tobacco	0.744[a] (0.097)	16. Electricity, gas and water	0.697[a] (0.107)
5. Textiles	0.784[a] (0.083)	17. Construction	0.760[a] (0.110)
6. Clothing and leather	0.898[a] (0.113)	19. Distribution	0.703[a] (0.126)
7. Paper and printing	0.812[a] (0.093)	20. Sea and air transport services	0.606[a] (0.166)
8. Timber and stone	0.810[a] (0.109)	21. Other transport and communication	0.754[a] (0.092)
9. Chemical products	0.692[a] (0.075)	22. Banking and insurance	0.829[a] (0.088)
10. Primary metal products	0.467[a] (0.158)	24. Other services	0.781[a] (0.126)

Standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

The estimation results for the entire sample are not satisfactory: they yield a very high residual sum of squares, which is mainly due to the industries Mining (which has also been an outlier in the cross-section sample of the previous section) and Mineral oil refining. The results for the sample consisting of the 20 other industries are reported in Table 8.6. The coefficients of the products of the Theil coefficient with capacity utilization and with the budget/cost share are significantly different from zero; they are respectively negative and positive; the products of the Theil coefficient with the other variables have coefficients that are not significantly different from zero. Thus the more concentrated an industry is, the more its price reacts to changes in capacity utilization and the less it reacts to changes in the budget/cost share. The correlation between concentration and the coefficient of capacity utilization is possibly due to the correlation between concentration and capital intensity (see Figures 8.6 and 8.7). The fact that the coefficient of the product of the Theil coefficient and the budget/cost share is positive contradicts the sign restrictions (8.25); it shows that my model is not appropriate here:

there must operate some other factors, for example those of the administered-price hypothesis.

The F-statistic for testing model (8.26) against the model in which the coefficients are unrestricted across industries [that is (7.33), whose estimation results are reported in Table 7.1] is equal to 4.51; its degrees of freedom are 101 and 247. Thus if we test (8.26) against (7.33), then model (8.26) has to be rejected.

8.7. Summary

Several models that describe relations between market structure and price formation have been reviewed; they include Saving's model in which a cartel acts as price leader, Bain's model in which plant size is a barrier to entry, and Cowling and Waterson's model of oligopoly pricing. The model of Cowling and Waterson has been extended to heterogeneous products with constant relative prices.

I have constructed a model that has elements of these three theories; in this model the ratio of price to marginal cost in an industry depends on the price elasticity of demand, the degree of concentration, and a barrier to entry (minimum efficient scale relative to industry output). Combining this model with the results of Chapter 7 on the price elasticity of demand, we get a model in which the ratio of price to marginal cost depends on the degree of concentration, the barrier to entry, the domestic market share, and the budget/cost share.

Assuming that marginal cost equals average cost, I have estimated the model on cross-section data from the years 1963 and 1971, for 22 and 11 industries respectively. The model could not in a satisfactory way describe differences in the price-cost ratio between industries.

I have also tested an extension of the administered-price hypothesis, in which the way price reacts to cost, capacity utilization, price controls, domestic market share, and budget/cost share, depends on concentration; this model is a mixture of the model in Chapter 7 and that of the earlier sections in Chapter 8. The estimation results for 20 industries in the period 1961-1979 indicate that the more concentrated an industry is, the more its output price reacts to changes in capacity utilization and the less it reacts to changes in the budget/cost share.

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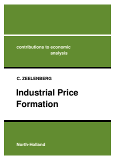


CHAPTER 9

Price formation in general equilibrium under imperfect competition

This chapter deals with the comparative statics of the model of Chapter 7. In Section 7.1 I have derived an equation that relates the change in the output price of a monopolist to the changes in marginal cost, the domestic market share, and the budget share of the good. As said at the end of Section 7.1, the domestic market share and the budget share depend in their turn on domestic prices, foreign prices, and income; also marginal cost is a function of the prices of the other domestic industries, foreign prices, primary-input prices, and output. To analyse comparative statics fully we must take these four relationships into account; thus we arrive at a general-equilibrium model, which will be analysed in this chapter. As I have done in the other chapters of Part 3, I assume that the primary-input prices are exogenous.

In Section 9.1 the comparative statics of consumer-good prices are analysed, and in Section 9.2 a two-good example is given; in both sections I assume that *all* input prices are exogenous. Section 9.3 deals with the dependence of marginal cost on domestic and foreign prices and output. I assume that there are constant returns to scale and that the monopolist discriminates between consumers and producers; these two assumptions allow me to analyse consumer-good prices separate from producer-good prices. In Section 9.4 I show how the elasticities of domestic prices with respect to exogenous average cost, foreign prices, and income can be computed from the empirical results in Section 7.6; the results are summarized and discussed in Section 9.5; the complete elasticity matrices and their standard errors are given in Appendix 9.1.

9.1. Comparative statics of consumer-good prices

In this section and the next one, I assume that producers produce only consumer goods and use only primary inputs (so that marginal cost is exogenous).

First I shall review the theories of price formation and consumer demand developed in Chapter 6 and Section 7.1. Thereafter I shall derive the equations that describe comparative statics in general equilibrium.

Price formation

In each industry there is one domestic monopolist, who produces a variety of a good, and there are foreign competitors, who produce another variety. It is assumed that the domestic monopolist takes the foreign price as given. The output price of the domestic monopolist is then given by [see equation (6.2)]

$$p_{di} = \Delta_i \left(1 + \frac{1}{\varepsilon_{di,di}}\right)^{-1}, \quad i = 1, 2, \ldots, N,$$

where p_{di} is the output price of the domestic monopolist, Δ_i is his marginal cost, $\varepsilon_{di,di}$ is the price elasticity of demand for the domestic product, and N is the number of goods (equal to the number of industries).

The consumer is supposed to follow a two-stage budgeting procedure: first he allocates his income to goods (such as food and clothing) and then he allocates for each good its expenditure to the domestic and the foreign product (thus domestic and foreign food, respectively domestic and foreign clothing); cf. Armington (1969a, 1969b). The allocation of income to goods is described by the global absolute version of the Rotterdam system [Theil (1980, pp. 15 and 160)]; the allocation of the expenditure on a good to the foreign and domestic product is described by a CES (constant-elasticity-of-substitution) demand system; see below for more details. It has been shown in Chapter 7 that the price elasticity of demand is under two-stage budgeting with Rotterdam and CES demand equations a function of two shares: the budget share of the good and the domestic market share (that is the share the domestic producer has in total expenditure on the good). Therefore the change[1] in the output price of the domestic monopolist is a function of the changes in marginal cost, the domestic market share, and the budget share [see equation (7.11)]:

$$\tilde{p}_{di} = \tilde{\Delta}_i + \gamma_i \tilde{w}^i_d + \delta_i \tilde{w}_i, \quad i = 1, 2, \dots, N, \tag{9.1}$$

where w^i_d is the domestic market share, w_i is the budget share of the good, and a tilde (˜) denotes a relative differential [for example $\tilde{p}_{di} = (\mathrm{d}p_{di})/p_{di}$]. The coefficients γ_i and δ_i depend on the initial situation; they are functions of w^i_d, w_i, and the price elasticity of demand [see (7.11) and also below]. There holds $\delta_i > 0$ and possibly $\gamma_i > 0$; sufficient for $\gamma_i > 0$ is that the price elasticity of demand for the good (not for the domestic product) is larger than -1. Here I assume that $\gamma_i > 0$ holds indeed. It follows from (9.1) that to analyse comparative statics in general equilibrium we must express the changes of the domestic market share and the budget share in domestic and foreign prices and income.

Demand for products

Demand for products is modelled by CES demand functions. Since we are interested in the domestic market share and there are only two products of each good, it is sufficient to express the change of the ratio of the quantities of the domestic and the foreign product in terms of the change of the price ratio. For a CES demand function there holds [see equation (B.3) in Appendix B.1]

$$\tilde{w}^i_d = (1 - \sigma^i)(1 - w^i_d)(\tilde{p}_{di} - \tilde{p}_{mi}), \tag{9.2}$$

where p_{mi} is the price of the foreign product, and σ^i is the elasticity of substitution between the domestic and the foreign product with utility of the good constant.

[1] 'Change' always means 'relative change'.

Demand for goods

The demand for goods is modelled by the global absolute version of the Rotterdam system [see Appendix B.2]:

$$w_i\tilde{q}_i = \mu_i(\tilde{y} - \tilde{P}) + \sum_{j=1}^{N} \pi_{ij}\tilde{p}_j, \;\; i = 1, 2, \ldots, N, \tag{9.3}$$

where q_i is the Divisia index of the quantities of the domestic and foreign products of good i $[\tilde{q}_i = w_d^i\tilde{q}_{di} + (1 - w_d^i)\tilde{q}_{mi}]$, y is income, p_j is the Divisia index of the prices of the domestic and foreign products of good j $[\tilde{p}_j = w_d^j\tilde{p}_{dj} + (1 - w_d^j)\tilde{p}_{mj}]$, P is the Divisia index of the prices of the goods ($\tilde{P} = \sum_{j=1}^{N} w_j\tilde{p}_j$), μ_i is the marginal budget share of good i (thus μ_i/w_i is the income elasticity), and (π_{ij}) is a negative semi-definite matrix that satisfies $\sum_{j=1}^{N} \pi_{ij} = 0$ ($i = 1, 2, \ldots, N$); the π_{ij} are called the Slutsky coefficients. It is assumed that the marginal budget shares and the Slutsky coefficients are constant.

It follows that the change in the budget share is

$$\begin{aligned} \tilde{w}_i &= \tilde{p}_i + \tilde{q}_i - \tilde{y} \\ &= \left(\frac{\mu_i}{w_i} - 1\right)\tilde{y} + w_d^i\tilde{p}_{di} + (1 - w_d^i)\tilde{p}_{mi} \\ &\quad + \sum_{j=1}^{N} \frac{1}{w_i}(\pi_{ij} - \mu_i w_j)[w_d^j\tilde{p}_{dj} + (1 - w_d^j)\tilde{p}_{mj}], \quad i = 1, 2, \ldots, N. \end{aligned} \tag{9.4}$$

The comparative-statics equations

The comparative-statics equations, which relate the domestic prices to income, marginal cost, and foreign prices, are obtained as follows. After substitution of (9.2) and (9.4) into (9.1) we obtain an equation that gives $\tilde{p}_{di}$ as a function of $\tilde{y}$, $\tilde{p}_{dj}$, and $\tilde{p}_{mj}$, $j = 1, 2, \ldots, N$. In matrix notation this equation reads

$$\tilde{p}_d = \tilde{\Delta} + E_d\tilde{p}_d + E_m\tilde{p}_m + a\tilde{y}, \tag{9.5}$$

where

$$E_{dii} = \gamma_i(1 - \sigma^i)(1 - w_d^i) + \delta_i w_d^i\left(1 + \frac{\pi_{ii}}{w_i} - \mu_i\right), \tag{9.6a}$$

$$E_{dij} = \delta_i w_d^j\left(\frac{\pi_{ij}}{w_i} - \frac{\mu_i}{w_i}\,w_j\right), \;\; j \neq i, \tag{9.6b}$$

$$E_{mii} = -\,\gamma_i(1 - \sigma^i)(1 - w_d^i) + \delta_i(1 - w_d^i)\left(1 + \frac{\pi_{ii}}{w_i} - \mu_i\right), \tag{9.6c}$$

$$E_{mij} = \delta_i(1 - w_d^j)\left(\frac{\pi_{ij}}{w_i} - \frac{\mu_i}{w_i} w_j\right), \quad j \neq i, \tag{9.6d}$$

$$a_i = \delta_i\left(\frac{\mu_i}{w_i} - 1\right), \tag{9.6e}$$

$$i, j = 1, 2, \ldots, N.$$

Using the definitions of the price and income elasticities of the goods [see (7.6) and (7.7) or (9.3)], respectively

$$\varepsilon_{ij} = \frac{\pi_{ij}}{w_i} - \frac{\mu_i}{w_i} w_j, \quad i, j = 1, 2, \ldots, N$$

and

$$\eta_i = \frac{\mu_i}{w_i}, \quad i = 1, 2, \ldots, N,$$

we can write (9.6) as

$$E_{dii} = \gamma_i(1 - \sigma^i)(1 - w_d^i) + \delta_i w_d^i(1 + \varepsilon_{ii}), \tag{9.7a}$$

$$E_{dij} = \delta_i w_d^j \varepsilon_{ij}, \; j \neq i, \tag{9.7b}$$

$$E_{mii} = -\gamma_i(1 - \sigma^i)(1 - w_d^i) + \delta_i(1 - w_d^i)(1 + \varepsilon_{ii}), \tag{9.7c}$$

$$E_{mij} = \delta_i(1 - w_d^j)\varepsilon_{ij}, \quad j \neq i, \tag{9.7d}$$

$$a_i = \delta_i(\eta_i - 1), \tag{9.7e}$$

$$i, j = 1, 2, \ldots, N.$$

Because δ_i is positive, E_{dij} and E_{mij} are positive if goods i and j are gross substitutes. The term a_i is positive if good i is a luxury.

Using $\sum_{j=1}^N \pi_{ij} = 0$ and $\sum_{j=1}^N w_j = 1$, one can easily show that

$$\sum_{j=1}^N E_{dij} + \sum_{j=1}^N E_{mij} + a_i = 0, \quad i = 1, 2, \ldots, N;$$

i.e.

$$E_d\iota + E_m\iota + a = 0, \tag{9.8}$$

where $\iota = (1, 1, \ldots, 1)'$ is the $(N, 1)$-vector with unit elements. Solving (9.5) for $\tilde{p}_d$ we get

$$\tilde{p}_d = (I - E_d)^{-1}(\tilde{\Delta} + E_m\tilde{p}_m + a\tilde{y}). \tag{9.9}$$

From (9.8) it follows that

$$(I - E_d)^{-1}(\iota + E_m\iota + a) = \iota. \tag{9.10}$$

Thus $\tilde{p}_{di}$ is a linearly homogeneous function[2] of $\tilde{\Delta}_j$, $\tilde{p}_{mj}$, and $\tilde{y}$ $(j = 1, 2, \ldots, N)$.

[2] Note that equations (9.9) and (9.10) are the generalizations of (6.18) and (6.20) respectively.

Therefore, if income, all marginal costs, and all foreign prices rise with the same proportion, then all domestic prices will also rise with that proportion.

Equations (9.9) and (9.10) do not hold only for the specific demand system (CES / Rotterdam) chosen here; Nieuwenhuis (1980) has shown that they hold for an arbitrary demand system.

Numeraire

I have closed the general-equilibrium model by assuming that the foreign prices and the primary-input prices are exogenous. It is possible to close the model in some other way. For example, we can assume that the foreign prices and the primary-input prices are determined in a similar way as the final-goods prices [such as in equation (9.1) or in perfect competition]. Because all equations of such an enlarged model are homogeneous of degree zero in all prices, we must then choose a numeraire. However, with the closing rule I have chosen, there is formally no need to choose a numeraire. Because in fact most nominal prices tend to move together, it may be more appropriate to incorporate this in the model by deflating all prices with a general price index (which is equivalent to choosing a numeraire); but I have not done this.

9.2. Two-good example

Because in the general case of N goods nothing can be derived about the signs of the elasticity matrices (not even with the specific demand systems that have been chosen here or with the assumption that all goods are gross substitutes), we now turn to a two-good example.

In this section I assume that there are two goods: good 1 is an internationally traded good and good 2 is a non-traded good. Thus the consumer buys three products: the domestic product of good 1, the foreign product of good 1, and the domestic product of good 2. Because good 2 is not internationally traded, there holds $w_d^2 = 1$ and $\tilde{w}_d^2 = 0$. Thus, $\tilde{w}_d^2$ disappears from (9.1) for $j = 2$, equation (9.2) disappears for $j = 2$, $\tilde{p}_{m2}$ disappears from (9.4), and in (9.4) we must take $w_d^2 = 1$. Therefore (9.7) changes to

$$
\begin{aligned}
E_{d11} &= \gamma_1(1 - \sigma^1)(1 - w_d^1) + \delta_1 w_d^1(1 + \varepsilon_{11}),\\
E_{d22} &= \delta_2(1 + \varepsilon_{22}),\\
E_{d12} &= \delta_1 \varepsilon_{12},\\
E_{d21} &= \delta_2 w_d^1 \varepsilon_{21},\\
E_{m11} &= -\gamma_1(1 - \sigma^1)(1 - w_d^1) + \delta_1(1 - w_d^1)(1 + \varepsilon_{11}),\\
E_{m21} &= \delta_2(1 - w_d^1)\varepsilon_{21},\\
a_1 &= \delta_1(\eta_1 - 1),\\
a_2 &= \delta_2(\eta_2 - 1).
\end{aligned}
$$

Note that the matrix E_m is now a (2, 1)-column vector, because p_{m2} is not relevant for the consumer.

For $N = 2$, equation (9.8) can now be written as[3]

$$\begin{pmatrix}\tilde{p}_{d1}\\ \tilde{p}_{d2}\end{pmatrix} = \begin{pmatrix}e^{11} & e^{12}\\ e^{21} & e^{22}\end{pmatrix}\left[\begin{pmatrix}\tilde{\Delta}_1\\ \tilde{\Delta}_2\end{pmatrix} + \begin{pmatrix}E_{m11}\\ E_{m21}\end{pmatrix}\tilde{p}_{m1} + \begin{pmatrix}a_1\\ a_2\end{pmatrix}\tilde{y}\right], \tag{9.11}$$

where e^{ij} is the $(i,\ j)$-th element of $(I - E_d)^{-1}$ $(i,\ j = 1, 2)$:

$$(I - E_d)^{-1} = \begin{pmatrix}e^{11} & e^{12}\\ e^{21} & e^{22}\end{pmatrix} =$$

$$= \frac{1}{(1 - E_{d11})(1 - E_{d22}) - E_{d12}E_{d21}}\begin{pmatrix}1 - E_{d22} & E_{d12}\\ E_{d21} & 1 - E_{d11}\end{pmatrix}.$$

The signs of the elasticities can be determined as follows. From the condition (7.2) for a profit maximum it follows that $\varepsilon_{d2,d2} < -1$. Since there is no competing foreign product for good 2, there holds $\varepsilon_{22} = \varepsilon_{d2,d2}$; thus

$$\varepsilon_{22} < -1 \tag{9.12}$$

and

$$E_{d22} \leq 0. \tag{9.13}$$

Using $\varepsilon_{22} < -1$ and the Cournot-aggregation property[4]

$$\sum_{i=1}^{N} w_i\varepsilon_{ij} + w_j = 0, \quad j = 1, 2, \ldots, N, \tag{9.14}$$

for $N = 2$, $j = 2$, we get

$$\varepsilon_{12} > 0. \tag{9.15}$$

Therefore

$$E_{d12} \geq 0. \tag{9.16}$$

To obtain definite results about the signs of the elasticities, more specific cases will be analysed: firstly $\varepsilon_{11} = -1$ and secondly $\eta_1 = \eta_2 = 1$ (homotheticity).

The case $\varepsilon_{11} = -1$

If $\varepsilon_{11} = -1$, then the budget share of good 1 does not change when the price of the domestic or the foreign product of good 1 changes. Therefore $\tilde{w}_1$ disappears from equation (9.1) for $i = 1$, i.e. $\delta_1 = 0$ (see Section 7.1). In Chapter 6 we have found

[3] Equation (9.11) may also be derived from (9.1), (9.2), and (9.4) with $\gamma_2 = 0$ and $w_d^2 = 1$.

[4] See Deaton and Muellbauer (1980, p. 16).

that, if $\varepsilon_{11} = -1$, the domestic price of product 1 depends only on marginal cost of industry 1 and the price of foreign product 1 [see (6.18)]. It will appear that this conclusion does not change in a general-equilibrium analysis; moreover it will appear that the price of industry 2 depends on marginal cost of industry 2 and income, but not on the price of the foreign product.

When $\varepsilon_{11} = -1$ there holds $\gamma_1 > 0$, $\sigma^1 > 1$, and $\delta_1 = 0$ (see Sections 6.2 and 6.3). From (9.7) we then have

$$\begin{aligned} &E_{d11} < 0, \quad E_{d12} = 0, \\ &a_1 = 0, \qquad E_{m11} = 0. \end{aligned}$$

Using the Cournot-aggregation property (9.14) for $j = 1$, we get

$$\varepsilon_{21} = 0. \tag{9.17}$$

Therefore

$$E_{d21} = E_{m21} = 0.$$

From the condition for a profit maximum of a monopolist, $\varepsilon_{22} < -1$, equation (9.17), and the homogeneity-aggregation property[5]

$$\sum_{j=1}^{N} \varepsilon_{ij} + \eta_i = 0, \;\; i = 1, 2, \ldots, N, \tag{9.18}$$

we get

$$\eta_2 > 1.$$

Thus the non-traded good is a luxury and the traded products are necessities. Therefore

$$a_2 > 0.$$

Equation (9.11) now becomes

$$\tilde{p}_{d1} = \frac{1}{1 - E_{d11}}\,\tilde{\Delta}_1 + \frac{E_{m11}}{1 - E_{d11}}\,\tilde{p}_{m1}, \tag{9.19}$$

$$\tilde{p}_{d2} = \frac{1}{1 - E_{d22}}\,\tilde{\Delta}_2 + \frac{a_2}{1 - E_{d22}}\,\tilde{y}. \tag{9.20}$$

We see that the price of the traded domestic product 1 depends on marginal cost of industry 1 and the price of the foreign product, but not on marginal cost of industry 2 and income; since the coefficients in (9.19) are positive, an increase in marginal cost of industry 1 or in the price of the foreign product leads to an increase in the domestic price of product 1. The price of the non-traded domestic good 2 depends on marginal cost of industry 2 and income, but not on marginal cost of industry 1 and the price of the foreign product; since the coefficients in (9.20) are positive, an increase in marginal cost of industry 2 or income leads to an increase in the price of domestic good 2.

[5] See Deaton and Muellbauer (1980, p. 16).

Figure 9.1 illustrates the equations (9.19) and (9.20); the plus sign indicates that a rise in one of the variables on the left-hand side leads to a rise in the variables on the right-hand side.

foreign price
marginal cost of traded product } $\xrightarrow{+}$ price of traded product

marginal cost of non-traded product
income } $\xrightarrow{+}$ price of non-traded good

Figure 9.1 *Relationships between the domestic prices and the foreign price, marginal cost, and income when* $\varepsilon_{11} = -1$

Homothetic preferences

If preferences are homothetic, then the income elasticities η_i are equal to 1 and the marginal budget shares μ_i are equal to the average budget shares w_i. Since in the derivation of (9.1) it has been assumed that μ_i is constant (see Section 7.1), the price equation should be derived again. It is easily seen that the form of (9.1) remains the same, but the definition of δ_i changes to

$$\delta_i = -\frac{[1 + \pi_{ii}/w_i^2]w_d^i w_i}{\varepsilon_{di,di}(\varepsilon_{di,di} + 1)} .$$

I assume that $\gamma_1 > 0$ and $\delta_i > 0$, $(i = 1, 2)$. Necessary and sufficient for $\delta_i > 0$ is $\varepsilon_{ii} < -2w_i$; it appears from Table 6.1 that this condition on ε_{ii} holds for most of the 24 industries distinguished in the empirical part of this chapter.

Since $\eta_i = 1$, there holds $a_i = 0$. Thus changes in income do not have an effect on domestic prices. I shall show that, under the assumptions made, the elasticities of domestic prices with respect to marginal cost and foreign prices are positive. It must be shown therefore that $(I - E_d)^{-1} > 0$ and $E_m > 0$. Using the necessary condition for a profit maximum in industry 2, $\varepsilon_{22} < -1$, and the Cournot and homogeneity aggregation properties (9.14) and (9.18), one can easily show that

$$\varepsilon_{21} > 0, \quad \varepsilon_{11} < -1.$$

Thus the two goods are gross substitutes. It now follows from (9.7) that

$$E_{d21} > 0, \quad E_{m21} > 0. \tag{9.21}$$

From (7.10) and the assumption that $\gamma_1 > 0$ we have

$$\sigma^1 > 1.$$

Therefore

$$E_{d11} < 0, \quad E_{m11} > 0. \tag{9.22}$$

Using (9.13), (9.16), (9.21), and (9.22), one easily shows that $(I - E_d)^{-1} > 0$ and $E_m > 0$ and that all elasticities are positive. Thus, if the income elasticities are equal to one, then an increase in marginal cost of an industry or in the price of the foreign product leads to an increase in both domestic prices.

9.3. Comparative statics with consumer and producer goods

If the products of an industry are used not only as consumer goods, but also as producer goods, then three changes must be made in the analysis of Section 9.1. In the first place, marginal cost becomes a function of domestic and foreign prices and output:

$$\Delta_i = \Delta_i(p_d, p_m, r, q_{di}), \; i = 1, 2, \ldots, N, \tag{9.23}$$

where r is the vector with prices of the exogenous primary inputs, such as labour and capital, and q_{di} is output of industry i. Totally differentiating (9.23) we get

$$\tilde{\Delta}_i = \sum_{j=1}^{N} a_{dji}\tilde{p}_{dj} + \sum_{j=1}^{N} a_{mji}\tilde{p}_{mj} + \sum_{h=1}^{M} b_{hi}\tilde{r}_h + d_i\tilde{q}_{di}, \tag{9.24}$$

where a_{dji}, a_{mji}, b_{hi}, and d_i are the elasticities of marginal cost of industry i with respect to domestic price p_{dj}, foreign price p_{mj}, primary-input price r_h, and output q_{di}. In matrix notation (9.24) reads

$$\tilde{\Delta} = A'_d\tilde{p}_d + A'_m\tilde{p}_m + B^*\tilde{l} + \hat{d}\tilde{q}_d, \tag{9.25}$$

where $\tilde{l}_i$ is a weighted average of the changes in the primary-input prices:

$$\tilde{l}_i = \frac{\sum_{h=1}^{M} b_{hi}\tilde{r}_h}{\sum_{h=1}^{M} b_{hi}},$$

B^* is a diagonal matrix:

$$b^*_{ii} = \sum_{h=1}^{M} b_{hi},$$

and $\hat{d}$ is the diagonal matrix with as elements d_i ($i = 1, 2, \ldots, N$). If there are constant returns to scale, then marginal cost equals average cost; then $\hat{d}$ is zero, A_d is equal to the matrix with the cost shares of the domestic intermediate inputs, A_m is equal to the matrix with the cost shares of the imported intermediate inputs, and B^* is equal to the diagonal matrix with the sum of the cost shares of the primary inputs:

$$a_{dji} = \frac{p_{dj} q_{dji}}{C_i},$$

$$a_{mji} = \frac{p_{mj} q_{mji}}{C_i},$$

$$B^*_{ii} = \frac{l_i q_{di}}{C_i} = \frac{\sum_{h=1}^{M} r_h v_{hi}}{C_i},$$

$$i,\ j = 1, 2, \ldots, N,$$

where q_{dji} is the quantity of good j that producer i buys from domestic producer j, q_{mji} is the quantity of good j that producer i buys from foreign producer j, v_{hi} is the quantity of primary input h that is used by producer i, and C_i is total cost of producer i.

Secondly, the change in output is a function of the change in output price; by the definition of the price elasticity of demand we have

$$\tilde{q}_{di} = \varepsilon_{di,di} \tilde{p}_{di}.$$

Thirdly, most industries produce consumer goods as well as producer goods. Then the change in output becomes a function of both the consumer price and the producer price. Thus even if price discrimination is practised, we cannot separate consumer prices and producer prices. It is only when there are constant returns to scale [and thus $\tilde{q}_{di}$ disappears from (9.24)] and the monopolist discriminates between consumers and producers that both types of goods can be analysed separately. Although the appropriate equations for the general case can be worked out, I have chosen to assume constant returns to scale and price discrimination; the main reason for these assumptions is that an empirical analysis for the general case would be too complicated.

Substitution of (9.25) with $\hat{d} = 0$ into (9.5) and rearrangement give

$$\tilde{p}_d = (I - E_d - A'_d)^{-1}[(E_m + A'_m)\tilde{p}_m + B^* \tilde{l} + a\tilde{y}]. \tag{9.26}$$

Since under constant returns to scale the matrices A_d, A_m, and B^* contain the cost shares of the inputs, and by definition the sum of the cost shares in an industry is one, there holds

$$\sum_{j=1}^{N} a_{dji} + \sum_{j=1}^{N} a_{mji} + b^*_{ii} = 1;$$

i.e.

$$(A'_d + A'_m + B^*)\iota = \iota. \tag{9.27}$$

Using (9.8) and (9.27) one easily shows that

$$(I - E_d - A'_d)^{-1}(E_m + A'_m + B^*)\iota + a = \iota; \tag{9.28}$$

thus the changes in domestic prices are a linearly homogeneous function of the changes in exogenous average cost, foreign prices, and income.

9.4. Specification of the elasticity matrices

To be able to compute the elasticity matrices in the comparative statics equation (9.26), we must know the following parameters:
— the coefficients γ_i and δ_i;
— the elasticities of substitution σ^i between domestic and foreign products;
— the marginal budget shares μ_i of the goods;
— the Slutsky coefficients π_{ij};
— the domestic market shares w_d^i and the budget shares w_i;
— the cost share matrices A_d, A_m, and B^*.

The coefficients γ_i and δ_i have been estimated in Chapter 7; see Table 7.1. I have computed the budget and domestic market shares and the input-output matrices from the 1969 input-output tables; see CBS (1960-1983, Part 6, Table 9). Because there exists a break in the series used in Chapters 6 and 7, the shares are not the shares on the consumer market, but the shares on the consumer and producer market together.

The marginal budget shares μ_i are the product of w_i and the income elasticities computed from Table 4 in Keller and Van Driel (1982), who have estimated a consumer demand system for 106 goods; the income elasticities have been reported in Table 7.3. The marginal budget shares have been normalized such that their sum equals 1. With these values of μ_i it is possible to compute the elasticities of substitution σ^i and the own Slutsky coefficients π_{ii} from the estimates of γ_i and δ_i obtained in Chapter 7; the results for σ^i have been reported in Table 7.3.

The cross Slutsky coefficients π_{ij} $(i \neq j)$ have been computed as follows. Keller (1984) proposes a model for the Slutsky coefficients that is suitable to my analysis:

$$\pi_{ij} = \chi \phi_i(\delta_{ij} - \phi_j), \;\; i, j = 1, 2, \ldots, N, \tag{9.29}$$

where $\chi \leq 0$, $0 \leq \phi_i \leq 1$, $\sum_{i=1}^{N} \phi_i = 1$, and δ_{ij} is the Kronecker delta ($\delta_{ii} = 1$; $\delta_{ij} = 0$, $i \neq j$). This factorization of the Slutsky coefficients is called *substitution independence*; I shall call the ϕ_i the *Slutsky factors*.

The term χ can be interpreted as the income flexibility (the inverse of the income elasticity of the marginal utility of income) or as the negative of the 'overall elasticity of substitution'; see Sato (1972). The condition $\sum_{i=1}^{N} \phi_i = 1$ is needed for $\sum_{j=1}^{N} \pi_{ij} = 0$, and the condition $0 \leq \phi_i \leq 1$ is needed for $\pi_{ii} \leq 0$. By construction π_{ij} is then negative semi-definite. A special case of (9.29) is where $\phi_i = \mu_i$; it can be shown that preferences are then additive; Theil (1980) calls this case preference independence.

For a given value of χ, one can compute ϕ_i from π_{ii} (which can be computed from the estimates of γ_i and δ_i in Chapter 7) using the equation

$$\pi_{ii} = \chi \phi_i(1 - \phi_i). \tag{9.30}$$

I have made these computations for values of χ in the interval [−1, 0]; this interval includes all plausible values of χ [see Sato (1972)]. It appears that for no value of χ the conditions $0 \leq \phi_i \leq 1$ and $\sum_{i=1}^{N} \phi_i$ are fulfilled. Therefore I have fixed χ at the value that is implied by the estimates of the compensated price elasticities given by Keller and Van Driel (1982), viz. −0.6585. Equation (9.30) has for given χ and π_{ii} two solutions for ϕ_i, whose sum is one.[6] For the smallest solutions there holds $\sum_{i=1}^{N} \phi_i < 1$, whereas some ϕ_i are negative; for the largest solutions there holds $\sum_{i=1}^{N} \phi_i > 1$, whereas some ϕ_i are larger than one. Therefore I have normalized the sum of the largest solutions to one; this ensures that $0 \leq \phi_i \leq 1$. Note that after the normalization of $\sum_{i=1}^{N} \phi_i$ to 1, there does not any longer hold that $\pi_{ii} = \chi \phi_i (1 - \phi_i)$ if for π_{ii} the estimates from Chapter 7 are taken. The sensitivity of the elasticities to these assumptions will be discussed in the next section.

The data, except the input-output matrices, needed for the computation of the elasticity matrices are given in Table 9.1. In this chapter the derivatives needed to compute asymptotic standard errors are computed numerically;[7] this is in contrast with the other chapters, where the derivatives are computed analytically.

9.5. Empirical analysis

This section reports the estimates of the elasticity matrices from (9.26); these estimates are based on the data in Table 9.1. The complete elasticity matrices and their standard errors are reproduced in the appendix to this chapter; in this section I shall look only at the diagonals, the row sums, and the important off-diagonal elements (important is here defined as larger than 0.10 or larger than the diagonal element in the same row).

Many standard errors will appear to be small, even though many of the estimates of γ_i and δ_i have large standard errors. There are several reasons for this. Firstly, many off-diagonal elements of the elasticity matrices are almost completely determined by the input-output-coefficient matrices A_d and A_m, which have no standard errors.

Secondly, the derivatives of the elasticity matrices with respect to γ_i and δ_i tend to be small, because the elasticity matrices are the product of two matrices that are both functions of γ_i and δ_i, but one of which is an inverse; thus the standard errors of the elasticity matrices can be small, even if the standard errors of γ_i and δ_i are large.[8] Perhaps this is partly an arithmetical artifact; therefore the standard errors should be regarded with some scepticism.

Table 9.2 presents the diagonal elements of the elasticity matrices, i.e. the elasticities of domestic price with respect to own exogenous average cost (compensation of employees, capital consumption, indirect taxes less subsidies, and imputed labour income of self employed), the price of the competing foreign product, and income.

The elasticity with respect to own exogenous average cost is larger than 0.75 in the services industries, except Housing services and Distribution; in Timber and stone,

[6] When the resulting values for ϕ_i were complex I have set both solutions to 0.5.

[7] That is: the derivative of a function f in a point x is approximated by the difference ratio $[f(x+h) - f(x-h)] \,/\, (2h)$, where h is a small number. For h I have taken 10^{-4}. The standard errors appeared to be very insensitive to changes in h.

[8] The same phenomenon has been observed in Section 6.4.

Table 9.1 *Data for the computation of the elasticity matrices*

	Domestic market share (per mille, 1969)	Budget share (per mille, 1969)	Coefficient of domestic market share (γ_i)		Coefficient of budget share (δ_i)		Elasticity of substitution (σ^i)		Marginal budget share (μ_i) × 1000	Slutsky factor (ϕ_i) × 1000	Correlation coefficient between γ_i and δ_i
1. Agriculture	809.4	76.0	1.041[a]	(0.545)	0.234	(0.284)	7.698	(22.974)	23.1	33.7	−0.131
2. Meat and dairy	866.0	37.4	−0.382	(0.359)	0.034	(0.098)	−715.861	(10950.901)	17.5	20.9	0.141
3. Other food	833.2	67.7	−0.051	(0.463)	−0.342	(0.200)	−1.545	(1.755)	10.4	46.9	0.106
4. Drink and tobacco	897.5	18.7	0.893[a]	(0.431)	0.478[a]	(0.065)	5.864[a]	(1.364)	5.7	39.3	0.114
5. Textiles	484.3	33.3	0.020[a]	(0.127)	0.112	(0.119)	5.035	(4.460)	77.1	30.8	−0.908
6. Clothing and leather	640.0	19.6	−0.081[a]	(0.059)	0.164[a]	(0.043)	3.462[a]	(1.464)	34.9	30.8	0.097
7. Paper and printing	792.5	38.4	0.531[a]	(0.149)	−0.074	(0.126)	358.159	(1269.169)	27.2	99.8	−0.061
8. Timber and stone	655.9	36.8	−0.032	(0.097)	0.317[a]	(0.082)	2.842[a]	(0.587)	69.4	33.0	0.178
9. Chemical products	454.1	52.9	0.142	(0.109)	0.448[a]	(0.173)	2.132[a]	(0.365)	67.7	35.9	0.631
10. Primary metal prod.	332.6	26.1	0.471	(0.264)	0.251	(0.151)	2.012[a]	(0.344)	67.9	40.7	0.137
11. Metal products and machinery	525.4	70.4	−0.203	(0.161)	−0.074	(0.095)	−3.680	(4.389)	152.9	45.9	0.310
12. Electrical products	403.1	36.2	−0.142	(0.196)	−0.208	(0.248)	−0.526	(1.510)	61.6	42.5	0.315
13. Transport equipment	403.1	31.7	−0.065	(0.093)	−0.053	(0.120)	−4.266	(11.063)	49.8	45.5	−0.364
14. Mineral oil refining	818.3	24.1	0.301[a]	(0.141)	0.620[a]	(0.063)	2.683[a]	(0.365)	3.7	38.7	0.005
15. Mining	256.0	28.1	0.702[a]	(0.176)	1.198[a]	(0.112)	1.297[a]	(0.017)	46.9	39.7	0.257
16. Electricity, gas and water	1000	21.5			0.296[a]	(0.106)			8.1	33.4	
17. Construction	1000	97.9			0.056	(0.062)			140.4	20.9	
18. Housing services	1000	24.0			0.313	(0.327)			1.6	33.3	
19. Distribution	1000	95.6			−0.111	(0.106)			87.2	71.8	
20. Sea and air transport services	1000	2.0			−0.020	(0.063)			−0.2	47.8	
21. Other transport and communication	1000	41.1			0.536[a]	(0.194)			−4.0	32.9	
22. Banking and insurance	1000	30.2			−0.094	(0.235)			9.0	56.2	
23. Health services	1000	26.2			−0.073	(0.071)			16.9	58.6	
24. Other services	1000	63.8			0.188[a]	(0.076)			25.2	20.9	

Standard errors are in parentheses.

[a] Significantly different from 0 at 5% level.

Table 9.2 *Own elasticities*

	Own elasticity with respect to					
	exogenous average cost		foreign prices		income	
1. Agriculture	0.22[a]	(0.06)	0.68[a]	(0.17)	–0.05	(0.15)
2. Meat and dairy	0.0006	(0.0006)	0.98[a]	(0.02)	–0.002	(0.004)
3. Other food	0.27	(0.39)	0.11	(0.44)	0.27	(0.86)
4. Drink and tobacco	0.44[a]	(0.05)	0.30[a]	(0.06)	–0.22	(0.15)
5. Textiles	0.37[a]	(0.03)	0.34	(0.45)	0.17	(0.13)
6. Clothing and leather	0.41[a]	(0.03)	0.06	(0.06)	0.16[a]	(0.04)
7. Paper and printing	0.009[a]	(0.002)	0.99[a]	(0.008)	–0.0002	(0.002)
8. Timber and stone	0.57[a]	(0.04)	0.13[a]	(0.06)	0.36[a]	(0.04)
9. Chemical products	0.38[a]	(0.04)	0.51[a]	(0.11)	0.13[a]	(0.05)
10. Primary metal products	0.36[a]	(0.05)	0.43	(0.30)	0.32[a]	(0.09)
11. Metal products and machinery	0.32[a]	(0.09)	0.41[a]	(0.18)	–0.06	(0.08)
12. Electrical products	0.36	(0.21)	0.33	(1.08)	–0.14	(0.21)
13. Transport equipment	0.31[a]	(0.13)	0.27	(0.33)	–0.03	(0.04)
14. Mineral oil refining	0.30[a]	(0.02)	0.12[a]	(0.03)	–0.48[a]	(0.21)
15. Mining	0.60[a]	(0.08)	0.18	(0.28)	0.71[a]	(0.16)
16. Electricity, gas and water	0.55[a]	(0.10)			–0.06	(0.16)
17. Construction	0.50[a]	(0.02)			0.06[a]	(0.03)
18. Housing services	0.70[a]	(0.17)			–0.30[a]	(0.12)
19. Distribution	0.65[a]	(0.06)			–0.16[a]	(0.03)
20. Sea and air transport services	1.11	(14.40)			–0.04	(0.10)
21. Other transport and communication	1.12[a]	(0.07)			–0.90[a]	(0.18)
22. Banking and insurance	0.77	(3.43)			0.006	(0.67)
23. Health services	0.79	(0.67)			0.01	(0.11)
24. Other services	0.88[a]	(0.05)			–0.16[a]	(0.05)

Asymptotic standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

Mining, Electricity, gas, and water, Construction, Housing services, and Distribution it lies between 0.50 and 0.75; in Meat and dairy and Paper and printing it is almost zero; and in the other 10 industries it lies between 0.25 and 0.75. The own elasticity is significantly different from 0 in 18 of the 24 industries.

Judged by the elasticity of the domestic price with respect to the price of the competing foreign product, foreign competition is important in Meat and dairy and Paper and printing; it is relatively unimportant in Other food, Clothing and leather, Timber and stone, and Mineral oil refining; in most other industries it is about as important as exogenous average cost. The elasticity with respect to the foreign price is significantly different from 0 in 8 of the 15 industries.

The elasticity with respect to income has a large positive value in Mining and a large negative value in Mineral oil refining and Other transport and communication services. Other industries where income is of some importance are Timber and stone, Primary metal products, Mineral oil refining, and Housing services. The elasticity with respect to income is significantly different from 0 in 11 of the 24 industries. The absolute size of the elasticity is positively correlated with the coefficient (δ_i) of the budget/cost share.

In Table 9.3 the row sums of the elasticity matrices are given; these measure the influence of exogenous average cost and foreign prices if we take also the off-diagonal elements into account. The row sum of the three columns in Table 9.3 is for each industry equal to one, as it should be according to equation (9.28). The off-diagonal elements of the elasticity matrices are in general not large (see Appendix 9.1), so that the first two columns of Table 9.3 are of about the same size as the first two columns of Table 9.2.

Industries where the absolute value of the row sum of the cross elasticities with respect to exogenous average cost is larger than 0.20 are Drink and tobacco, Mineral oil refining, Mining, Electricity, gas, and water, Housing services, Distribution, and Other transport and communication services. Industries where the absolute value of the sum of the cross elasticities with respect to foreign prices is larger than 0.20 are Other food, Drink and tobacco, Clothing and leather, Metal products and machinery, Electrical products, Transport equipment, Mineral oil refining, Mining, Construction, Housing services, and Other transport and communication services.

Industries where cross elasticities are larger than 0.10 or larger than the own elasticity are given in Tables 9.4 and 9.5. Most of these large cross elasticities are caused by large intermediate domestic or foreign inputs. There are 33 (i.e. 6 per cent) cross elasticities with respect to exogenous average cost that are significantly different from 0, but only 3 of them are larger than 0.10; and of the cross elasticities with respect to foreign prices there are 13 (i.e. 4 per cent) significantly different from 0, but only 4 of them are larger than 0.10.

I have also computed the elasticity matrices under some alternative assumptions. Firstly, I have tried several other values for the Slutsky factors ϕ_i: a. $\phi_i = \mu_i$ (i.e. additive preferences); b. the ϕ_i implied by the estimates of Keller and Van Driel (1982); c. the set of the smallest solutions of (9.30); d. the same values of ϕ_i as under c, with negative and complex values set to 0. These alternatives give for most industries nearly the same results as those reported above.

Secondly, I have computed the elasticity matrices under the assumption that price equals average cost. Then demand has no influence on prices, so that (9.26) changes to

$$\tilde{p}_d = (I - A'_d)^{-1}(A_l \tilde{l} + A'_m \tilde{p}_m).$$

The elasticities are for most industries not significantly different from those under imperfect competition. The only exceptions are Meat and dairy and Paper and Printing; these exceptions are probably caused by the very large absolute values of the

Table 9.3 *Sum of the elasticities*

	Row sums of the elasticity matrices with respect to					
	exogenous average cost		foreign prices		income	
1. Agriculture	0.31[a]	(0.03)	0.74[a]	(0.02)	–0.05	(0.15)
2. Meat and dairy	0.009[a]	(0.0001)	0.99[a]	(0.00007)	–0.002	(0.004)
3. Other food	0.33	(0.36)	0.39	(0.23)	0.27	(0.86)
4. Drink and tobacco	0.66	(1.47)	0.56	(1.50)	–0.22	(0.15)
5. Textiles	0.38[a]	(0.07)	0.45[a]	(0.13)	0.17	(0.13)
6. Clothing and leather	0.48[a]	(0.24)	0.36	(0.24)	0.16[a]	(0.04)
7. Paper and printing	0.01[a]	(0.00005)	0.99[a]	(0.00003)	–0.0002	(0.002)
8. Timber and stone	0.53	(0.37)	0.10	(0.37)	0.36[a]	(0.04)
9. Chemical products	0.37	(0.40)	0.50	(0.40)	0.13[a]	(0.05)
10. Primary metal products	0.30	(0.19)	0.38	(0.22)	0.32[a]	(0.09)
11. Metal products and machinery	0.45[a]	(0.01)	0.61[a]	(0.02)	–0.06	(0.08)
12. Electrical products	0.54[a]	(0.15)	0.60	(0.34)	–0.14	(0.21)
13. Transport equipment	0.46[a]	(0.02)	0.56[a]	(0.03)	–0.03	(0.04)
14. Mineral oil refining	0.59	(3.57)	0.89	(3.65)	–0.48[a]	(0.21)
15. Mining	0.35	(4.94)	–0.06	(4.98)	0.71[a]	(0.16)
16. Electricity, gas and water	0.82	(2.71)	0.24	(2.76)	–0.06	(0.16)
17. Construction	0.69[a]	(0.03)	0.25[a]	(0.03)	0.06[a]	(0.03)
18. Housing services	1.07	(0.78)	0.23	(0.82)	–0.30[a]	(0.12)
19. Distribution	0.99[a]	(0.05)	0.17[a]	(0.06)	–0.16[a]	(0.03)
20. Sea and air transport services	1.12	(72.38)	–0.08	(71.21)	–0.04	(0.10)
21. Other transport and communication	1.50	(2.16)	0.40	(2.24)	–0.90[a]	(0.18)
22. Banking and insurance	0.93	(3.54)	0.06	(6.52)	0.006	(0.67)
23. Health services	0.90[a]	(0.12)	0.09	(0.21)	0.01	(0.11)
24. Other services	0.99[a]	(0.05)	0.17[a]	(0.05)	–0.16[a]	(0.05)

Asymptotic standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

elasticities of substitution for these two industries.

9.6. Summary

In Chapters 6 and 7 I have derived a price equation that relates the output price of an industry to its marginal cost, its domestic market share, and its budget/cost share. Because the three explanatory variables are themselves functions of domestic and

Table 9.4 *Large cross elasticities with respect to exogenous average cost*

Industry	Elasticity with respect to exogenous average cost of		
2. Meat and dairy products:	1. Agriculture	0.004	(0.004)
	3. Other food products	0.0008	(0.001)
	19. Distribution	0.0007	(0.0009)
16. Electricity, gas and water:	15. Mining	0.15[a]	(0.06)
18. Housing services:	17. Construction	0.16[a]	(0.04)
19. Distribution:	21. Other transport and communication services	0.20[a]	(0.02)

Asymptotic standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

Table 9.5 *Large cross elasticities with respect to foreign prices*

Industry	Elasticity with respect to price of foreign product competing with		
3. Other food products:	1. Agriculture	0.22	(0.28)
5. Textiles:	9. Chemical products	0.15[a]	(0.03)
6. Clothing and leather:	5. Textiles	0.23[a]	(0.08)
11. Metal products and machinery:	10. Primary metal products	0.11[a]	(0.03)
13. Transport equipment:	11. Metal products and machinery	0.11[a]	(0.04)
14. Mineral oil refining:	15. Mining	0.50	(0.24)
16. Electricity, gas and water:	15. Mining	0.12	(0.21)

Asymptotic standard errors are in parentheses.
[a] Significantly different from 0 at 5% level.

foreign prices, I have made in this chapter a general-equilibrium analysis of the dependence of domestic prices on foreign prices, exogenous average cost, and income. It has been shown that domestic output prices are a linearly homogeneous function of foreign prices, exogenous average cost, and income, i.e. if these latter variables increase all by the same percentage, all domestic prices will also rise by that percentage. For two simple two-good cases I have shown that the elasticities of domestic prices with respect to foreign prices, marginal cost, and income are positive.

Using a model of consumer behaviour under substitution independence, I have computed for 1969 the elasticity matrices from the empirical results of Chapter 7. The income elasticity of domestic price is relatively high in Mining and it is appreciably negative in Mineral oil refining and Other transport and communication services. Foreign prices are important determinants of the domestic price in the industries Agriculture, Meat and dairy, and Paper and printing. Exogenous average cost is an important factor in domestic price formation in the services industries, Electricity, gas, and water, and Construction. Foreign prices and exogenous average cost are about equally important in the other industries.

Appendix 9.1. The elasticity matrices

Table 9.6 *Elasticities with respect to exogenous average cost*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0.221	0.000	0.036	0.000	0.000	0.000	0.000	0.002	0.006	0.000	0.002	0.000	0.000	0.002	0.001	0.002	0.002	-0.000	0.012	0.002	0.007	0.004	0.002	0.007
2	0.004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000
3	0.024	0.000	0.267	-0.001	0.000	-0.001	0.000	0.002	0.002	-0.000	0.003	-0.000	-0.000	0.003	0.000	0.003	0.003	0.002	0.025	-0.007	0.012	-0.002	-0.005	0.011
4	0.003	0.000	0.010	0.438	0.002	0.003	0.000	0.012	0.005	0.002	0.005	0.003	0.003	0.007	0.006	0.010	0.003	0.008	0.034	0.025	0.031	0.020	0.018	0.015
5	-0.004	-0.000	-0.004	-0.001	0.373	-0.001	0.000	-0.004	0.018	-0.001	-0.002	-0.001	-0.001	0.002	0.001	0.005	-0.013	-0.003	0.015	0.005	0.001	0.000	-0.003	0.003
6	-0.004	-0.000	-0.004	0.001	0.046	0.408	0.000	-0.005	0.007	-0.000	-0.002	-0.001	-0.000	0.002	0.001	0.003	-0.014	-0.001	0.016	0.012	0.007	0.004	0.002	0.003
7	0.000	-0.000	-0.000	-0.000	0.000	-0.000	0.009	0.000	0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	0.000	0.000	-0.000	0.000	-0.000	0.001	0.000	-0.000	0.001
8	-0.008	-0.000	-0.011	-0.002	0.003	-0.001	0.000	0.567	0.001	0.000	-0.003	-0.002	-0.001	0.003	0.022	0.010	-0.032	-0.007	0.013	0.014	-0.008	-0.001	-0.004	0.019
9	-0.008	-0.000	-0.005	-0.000	0.001	-0.001	0.000	-0.006	0.383	-0.000	0.001	-0.001	-0.001	0.014	0.012	0.019	-0.025	-0.005	-0.004	0.015	-0.009	0.002	-0.002	0.013
10	-0.006	-0.000	-0.007	-0.001	-0.002	-0.001	0.000	-0.006	-0.003	0.356	-0.001	0.002	0.000	0.001	0.003	0.010	-0.022	-0.004	-0.001	0.010	-0.010	0.002	-0.001	0.021
11	0.001	0.000	0.001	0.001	0.001	0.000	0.000	0.006	0.005	0.017	0.322	0.006	0.001	0.003	0.003	0.007	0.011	0.001	0.022	0.001	0.017	0.006	0.002	0.014
12	0.003	0.000	0.004	0.001	0.002	0.001	0.000	0.010	0.008	0.012	0.011	0.360	0.001	0.004	0.003	0.007	0.020	0.002	0.027	-0.003	0.028	0.008	0.001	0.029
13	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.014	0.007	0.015	0.034	0.009	0.308	0.002	0.002	0.006	0.009	0.000	0.021	0.000	0.015	0.005	-0.000	0.011
14	0.002	0.000	0.005	0.009	0.004	0.004	0.000	0.008	0.014	0.004	0.009	0.004	0.004	0.300	0.018	0.017	0.006	0.012	0.027	0.036	0.034	0.028	0.027	0.015
15	-0.019	-0.000	-0.019	0.001	-0.006	-0.001	0.000	-0.022	-0.006	-0.002	-0.009	-0.002	-0.000	-0.001	0.597	0.005	-0.068	-0.007	-0.065	0.050	-0.032	0.005	0.008	0.058
16	-0.004	-0.000	-0.003	0.005	0.000	0.002	0.000	-0.001	0.004	0.006	0.005	0.013	0.002	0.020	0.153	0.546	-0.008	0.004	0.000	0.033	0.014	0.017	0.016	0.003
17	-0.003	-0.000	-0.003	-0.000	0.001	-0.000	0.000	0.084	0.009	0.004	0.021	0.004	0.000	0.006	0.005	0.005	0.497	-0.002	0.030	0.004	0.014	0.003	-0.001	0.007
18	0.001	0.000	0.002	0.005	0.002	0.002	0.000	0.030	0.005	0.003	0.011	0.004	0.002	0.006	0.006	0.008	0.159	0.695	0.024	0.019	0.023	0.028	0.014	0.016
19	0.002	0.000	0.002	0.002	0.002	0.001	0.000	0.005	0.005	0.001	0.006	0.002	0.002	0.008	0.004	0.010	0.011	0.003	0.654	0.006	0.204	0.013	0.004	0.045
20	-0.002	-0.000	-0.004	-0.003	-0.001	-0.003	-0.000	-0.005	-0.000	-0.001	-0.000	-0.002	0.015	0.008	-0.004	-0.005	-0.004	-0.009	-0.013	1.110	0.063	-0.008	-0.018	0.005
21	0.004	0.000	0.006	0.009	0.006	0.004	0.001	0.012	0.012	0.005	0.013	0.008	0.010	0.019	0.011	0.024	0.018	0.011	0.042	0.032	1.122	0.037	0.023	0.074
22	-0.000	0.000	-0.000	-0.000	0.000	-0.001	0.000	0.001	0.002	0.000	0.005	0.000	0.000	0.005	0.002	0.007	0.007	-0.002	0.002	-0.002	0.076	0.774	-0.001	0.057
23	0.001	0.000	0.003	-0.000	0.002	-0.001	0.000	0.003	0.010	0.000	0.005	0.002	-0.000	0.005	0.002	0.008	0.009	-0.002	0.010	-0.003	0.015	0.000	0.795	0.031
24	0.001	0.000	0.004	0.016	0.001	0.000	0.000	0.003	0.004	0.003	0.005	0.005	0.002	0.005	0.003	0.009	0.001	0.000	0.013	0.006	0.019	0.005	0.002	0.881

Table 9.7 *Standard errors elasticities with respect to exogenous average cost*

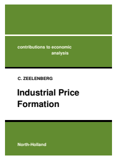
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0.055	0.000	0.056	0.008	0.003	0.003	0.000	0.006	0.004	0.003	0.004	0.003	0.003	0.006	0.006	0.010	0.005	0.011	0.016	0.106	0.024	0.039	0.019	0.009
2	0.004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.005	0.001	0.002	0.001	0.000
3	0.027	0.000	0.385	0.042	0.014	0.019	0.001	0.031	0.016	0.014	0.017	0.015	0.014	0.030	0.033	0.050	0.026	0.058	0.070	0.442	0.128	0.126	0.100	0.042
4	0.018	0.000	0.060	0.050	0.016	0.023	0.002	0.044	0.020	0.016	0.022	0.021	0.018	0.016	0.042	0.064	0.038	0.076	0.125	1.996	0.025	0.483	0.151	0.050
5	0.003	0.000	0.005	0.011	0.031	0.005	0.000	0.008	0.005	0.003	0.004	0.004	0.004	0.007	0.009	0.014	0.008	0.016	0.024	0.338	0.020	0.065	0.030	0.008
6	0.007	0.000	0.014	0.019	0.009	0.030	0.001	0.018	0.008	0.006	0.009	0.008	0.007	0.006	0.017	0.026	0.015	0.030	0.050	0.813	0.009	0.166	0.057	0.020
7	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.001	0.001	0.001	0.000
8	0.008	0.000	0.013	0.024	0.008	0.012	0.001	0.044	0.010	0.008	0.011	0.010	0.009	0.007	0.021	0.032	0.019	0.037	0.062	1.018	0.007	0.181	0.068	0.025
9	0.008	0.000	0.017	0.025	0.008	0.012	0.001	0.023	0.039	0.008	0.011	0.010	0.009	0.008	0.022	0.034	0.020	0.039	0.064	1.048	0.011	0.205	0.072	0.026
10	0.006	0.000	0.010	0.018	0.006	0.009	0.001	0.016	0.007	0.053	0.008	0.008	0.007	0.007	0.015	0.024	0.014	0.027	0.044	0.714	0.017	0.140	0.051	0.017
11	0.001	0.000	0.003	0.003	0.001	0.001	0.000	0.002	0.001	0.006	0.090	0.004	0.001	0.002	0.002	0.003	0.006	0.004	0.007	0.070	0.004	0.040	0.008	0.006
12	0.003	0.000	0.009	0.030	0.008	0.013	0.001	0.013	0.007	0.004	0.006	0.207	0.010	0.022	0.022	0.034	0.011	0.038	0.046	0.277	0.073	0.066	0.072	0.007
13	0.002	0.000	0.004	0.011	0.003	0.005	0.000	0.004	0.003	0.005	0.015	0.006	0.129	0.009	0.008	0.012	0.002	0.015	0.016	0.034	0.030	0.031	0.027	0.005
14	0.027	0.000	0.077	0.074	0.026	0.036	0.003	0.068	0.032	0.024	0.035	0.033	0.028	0.025	0.066	0.100	0.059	0.118	0.194	3.117	0.034	0.752	0.237	0.078
15	0.030	0.000	0.059	0.086	0.030	0.042	0.004	0.080	0.037	0.028	0.039	0.037	0.032	0.026	0.079	0.118	0.070	0.136	0.227	3.705	0.028	0.705	0.260	0.090
16	0.023	0.000	0.056	0.064	0.022	0.031	0.003	0.060	0.028	0.021	0.030	0.033	0.024	0.020	0.059	0.098	0.052	0.102	0.169	2.729	0.027	0.604	0.200	0.067
17	0.003	0.000	0.004	0.007	0.002	0.003	0.000	0.009	0.003	0.002	0.007	0.005	0.003	0.002	0.006	0.010	0.020	0.011	0.019	0.298	0.003	0.069	0.020	0.008
18	0.013	0.000	0.035	0.035	0.012	0.017	0.001	0.032	0.015	0.012	0.017	0.016	0.013	0.013	0.031	0.047	0.044	0.171	0.092	1.435	0.026	0.416	0.110	0.038
19	0.003	0.000	0.011	0.010	0.003	0.005	0.000	0.008	0.004	0.003	0.005	0.005	0.004	0.004	0.008	0.012	0.008	0.015	0.063	0.359	0.022	0.127	0.029	0.012
20	0.113	0.000	0.187	0.323	0.111	0.158	0.014	0.303	0.139	0.105	0.148	0.126	0.114	0.088	0.293	0.449	0.268	0.498	0.858	14.399	0.044	0.731	0.838	0.333
21	0.021	0.000	0.063	0.058	0.020	0.028	0.002	0.054	0.025	0.019	0.028	0.028	0.024	0.020	0.052	0.078	0.046	0.092	0.152	2.412	0.073	0.649	0.184	0.062
22	0.032	0.000	0.055	0.109	0.037	0.049	0.003	0.085	0.044	0.034	0.034	0.036	0.035	0.064	0.080	0.102	0.042	0.152	0.254	0.328	0.059	3.432	0.240	0.127
23	0.005	0.000	0.007	0.020	0.005	0.009	0.001	0.014	0.002	0.006	0.006	0.006	0.007	0.011	0.015	0.019	0.006	0.029	0.041	0.224	0.057	0.057	0.671	0.006
24	0.003	0.000	0.014	0.009	0.003	0.004	0.000	0.008	0.004	0.003	0.005	0.006	0.004	0.003	0.008	0.012	0.007	0.014	0.024	0.370	0.008	0.089	0.027	0.050

Table 9.8 *Elasticities with respect to foreign prices*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.675	0.005	0.014	0.001	0.002	-0.000	0.008	0.001	0.017	0.002	0.004	0.001	0.000	0.003	0.005
2	0.014	0.977	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
3	0.216	0.040	0.107	0.000	-0.001	-0.001	0.015	0.001	0.014	-0.001	0.005	-0.002	-0.003	0.004	0.002
4	0.019	0.010	0.017	0.303	0.010	0.005	0.067	0.017	0.026	0.016	0.016	0.012	0.013	0.006	0.024
5	-0.017	-0.007	-0.004	-0.001	0.344	-0.001	0.014	-0.004	0.150	-0.005	-0.009	-0.006	-0.004	0.001	-0.001
6	-0.016	0.024	-0.004	0.001	0.235	0.062	0.024	-0.005	0.043	-0.002	-0.002	-0.004	-0.001	0.001	0.002
7	0.000	-0.000	-0.000	-0.000	0.000	-0.000	0.988	0.000	0.001	0.000	0.000	-0.000	-0.000	0.000	0.000
8	-0.013	-0.025	-0.011	-0.002	0.000	-0.002	0.010	0.133	0.007	0.010	-0.013	-0.013	-0.009	0.005	0.026
9	-0.034	-0.017	0.004	-0.000	-0.005	-0.002	0.043	-0.007	0.510	-0.004	-0.013	-0.009	-0.007	0.012	0.033
10	-0.029	-0.016	-0.007	-0.001	-0.008	-0.001	0.004	-0.008	-0.004	0.432	-0.011	-0.004	-0.004	0.014	0.026
11	0.006	0.003	0.002	0.001	0.003	0.001	0.017	0.005	0.019	0.106	0.406	0.028	0.003	0.004	0.010
12	0.016	0.009	0.004	0.001	0.007	0.001	0.020	0.010	0.044	0.076	0.057	0.333	0.004	0.004	0.013
13	0.003	0.001	0.001	0.000	0.003	0.000	0.009	0.008	0.026	0.075	0.114	0.035	0.274	0.003	0.009
14	0.011	0.009	0.006	0.009	0.014	0.007	0.069	0.009	0.055	0.024	0.027	0.018	0.019	0.115	0.502
15	-0.086	-0.048	-0.020	0.001	-0.021	-0.002	0.029	-0.019	-0.022	-0.014	-0.014	-0.018	-0.009	0.000	0.184
16	-0.018	-0.009	-0.003	0.005	0.002	0.003	0.047	0.000	0.017	0.017	0.014	0.016	0.008	0.017	0.120
17	-0.007	-0.007	-0.003	-0.000	-0.001	-0.001	0.012	0.091	0.033	0.041	0.052	0.017	-0.002	0.006	0.020
18	0.006	0.004	0.003	0.004	0.007	0.003	0.038	0.033	0.022	0.025	0.029	0.015	0.010	0.006	0.023
19	0.008	0.005	0.002	0.002	0.005	0.001	0.054	0.005	0.023	0.008	0.015	0.007	0.007	0.008	0.019
20	-0.011	-0.005	-0.004	-0.004	-0.008	-0.005	-0.033	-0.006	-0.005	-0.010	0.004	-0.010	0.010	0.009	0.000
21	0.019	0.014	0.007	0.008	0.016	0.006	0.074	0.013	0.050	0.027	0.040	0.023	0.025	0.025	0.053
22	-0.001	0.000	-0.001	-0.000	-0.001	-0.001	0.041	0.001	0.007	-0.000	0.008	-0.001	-0.000	0.002	0.007
23	0.005	0.014	0.001	-0.000	0.001	-0.001	0.008	0.002	0.038	0.002	0.009	0.002	-0.001	0.004	0.010
24	0.005	0.017	0.002	0.015	0.002	0.000	0.032	0.001	0.019	0.007	0.016	0.009	0.029	0.004	0.012

Table 9.9 *Standard errors elasticities with respect to foreign prices*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.167	0.006	0.063	0.007	0.010	0.005	0.042	0.007	0.015	0.016	0.013	0.013	0.013	0.006	0.028
2	0.013	0.024	0.001	0.000	0.000	0.000	0.002	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.001
3	0.277	0.028	0.441	0.038	0.055	0.029	0.212	0.037	0.070	0.088	0.071	0.069	0.071	0.032	0.148
4	0.091	0.053	0.068	0.065	0.074	0.036	0.284	0.051	0.099	0.107	0.074	0.102	0.056	0.019	0.152
5	0.013	0.009	0.006	0.011	0.453	0.008	0.069	0.009	0.025	0.023	0.014	0.018	0.015	0.007	0.037
6	0.033	0.021	0.016	0.019	0.075	0.057	0.115	0.021	0.040	0.043	0.029	0.038	0.022	0.007	0.061
7	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001
8	0.040	0.026	0.015	0.023	0.038	0.018	0.143	0.061	0.049	0.053	0.036	0.045	0.026	0.009	0.075
9	0.042	0.027	0.020	0.024	0.039	0.019	0.148	0.026	0.114	0.055	0.038	0.048	0.028	0.009	0.078
10	0.029	0.019	0.011	0.017	0.026	0.013	0.107	0.018	0.035	0.296	0.026	0.039	0.021	0.008	0.056
11	0.007	0.003	0.004	0.003	0.004	0.002	0.016	0.003	0.006	0.033	0.183	0.021	0.004	0.002	0.008
12	0.016	0.016	0.011	0.029	0.032	0.019	0.170	0.016	0.029	0.027	0.017	1.080	0.046	0.024	0.100
13	0.008	0.008	0.005	0.011	0.013	0.007	0.065	0.005	0.012	0.023	0.040	0.029	0.334	0.009	0.038
14	0.136	0.083	0.088	0.073	0.116	0.056	0.442	0.080	0.154	0.166	0.115	0.159	0.087	0.033	0.237
15	0.150	0.097	0.068	0.085	0.131	0.065	0.520	0.093	0.179	0.193	0.132	0.173	0.096	0.032	0.284
16	0.115	0.072	0.064	0.063	0.099	0.049	0.386	0.069	0.134	0.144	0.099	0.159	0.074	0.025	0.207
17	0.012	0.008	0.005	0.007	0.011	0.005	0.043	0.012	0.015	0.017	0.017	0.024	0.008	0.003	0.023
18	0.064	0.039	0.040	0.035	0.055	0.027	0.208	0.038	0.073	0.079	0.056	0.077	0.043	0.016	0.113
19	0.017	0.010	0.012	0.009	0.015	0.007	0.054	0.010	0.019	0.021	0.015	0.023	0.013	0.004	0.030
20	0.559	0.365	0.214	0.317	0.474	0.245	1.993	0.353	0.679	0.723	0.491	0.574	0.328	0.103	1.026
21	0.107	0.065	0.072	0.057	0.092	0.044	0.345	0.062	0.121	0.130	0.091	0.133	0.072	0.024	0.186
22	0.158	0.111	0.062	0.104	0.146	0.075	0.411	0.099	0.201	0.227	0.167	0.172	0.178	0.084	0.359
23	0.024	0.009	0.010	0.020	0.026	0.014	0.110	0.017	0.012	0.042	0.030	0.031	0.034	0.014	0.066
24	0.018	0.010	0.016	0.009	0.015	0.007	0.054	0.010	0.019	0.021	0.015	0.028	0.011	0.004	0.029



APPENDICES

APPENDIX A

Two-stage budgeting

In this book foreign competition has a prominent place in price formation; to model this I have used the theory of two-stage budgeting. This Appendix gives a derivation of the formulae for the price elasticities that have been used in Chapters 6 and 7; the results can be extended to budgeting in an arbitrary number of stages. I assume that the reader is familiar with consumer and producer theory; see for example Varian (1978, Chapters 1 and 3), Deaton and Muellbauer (1980, Chapter 2), and Diewert (1982).

A.1. Consumer demand under two-stage budgeting

In Chapters 5, 6, and 7 the consumer is supposed to allocate his budget in two stages: first he allocates his income to goods and then for each good he allocates the expenditure on it to two products: a domestic one and a foreign one. In this Appendix I shall generalize this by assuming that there is an arbitrary number of products of each good.

Two-stage budgeting[1]

Let there be N goods and n_G products of good G ($G = 1, 2, \ldots, N$). I assume that the preferences of the consumer can be represented by a utility function u that is twice continuously-differentiable, strictly quasi-concave, and increasing in its arguments:

$$u(q) = u[q_{11}, q_{12}, \ldots, q_{1n_1}; q_{21}, q_{22}, \ldots, q_{2n_2}; \cdots; q_{N1}, q_{N2}, \ldots, q_{Nn_N}],$$

where q_{Gi} ($G = 1, 2, \ldots, N$; $i = 1, 2, \ldots, n_G$) is the quantity of product i of good G. The consumer's allocation problem is to maximize the utility function subject to his budget constraint:

$$\begin{aligned} &\max\ u(q) \\ &\text{s.t.} \sum_{G=1}^{N} \sum_{i=1}^{n_G} p_{Gi} q_{Gi} = y, \end{aligned} \qquad \text{(A.1)}$$

[1] This subsection draws on Deaton and Muellbauer (1980, pp. 129-31).

where p_{Gi} is the price of product Gi, and y is income.

It can be shown that, if the consumer allocates his income in two stages, his preferences must be separable in the goods; i.e. his utility function can be written as

$$u(q) = U[u_1(q_1), u_2(q_2), \ldots, u_N(q_N)],$$

where $q_G = (q_{G1}, q_{G2}, \ldots, q_{Gn_G})$ and U and u_G $(G = 1, 2, \ldots, N)$ are twice continuously-differentiable, strictly quasi-concave, and increasing in the arguments; U is called the macro-utility function, and the u_G are called the sub-utility functions.

The allocation in the second stage is now simply to maximize the u_G subject to the constraint that total expenditure on good G equals the expenditure on it determined in the first stage:

$$\max u_G(q_G)$$
$$\text{s.t.} \sum_{i=1}^{n_G} p_{Gi} q_{Gi} = y_G,$$

where y_G is determined in the first stage. The solution of this maximization gives demand functions q_{Gi} that are functions of the prices p_{Gi} and the budget y_G:

$$q_{Gi} = f_{Gi}(y_G, p_G), \;\; G = 1, 2, \ldots, N, \tag{A.2}$$

where $p_G = (p_{G1}, p_{G2}, \ldots, p_{Gn_G})$ is the vector with prices of the products of good G.

The allocation in the first stage is not so easy. Gorman (1959) has shown that the two-stage procedure gives the same demands for the products as the one-stage procedure (A.1) only if one of the following two conditions holds:

1. there are two goods;
2. the macro-utility function can be written as

$$U = F\{u_1(q_1) + u_2(q_2) + \cdots + u_d(q_d)$$
$$+ f[u_{d+1}(q_{d+1}), u_{d+2}(q_{d+2}), \ldots, u_N(q_N)]\},$$

where $0 \le d \le N$, u_G is linearly homogeneous for $G = d+1, d+2, \ldots, N$, and the indirect utility function corresponding to u_G $(G = 1, 2, \ldots, d)$ is

$$\psi_G(p_G, y_G) = F_G\left[\frac{y_G}{h_G(p_G)}\right] + a_G(p_G) \tag{A.3}$$

with F_G monotonically increasing and h_G and a_G linearly homogeneous.

The form (A.3) is called the Gorman generalized polar form.

In Sections 6.2 and 7.1 I have assumed that condition 2 holds for $d = 0$, i.e. all sub-utility functions are homogeneous. Then the expenditure function c_G corresponding to u_G is [see Deaton and Muellbauer (1980, p. 143)]

$$c_G(u_G, p_G) = u_G b_G(p_G), \tag{A.4}$$

where b_G is linearly homogeneous.

If the allocation at the second stage is optimally carried out, there holds

$$y_G = c_G. \tag{A.5}$$

Using (A.4) and (A.5), we can now write the consumer's allocation problem (A.1) as

$$\begin{aligned} &\max U(u_1, u_2, \ldots, u_N) \\ &\text{s. t.} \sum_{G=1}^{N} u_G b_G(p_G) = y. \end{aligned} \tag{A.6}$$

Thus the sub-utility functions u_G can be interpreted as quantity indices and the unit cost functions b_G as price indices that make the first stage possible. The maximization problem (A.6) gives demand functions for the goods that are functions of income y and the price indices b_G:

$$u_G = f_G(y, b_1, b_2, \ldots, b_N). \tag{A.7}$$

The budget for good G, which is given in the second stage, is the product of the price and quantity indices:

$$y_G = u_G b_G. \tag{A.8}$$

A similar analysis can be made for the Gorman generalized polar form. The model of Section 5.6 is an example of the Gorman generalized polar form.

The quantity and price indices u_G and b_G can be interpreted as Divisia indices. For we have

$$\frac{\partial \log b_G}{\partial \log p_{Gi}} = \frac{\partial \log c_G}{\partial \log p_{Gi}} = \frac{p_{Gi} q_{Gi}}{y_G} = w_i^G, \tag{A.9}$$

where the second equality sign is based on Shephard's Lemma [see Diewert (1982, p. 546) or Deaton and Muellbauer (1980, pp. 40 and 43, Exercise 2.13)], and w_i^G is the within-good budget share of product Gi. Therefore

$$\tilde{b}_G = \sum_{i=1}^{n_G} w_i^G \tilde{p}_{Gi}, \tag{A.10}$$

where a tilde denotes a relative differential [for example $\tilde{b}_G = (\mathrm{d}b_G)/b_G$]. Similarly, we have

$$\frac{\partial \log u_G}{\partial \log q_{Gi}} = \frac{q_{Gi}}{\sum_j (\partial u_G / \partial q_{Gj})} \frac{\partial u_{Gi}}{\partial q_{Gi}} = \frac{p_{Gi} q_{Gi}}{y_G} = w_i^G,$$

where the first equality sign is based on Euler's Theorem and the second on Wold's Identity [see Diewert (1982, p. 557) or Deaton and Muellbauer (1980, p. 84, Exercise 3.12)]. Therefore

$$\tilde{u}_G = \sum_{i=1}^{n_G} w_i^G \tilde{q}_{Gi}. \tag{A.11}$$

Elasticities under two-stage budgeting

I shall derive formulae for the elasticities under two-stage budgeting when the sub-utility functions are homogeneous. To obtain the price elasticities of demand we differentiate (A.2) logarithmically:

$$\frac{\partial \log q_{Gi}}{\partial \log p_{Hj}} = \frac{\partial \log f_{Gi}}{\partial \log y_G} \frac{\partial \log y_G}{\partial \log p_{Hj}} + \frac{\partial \log f_{Gi}}{\partial \log p_{Hj}} \delta_{GH},$$

where δ_{GH} is the Kronecker delta ($\delta_{GH} = 1$ if $G = H$ and $\delta_{GH} = 0$ if $G \neq H$). Using (A.7) and (A.8) we get

$$\frac{\partial \log q_{Gi}}{\partial \log p_{Hj}} = \frac{\partial \log f_{Gi}}{\partial \log y_G} \left\{ \frac{\partial \log f_G}{\partial \log b_H} \frac{\partial \log b_H}{\partial \log p_{Hj}} + \frac{\partial \log b_G}{\partial \log p_{Hj}} \delta_{GH} \right\} + \frac{\partial \log f_{Gi}}{\partial \log p_{Hj}} \delta_{GH}. \tag{A.12}$$

Since the sub-utility functions are homogeneous, there holds

$$\frac{\partial \log f_{Gi}}{\partial \log y_G} = 1. \tag{A.13}$$

Using (A.9) and (A.13) we get from (A.12)

$$\frac{\partial \log q_{Gi}}{\partial \log p_{Hj}} = \frac{\partial \log f_{Gi}}{\partial \log p_{Gj}} \delta_{GH} + w_j^H \left(\frac{\partial \log f_G}{\partial \log b_H} + \delta_{GH} \right),$$

or, in elasticity notation,

$$\varepsilon_{Gi,Hj} = \varepsilon_{ij}^G \delta_{GH} + w_j^H (\varepsilon_{GH} + \delta_{GH}), \tag{A.14}$$

$$i = 1, 2, \ldots, n_G, \;\; j = 1, 2, \ldots, n_H, \;\; G, H = 1, 2, \ldots, N,$$

where $\varepsilon_{Gi,Hj} = \partial \log q_{Gi} / \partial \log p_{Hj}$ is the elasticity of demand for product Gi with respect to the price of product Hj, $\varepsilon_{ij}^G = \partial \log f_{Gi} / \partial \log p_{Gi}$ is the within-good elasticity of demand for product Gi with respect to the price of product Gj, and $\varepsilon_{GH} = \partial \log f_G / \partial \log p_H$ is the elasticity of demand for good G with respect to the price of good H.

In a similar way one can derive for the income elasticities

$$\frac{\partial \log q_{Gi}}{\partial \log y} = \frac{\partial \log f_G}{\partial \log y},$$

or, in elasticity notation,

$$\eta_{Gi} = \eta_G, \;\; i = 1, 2, \ldots, n_G, \;\; G = 1, 2, \ldots, N. \tag{A.15}$$

Thus all products of a good have the same income elasticities.

The Slutsky equation for products is

$$\varepsilon_{Gi,Hj} = \overset{*}{\varepsilon}_{Gi,Hj} - w_{Hj} \eta_{Gi},$$

where an asterisk denotes a compensated elasticity, and $w_{Hj} = p_{Hj}q_{Hj}/y$ is the budget share of product Hj. The within-good Slutsky equation for products is

$$\varepsilon_{ij}^{G} = \varepsilon_{ij}^{*G} - w_{j}^{G}$$

(remember that the within-good income elasticities $\partial \log f_{Gi}/\partial \log y_G$ are equal to 1). The Slutsky equation for goods is

$$\varepsilon_{GH} = \overset{*}{\varepsilon}_{GH} - w_H \eta_G,$$

where w_H is the budget share of good H.

Using (A.14), (A.15), and the three Slutsky equations one easily shows that

$$\overset{*}{\varepsilon}_{Gi,Hj} = \varepsilon_{ij}^{*G} \delta_{GH} + w_{j}^{H} \overset{*}{\varepsilon}_{GH}. \tag{A.16}$$

There are three elasticities of substitution: the elasticity of substitution between products:

$$\sigma_{Gi,Hj} = \frac{\overset{*}{\varepsilon}_{Gi,Hj}}{w_{Hj}},$$

the within-good elasticity of substitution between products:

$$\sigma_{ij}^{G} = \frac{\varepsilon_{ij}^{*G}}{w_{j}^{G}},$$

and the elasticity of substitution between goods:

$$\sigma_{GH} = \frac{\overset{*}{\varepsilon}_{GH}}{w_H}.$$

From (A.16) and these three definitions of the elasticities of substitution we get

$$\sigma_{Gi,Hj} = \sigma_{GH} + \frac{1}{w_G} \sigma_{ij}^{G} \delta_{GH}. \tag{A.17}$$

In particular, if $G \neq H$ there holds

$$\sigma_{Gi,Hj} = \sigma_{GH},$$

which is independent of i and j.

An alternative expression of (A.14) can now be derived:

$$\varepsilon_{Gi,Hj} = w_{j}^{H} (\sigma_{ij}^{G} \delta_{GH} + \varepsilon_{GH}).$$

A.2. Producer demand under two-stage budgeting

The derivations for a cost-minimizing producer are analogous to the derivations for a utility-maximizing consumer. As may be expected, the equations for the elasticities of producer demand are in form identical to those for the compensated elasticities of consumer demand. Therefore I give only the results. There holds

$$\varepsilon_{Gi,Hj} = \varepsilon_{ij}^{G} \delta_{GH} + w_{j}^{H} \varepsilon_{GH}, \tag{A.18}$$

where $\varepsilon_{Gi,Hj}$ is the elasticity of producer demand for product Gi with respect to the price of good Hj, ε_{ij}^{G} is the within-good elasticity of demand for product Gi with respect to the price of product Hj, ε_{GH} is the elasticity of demand for good G with respect to the price of good H, and w_j^H is the within-good cost share of product Hj (i.e. $w_j^H = w_{Hj}/w_H$, where w_{Hj} is the cost share of product Hj and w_H is the cost share of good H).

For the elasticities of substitution there holds

$$\sigma_{Gi,Hj} = \sigma_{GH} + \frac{1}{w_G}\,\sigma_{ij}^{G}\delta_{GH}, \tag{A.19}$$

where the definitions of the elasticities of substitution are analogous to the definitions for consumer behaviour in Appendix A.1 above.

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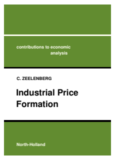

APPENDIX B

Consumer and producer demand systems

This appendix gives a survey of the two consumer and producer demand systems (the constant-elasticity-of-substitution (CES) demand system and the Rotterdam system) that are used in the main text. The notations in the two sub-appendices are identical, and are therefore introduced only once, in B.1.

B.1. The CES demand system[1]

Consumer behaviour

The constant-elasticity-of-substitution (CES) utility function is

$$u(q) = \left(\sum_{i=1}^{N} \delta_i^{1+\rho} q_i^{-\rho} \right)^{-1/\rho},$$

where q_i is the quantity of good i and N is the number of goods. It is assumed that $\rho \geq -1$, $0 < \delta_i < 1$, and $\sum_{i=1}^{N} \delta_i = 1$. It can be shown that the elasticity of substitution between goods i and j ($j \neq i$) is independent of i and j and is positive:

$$\sigma = \frac{1}{1+\rho}. \tag{B.1}$$

Some special cases of the CES utility function are given in Table B.1.

$$\max u(q)$$
$$\text{s. t.} \sum_{i=1}^{N} p_i q_i = y,$$

where y is income, and p_i is the price of good i. It is tedious, but straightforward, to show that the demand functions are

$$q_i(p, y) = y \frac{\delta_i p_i^{-\sigma}}{\sum_{j=1}^{N} \delta_j p_j^{1-\sigma}}. \tag{B.2}$$

The demand functions are obtained as the solution of Therefore we have

$$\log \frac{q_i}{q_j} = \log \frac{\delta_i}{\delta_j} - \sigma \log \frac{p_i}{p_j}.$$

[1] Cf. Layard and Walters (1978, pp. 272—5).

Table B.1 *Special cases of the CES utility function*

ρ	σ	utility function	
0	1	$\prod_{i=1}^{N} q_i^{\delta_i}$	(Cobb-Douglas)
−1	∞	$\sum_{i=1}^{N} q_i$	(perfect substitutes)
∞	0	$\min_i \frac{q_i}{\delta_i}$	(Leontief)

The budget share of good i is

$$w_i = \frac{p_i q_i}{y} = \frac{\delta_i p_i^{1-\sigma}}{\sum_{j=1}^{N} \delta_j p_j^{1-\sigma}}.$$

The relative change in the budget share is thus

$$\tilde{w_i} = \frac{\mathrm{d}w_i}{w_i} = (1-\sigma)(\tilde{p}_i - \tilde{P}), \tag{B.3}$$

where $\tilde{P} = \sum_{j=1}^{N} w_j \tilde{p}_j$ (i.e. P is the Divisia index of the prices). We see that the change in the budget share is proportional to the change in the relative price p_i/P; if σ > 1 then an increase in the relative price leads to a decrease in the budget share, if σ < 1 then an increase in the relative price leads to an increase in the budget share, and if σ = 1 then a change in the relative price does not influence the budget share.

We get the indirect utility function by substituting the demand functions (B.2) into the utility function; this gives

$$\psi(p, y) = \frac{y}{\left(\sum_{i=1}^{N} \delta_i p_i^{1-\sigma}\right)^{1/(1-\sigma)}};$$

the indirect utility function gives thus maximum utility that can be obtained with income y and prices p. We get the expenditure function by inverting the indirect utility function:

$$e(p, u) = u\left(\sum_{i=1}^{N} \delta_i p_i^{1-\sigma}\right)^{1/(1-\sigma)}.$$

Using (B.1) and (B.2), one easily shows that the following elasticity formulae hold:

$$\eta_i = \frac{\partial \log q_i}{\partial \log y} = 1,$$

$$\varepsilon_{ij}^* = \left.\frac{\partial \log q_i}{\partial \log p_j}\right|_{u\text{ const.}} = \sigma w_j, \;\; j \neq i,$$

$$\varepsilon_{ii}^* = \left.\frac{\partial \log q_i}{\partial \log p_i}\right|_{u\text{ const.}} = -\sum_{j\neq i} \varepsilon_{ij}^* = \sigma(w_i - 1),$$

$$\varepsilon_{ij} = \frac{\partial \log q_i}{\partial \log p_j} = \varepsilon_{ij}^* - w_j \eta_i = (\sigma - 1) w_j, \;\; j \neq i,$$

$$\varepsilon_{ii} = \frac{\partial \log q_i}{\partial \log p_i} = \varepsilon_{ii}^* - w_i \eta_i = \sigma(w_i - 1) - w_{i,} \;\; i,\, j = 1, 2, \ldots, N.$$

Thus all income elasticities are equal to one, and all goods are net substitutes; if $\sigma > 1$ then all goods are gross substitutes, and if $\sigma < 1$ then all goods are gross complements.

Producer behaviour

The CES production function is

$$q(v) = A\left(\sum_{i=1}^{N} \delta_i^{1+\rho} v_i^{-\rho}\right)^{-\nu/\rho},$$

where v_i is the quantity of input i, q is output, and A is the efficiency factor. It is assumed that $\rho \geq -1$, $0 < \delta_i < 1$, and $\sum_{i=1}^{N} \delta_i = 1$. It can be shown that the elasticity of substitution between inputs i and j ($j \neq i$) is independent of i and j and is positive:

$$\sigma = \frac{1}{1+\rho}\,.$$

The elasticity of scale is

$$\left(\frac{\partial \log C}{\partial \log q}\right)^{-1} = \nu,$$

where C is the total cost function (see below). Some special cases of the CES production function are given in Table B.2.

The cost-minimizing input demand functions are found as the solution of

$$\min \sum_{i=1}^{N} r_i v_i \quad \text{s. t. } q(v) = q,$$

where r_i is the price of input i. It can be shown that the demand functions are

$$v_i(q, r) = \left(\frac{q}{A}\right)^{\frac{1}{\nu}} \frac{\delta_i r_i^{-\sigma}}{\left(\sum_{j=1}^{N} \delta_j r_j^{1-\sigma}\right)^{\sigma/(\sigma-1)}}\,.$$

Table B.2 *Special cases of the CES production function*

ρ	σ	production function	
0	1	$\prod_{i=1}^{N} v_i^{\delta_i}$	(Cobb-Douglas)
−1	∞	$\sum_{i=1}^{N} v_i$	(perfect substitutes)
∞	0	$\min_i \frac{v_i}{\delta_i}$	(Leontief)

Therefore

$$\log \frac{v_i}{v_j} = \log \frac{\delta_i}{\delta_j} - \sigma \log \frac{r_i}{r_j} .$$

The cost function is obtained by multiplication of the demand functions by r_i and summation over i:

$$C(q,\ p) = \left(\frac{q}{A} \right)^{1/\nu} \left(\sum_{i=1}^{N} \delta_i r_i^{1-\sigma} \right)^{1/(1-\sigma)} .$$

Thus, the cost share of input i is

$$w_i = \frac{r_i v_i}{C} = \frac{\delta_i r_i^{1-\sigma}}{\sum_{j=1}^{N} \delta_j r_j^{1-\sigma}} ,$$

so that the relative change in the cost share is

$$\tilde{w}_i = \frac{\mathrm{d}w_i}{w_i} = (1 - \sigma)(\tilde{r}_i - \tilde{R}),$$

where R is the Divisia index of the input prices (i.e. $\tilde{R} = \sum_{j=1}^{N} w_j \tilde{r}_j$). The change in the cost share is proportional to the change in the relative price r_i/R; if $\sigma > 1$ then a rise in the relative price leads to a fall in the cost share, if $\sigma < 1$ then a rise in the relative price leads to a rise in the cost share, and if $\sigma = 1$ then a change in the relative price does not influence the cost share.

For the elasticities the following formulae hold:

$$\eta_i = \frac{\partial \log v_i}{\partial \log q} = \frac{1}{\nu} ,$$

$$\varepsilon_{ij} = \frac{\partial \log v_i}{\partial \log r_j} = \sigma w_j, \quad j \neq i,$$

$$\varepsilon_{ii} = \frac{\partial \log v_i}{\partial \log r_i} = -\sum_{j \neq i} \varepsilon_{ij} = \sigma(w_i - 1).$$

Thus all inputs are substitutes.

B.2. The Rotterdam system[2]

Consumer behaviour

The Rotterdam system is a flexible demand system, i.e. its price and income elasticities are not a priori restricted. Consider an arbitrary demand function[3]

$$q_i = q_i(p, y), \;\; i = 1, 2, \ldots, N.$$

Totally differentiating this demand function, we get

$$\tilde{q}_i = \eta_i \tilde{y} + \sum_{j=1}^{N} \varepsilon_{ij} \tilde{p}_j.$$

Using the Slutsky equation $\varepsilon_{ij} = \varepsilon^*_{ij} - w_j \eta_i$, we can write this as

$$\tilde{q}_i = \eta_i (\tilde{y} - \sum_{j=1}^{N} w_j \tilde{p}_j) + \sum_{j=1}^{N} \varepsilon^*_{ij} \tilde{p}_j.$$

Multiplying by the budget share w_i, we get

$$w_i \tilde{q}_i = \mu_i (\tilde{y} - \tilde{P}) + \sum_{j=1}^{N} \pi_{ij} \tilde{p}_j, \qquad \text{(B.4)}$$

where $\mu_i = w_i \eta_i$ is the marginal budget share of good i, P is the Divisia index of the prices and $\pi_{ij} = w_i \varepsilon^*_{ij}$; the π_{ij} are called the *Slutsky coefficients*. Note that $\tilde{y} - \tilde{P}$ is the change in real income. The term π_{ij} is equal to

$$\pi_{ij} = w_i \varepsilon^*_{ij} = \frac{p_i p_j}{y} \left. \frac{\partial q_i}{\partial p_j} \right]_{u \text{ const.}}.$$

Because the Slutsky substitution matrix $(\partial q_i / \partial p_j)\big]_{u \text{ const.}}$ is symmetric and negative semi-definite, (π_{ij}) is also symmetric and negative semi-definite. Because $\sum_{j=1}^{N} \varepsilon^*_{ij} = 0$, there holds $\sum_{j=1}^{N} \pi_{ij} = 0$.

Since (B.4) is derived from an arbitrary demand function, every demand system can be expressed in parameters of (B.4). For example for the CES demand system of Appendix B.1 there holds

$$\mu_i = w_i \eta_i = w_i,$$

$$\pi_{ij} = w_i \varepsilon^*_{ij} = \sigma w_i w_j, \;\; j \neq i,$$

[2] See Theil (1980).

[3] The notations in this sub-appendix are identical to those in B.1.

$$\pi_{ii} = w_i \varepsilon_{ii}^* = \sigma(w_i - 1)w_i,$$

$$i, \ j = 1, 2, \ldots, N.$$

If it is assumed that the parameters μ_i and π_{ij} in (B.4) are constant, then (B.4) is referred to as the Rotterdam consumer demand system. The income and price elasticities of the Rotterdam model are

$$\eta_i = \frac{\mu_i}{w_i},$$

$$\varepsilon_{ij} = \frac{\pi_{ij} - \mu_i w_j}{w_i},$$

$$\varepsilon_{ij}^* = \frac{\pi_{ij}}{w_i},$$

$$i, \ j = 1, 2, \ldots, N.$$

A simple model for the Slutsky coefficients π_{ij} has been proposed by Keller (1984):

$$\pi_{ij} = \chi \phi_i (\delta_{ij} - \phi_j), \quad i, \ j = 1, 2, \ldots, N,$$

where $\chi < 0$, $0 < \phi_i < 1$, $\sum_{i=1}^{N} \phi_i = 1$, and δ_{ij} is the Kronecker delta ($\delta_{ij} = 1$ if $i = j$, and $\delta_{ij} = 0$ if $i \neq j$). It can be shown [see Theil (1980, p. 14)] that χ is the inverse of the income flexibility:

$$\chi^{-1} = \frac{\partial \log \lambda}{\partial \log y},$$

where $\lambda = \partial \psi(p, \ y)/\partial y$ is the marginal utility of income.

It can also be shown [see Theil (1980, p. 12)] that if $\phi_i = \mu_i$, then the preferences underlying the Rotterdam system are additive.

Producer behaviour

Consider an arbitrary input demand function

$$v_i = v_i(q, \ r), \quad i = 1, 2, \ldots, N.$$

Totally differentiating we get

$$\tilde{v}_i = \eta_i \tilde{q} + \sum_{j=1}^{N} \varepsilon_{ij} \tilde{r}_j.$$

Multiply by the cost share w_i:

$$w_i \tilde{v}_i = w_i \eta_i \tilde{q} + \sum_{j=1}^{N} \pi_{ij} \tilde{r}_j,$$

where

$$\pi_{ij} = w_i \varepsilon_{ij} = \frac{r_i r_j}{C} \frac{\partial v_i}{\partial r_j}.$$

For $w_i\eta_i$ there holds

$$w_i\eta_i = \frac{q}{C}\,\frac{\partial(r_i v_i)}{\partial q} = \frac{\partial \log C}{\partial \log q}\,\frac{\partial(r_i v_i)/\partial q}{\partial C/\partial q} = \phi\mu_i,$$

where $\phi = (\partial \log C)/(\partial \log q)$ is the inverse of the elasticity of scale, and $\mu_i = [\partial(r_i v_i)/\partial q](\partial C/\partial q)$ is the marginal cost share of input i. Thus

$$w_i\tilde{v}_i = \phi\mu_i\tilde{q} + \sum_{j=1}^{N}\pi_{ij}\tilde{r}_j, \tag{B.5}$$

Because the substitution matrix $(\partial v_i/\partial r_j)$ is symmetric and negative semi-definite, (π_{ij}) is also symmetric and negative semi-definite. Since $\sum_{j=1}^{N}\varepsilon_{ij} = 0$, there holds $\sum_{j=1}^{N}\pi_{ij} = 0$. If it is assumed that the parameters ϕ, μ_i, and π_{ij} are constant, then (B.7) is referred to as the Rotterdam producer demand system. The elasticities for the Rotterdam system are

$$\eta_i = \frac{\partial \log v_i}{\partial \log q} = \frac{\phi\mu_i}{w_i},$$

$$\varepsilon_{ij} = \frac{\partial \log v_i}{\partial \log r_j} = \frac{\pi_{ij}}{w_i},$$

$$i,\ j = 1, 2, \ldots, N.$$

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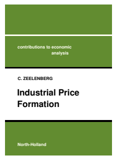

APPENDIX C

Data

C.1. Data for Part 1

In order to compute the production-period we need data on consumption of materials, output, shipments, and stocks of materials, work-in-process, and finished products. Below, the sources of the data and some comments are given by industry.

All industries: Except when the contrary is stated, all data are value data, and all sources are published by the Netherlands Bureau of Statistics (CBS).

Agriculture: The data are taken from the Production Account of Agriculture, Tables 4 and 5 [CBS (1982f) and earlier issues]. The industry groups Forestry and Fisheries, which account for 2 per cent of industry output, are excluded.

Mineral oil refining and natural gas production: The data are taken from Energy Supply in the Netherlands, Appendix 5, Table 1 [CBS (1981) and earlier issues]. The data refer to the weight of input, output, and stocks. The industry groups Oil and coal products (which produces 2 per cent of industry output) and Crude mineral oil and natural gas production (which produces 40 per cent of industry output) are excluded.

Primary metal products: Because the Production Statistics, published by the CBS, do not give data on stocks, the data are taken from the Yearly Report of Hoogovens [Hoogovens (1972)], which produces about 50 per cent of industry output. Because Hoogovens was merged with the German firm Hoesch from 1972 until 1982, the data refer to 1971 only.

Construction: The data are taken from Monthly Bulletin of Construction Statistics, Table 3.1 (for Buildings) and Table 3.20 (for Civil engineering work) [CBS (1982d) and earlier issues]. These Tables give the amount of work that is yet to be produced, but, as can be seen from comparing Figures 3.4 and 3.5, we can replace stocks of work-in-process in formula (3.3) by this amount. The data refer to construction activities of Hfl. 20,000 or more.

All other manufacturing industries: The data are taken from the yearly Production Statistics, Tables 2.5 (or 4.5) and 3.0 [CBS (1982g) and earlier issues]. These Production Statistics are published at the three-digit level; I have aggregated the data to the classification of the input-output tables. For most industries the data of 1974 and 1975 refer to firms with 50 or more employees; the data for 1976-1980 refer to firms with

10 or more employees. The difference in the production period caused by this change in 1976 are negligible. The industries most affected by the exclusion of firms with less than 10 employees are Other food, Leather and footwear, Timber and furniture, Printing and publishing, and Metal products and machinery; employment in these firms is in those industries more than 10 per cent of total employment [CBS (1979, Table 1a)].

Some industry groups are excluded from the Production Statistics or from the tables on stocks. The most important industry group that is excluded is Glass products, which produces about 12 per cent of the output of Stone, clay, and glass products. For Sugar refining (which produces 6 per cent of the output of Other food) no data on stocks are available. In all other industries the omissions account for less than 5 per cent of industry output.

C.2. Data for Part 2

In Chapters 4 and 5 I have used for 6 industry groups price index numbers of domestic sales by domestic producers and world-market unit-values.

The price index numbers of domestic sales are given in Table C.2. They have been computed as follows from the price index numbers of domestic sales used in Part 3 and given in Table C.5. Because the series of Table C.5 include sales tax for the years before 1969, I have first adjusted the data for 1961-1968 using the adjustment factors given in Table C.1. The adjustment factors for industries 1-15 have been computed from CBS (1969); the adjustment factors for the other industries have been guessed on the basis of the ruling tax rates in 1968. Then the 26 industries have been aggregated to the 6 commodity groups according to Table C.1; the 6 groups are:

1. Agricultural and food,
2. Fuels,
3. Chemical products,
4. Machinery and transport equipment,
5. Other manufactures,
6. Non-traded goods.

For the industries producing internationally-traded goods I have used as weights the shares in world trade in 1970; as weights for the other industries (nos. 16-26) I have used the shares in domestic sales in 1970. The shares in world trade have been computed from UN (1975) by allocating the SITC groups and subgroups to the industries on the basis of UN (1971).

Table C.3 gives the world-market unit-values (in US dollars) and the US-dollar/guilder exchange rate. They are taken from the UN Yearbook of International Trade Statistics [UN (1982, Tables A and D-III) and earlier issues]. The unit-values are Paasche index numbers; they refer to exports by market economies to developed countries. The exchange rate is the socalled 'import conversion factor'. The index numbers for 1961-1969 have been obtained by chaining the series with base 1958 and base 1963 to the series with base 1970.[1]

[1] Series as long as possible have been obtained for every base year. When series with a different base year overlap, they have been chained with a Fisher chain [see Allen (1975), pp. 156-63].

Table C.1 *Adjustment factors (1961-1968) and weights*

	Belongs to group no.	Adjustment factor 1961-1968	Weight in group
1. Agriculture	1	0.9819	0.3882
2. Meat and dairy	1	0.9788	0.2171
3. Other food	1	0.9626	0.2930
4. Drink and tobacco	1	0.8952	0.1017
5. Textiles	5	0.9808	0.2030
6. Clothing and leather	5	0.9448	0.1017
7. Paper and printing	5	0.8870	0.1376
8. Timber and stone	5	0.9035	0.1129
9. Chemical products	3	0.9111	1
10. Primary metal products	5	0.9066	0.4448
11. Metal products and machinery	4	0.8932	0.3985
12. Electrical products	4	0.8692	0.2265
13. Transport equipment	4	0.95	0.3750
14. Mineral oil refining	2	0.9596	0.6781
15. Mining	2	0.9482	0.3219
16. Electricity, gas and water	6	0.95	0.0404
17. Construction	6	0.95	0.1746
18. Housing services	6	1	0.0424
19. Distribution	6	1	0.1689
20. Sea and air transport services	6	0.95	0.0037
21. Other transport and communication.	6	0.97	0.0716
22. Banking and insurance	6	1	0.0544
23. Health services	6	1	0.0486
24. Other services	6	1	0.1152
25. Public sevices	6	1	0.1870
26. Capital consumption	6	1	0.0934

Table C.4 gives the quantity index numbers of real value added that have been used in Section 5.7. They have been taken from respectively the National Accounts of the Netherlands [CBS (1982b, Table 5) and earlier issues] and the National Accounts of the OECD [OECD (1983, p. 82)]. The data for the Netherlands refer to real national income and those for the rest of the world to gross domestic product of the OECD excluding the Netherlands.

Table C.2 *Price index numbers of domestic sales by domestic producers*

	Agricultural and food products	Fuels	Chemical products	Machinery and transport equipment	Other manufactures	Non-traded goods
1961	71.22	85.50	88.32	76.59	80.35	59.36
1962	72.12	86.37	88.39	77.43	80.00	61.67
1963	76.77	87.17	88.80	77.54	78.86	64.84
1964	82.01	88.92	91.78	80.44	82.62	70.46
1965	85.52	89.53	92.70	82.66	84.36	74.74
1966	89.88	91.33	93.63	86.16	86.06	79.88
1967	90.66	94.56	93.23	87.17	86.43	84.95
1968	92.63	94.90	94.31	88.67	87.61	88.84
1969	97.36	93.67	96.74	92.95	93.40	92.13
1970	100	100	100	100	100	100
1971	101.88	107.85	102.75	105.63	101.59	109.57
1972	107.46	103.53	106.38	110.09	104.62	118.90
1973	118.08	121.73	111.60	115.71	116.17	130.09
1974	123.19	177.74	137.74	129.38	143.71	146.22
1975	130.55	210.47	146.80	140.94	141.63	164.41
1976	143.14	240.25	152.54	149.31	147.94	179.27
1977	148.61	244.15	153.29	155.33	153.73	191.29
1978	145.24	241.32	152.54	159.37	155.73	202.85
1979	146.87	287.24	168.03	164.22	161.78	214.83

C.3. Data for Part 3

This Appendix gives the data for the 24 industries that are distinguished in Part 3 (Chapters 6-9).

Price index numbers

Table C.5 gives the price index numbers of domestic sales by domestic producers; for 1961-1968 they include sales tax. The sources of this table are:

Agriculture: From Tables 62 and 63 of the Statistics on Agriculture [CBS (1983) and earlier issues] I have computed the price index number of gross output and from Tables 49 and 50 of the National Accounts [CBS (1982b) and earlier issues) the price index number of exports. From these two series I have computed the price index of domestic sales, assuming that the price index of gross output is a Törnqvist index of the price

Table C.3 *World-market unit values (in US dollars) and exchange rate*

	Agricultural and food products	Fuels	Chemical products	Machinery and transport equipment	Other manufactures	Exchange rate[a]
1961	82.04	99.07	108.55	81.62	86.08	27.4081
1962	82.93	98.02	105.25	83.25	85.23	27.6243
1963	88.25	98.02	103.05	84.87	85.23	27.6243
1964	92.96	97.53	101.51	85.30	87.16	27.6243
1965	92.02	97.03	102.03	88.07	89.44	27.6243
1966	93.90	94.06	99.98	90.34	91.30	27.6243
1967	92.96	94.06	96.95	91.26	91.30	27.6243
1968	90.57	95.55	96.44	87.89	89.80	27.6243
1969	97.17	96.04	97.45	91.60	93.93	27.6243
1970	100	100	100	100	100	27.6243
1971	105.09	123	102	112	100	28.5600
1972	114.13	132	108	122	108	31.1517
1973	148.89	176	132	141	135	36.0458
1974	182	495	194	157	163	37.3230
1975	190	537	203	182	173	39.5815
1976	194	583	198	182	172	37.9621
1977	219	629	208	197	190	40.7577
1978	238	612	230	257	209	46.375
1979	264	868	279	287	256	49.903

[a] US cents per guilder

index numbers of domestic sales and exports. The Törnqvist index P of a set of price indices p_i, $i = 1, 2, \ldots, N$ is defined by

$$\log \frac{P_t}{P_{t-1}} = \sum_{i=1}^{N} ½ (w_{it} + w_{i,t-1}) \log \frac{p_{it}}{p_{i,t-1}} ,$$

where t indicates the time period and w_{it} is the value share of the i-th item in period t.

Paper and printing, Transport equipment, Construction, Distribution, Sea and air transport services, Other transport and communication services, Banking and insurance, and Other services: The price index numbers have been supplied by the Central Planning Bureau (CPB).

Manufacturing (excl. Paper and printing and Transport equipment), Mining, and Electricity, gas, and water: The price index numbers have been taken from the Monthly

Table C.4 *Quantity index numbers of real value added*

	Netherlands	Rest of the world
1961	61.16	64.56
1962	63.42	67.98
1963	66.48	71.29
1964	72.18	75.76
1965	76.30	79.74
1966	78.04	83.99
1967	82.45	87.18
1968	88.53	91.88
1969	93.51	96.77
1970	100	100
1971	102.84	103.70
1972	107.65	109.27
1973	114.36	115.88
1974	114.59	116.80
1975	111.58	116.53
1976	118.67	122.15
1977	121.45	126.79
1978	123.78	131.76
1979	125.31	135.92

Bulletin of Price Statistics [CBS (1982e, Tables 3.3.2 and 3.4.2) and earlier issues]; they are yearly averages of the monthly data. For some industries these series were not published in the early 1960's; the missing data have been supplied by the CPB.

Housing services: The series given is the price index number of gross rent; see Table 4 of CBS (1982c) and Tables 43 and 45 of CBS (1982b).

Health services: For the years 1961-1968 the data have been taken from Table 4 of CBS (1982c); for the years 1969-1979 they have been computed as a Törnqvist index of the price index numbers of Services of physicians and Hospital care, computed from the National Accounts [CBS (1982b) and earlier issues, Text-tables 7.7 and 7.8].

Public services: The series have been computed from Tables 16 and 17 of the National Accounts [CBS (1982b) and earlier issues].

Capital consumption: The series have been computed from Table 21 of the National Accounts [CBS (1982b) and earlier issues].

Cost, output, and imports

Tables C.6-C.8 give average variable cost, average fixed cost, and average cost; for 1961-1968 they include sales tax on domestic sales. To compute the average cost series we need the value of cost and the quantity index of output. The quantity index of output has been computed as a Törnqvist index of the quantity index numbers of domestic sales and exports, which have been computed by deflation of the value series with the price index; the sources of the price index numbers of exports are the same as those of the price index numbers of domestic sales.

The data on variable cost (intermediate consumption, compensation of employees, and indirect taxes less subsidies) and fixed cost (capital consumption) as well as the data on domestic sales, exports, and competing imports have been taken from the yearly input-output tables [CBS (1960-1983)].

The input-output tables give only the data on indirect taxes less subsidies separately for domestic sales and exports; all other cost components are given for domestic sales and exports together. Because in several industries taxes and subsidies differ much between domestic sales and exports, I have computed a series 'indirect taxes less subsidies relevant for domestic sales' as indirect taxes less subsidies on domestic sales multiplied by the ratio of gross output and domestic sales. This 'relevant series' has been used in the construction of the average cost series; in this way it is possible to take some of the cost differences between domestic sales and exports into account.

The series for the domestic market share and the budget/cost share have been computed from the data on domestic sales and competing imports; they are given in Tables C.10 and C.11.

Tables C.12 and C.13 give series that have been used as instruments in Appendix 7.1: average labour cost, the aggregate wage rate, and the aggregate import price index. The last two series have been taken from the yearly Central Economic Plan [CPB (1983) and earlier issues].

Industrial classification

The industrial classification of the input-output tables has been changed in 1969. I have recomputed the data for 1961-1968 using the Production Statistics (CBS) of the industry groups, the External Trade Statistics (CBS), and the detailed input-output tables for 1959 and 1967 [respectively Eurostat (1965) and CBS (1960-1983, Part 5, Appendix 2]. The classification of the External Trade Statistics has been linked to the industrial classification by means of UN (1971) and Eurostat (1975). I have also adjusted the data to the new System of National Accounts.

In 1977 there has been a revision of the National Accounts, involving some minor reclassification of industries and some major registration changes. The most important registration changes are: the direct intermediate deliveries of natural gas are not any longer recorded as a delivery via Electricity, gas, and water, and the within-firm production value in Primary metal products is not any longer imputed; using the Production Statistics, I have carried through these two changes also for the years 1961-1976.

Using the data for 1977 before and after revision, I have linked the data for 1978 and 1979 to those for 1961-1977.

Natural gas and crude mineral oil production was in the years 1970-1979 included in Mineral oil refining, and not in Mining. Using several sources I have re-included Natural gas and crude mineral oil production in Mining.

The value series of domestic sales, exports, competing imports, intermediate consumption, compensation of employees, and indirect taxes less subsidies are upon request available from the author.

Capacity utilization

For the years 1961-1972, I have taken capacity utilization in Primary metal products from Tables 3.4 and 3.14 of the Iron and Steel Yearbook [Eurostat (1979) and earlier issues] and Table 70 of EGKS (1978). The CBS has supplied for the years 1972-1979 data on capacity utilization in Textiles, Clothing and leather, Paper and printing, Timber and stone, Chemical products, Primary metal products, Metal products and machinery, and Transport equipment; since 1980 they are published in the monthly Results of the Business Survey, published by the European Community. For the other industries and for the years 1961-1972 I have constructed a Wharton-index, which has been linked to the CBS data.

Market-structure data

Table C.14 gives the Theil coefficients for the years 1950, 1963, and 1971. The data have been taken from Janus (1972) and Janus (1975). They have been adjusted to my industrial classification by means of the decomposition formula given in Section 8.1; the data necessary for the adjustment have been taken from CBS (1968-1970, Part 2, Tables 23 and 25), Eurostat (1969), and CBS (1973, Table 1). I have computed the Theil coefficient (and the four-firm concentration ratio in Table C.15) for Agriculture from LEI (1968, Table 21e), using the same methods as Janus [respectively, Phlips (1971, Statistical Appendix)]

Table C.15 gives some market-structure variables for 1963. The four-firm concentration ratio and the four-establishment concentration ratio of manufacturing industries have been taken from Phlips (1971, Tables A.1 and A.2); they are a weighted average of the concentration ratios at the three-digit level, with as weights the shares in gross output where possible, and otherwise the shares in employment [the weights have been taken from Eurostat (1969, Tables A02, A17, D02, and D11)]. I have computed the concentration ratios of the non-manufacturing industries from CBS (1968-1970, Part 4, Tables 2 and 3), using the same methods as Phlips. Capital consumption per establishment has been computed as the product of capital consumption per employee and the number of employees per establishment; the latter variable is a weighted average of the number of employees per establishment at the four-digit level, with the shares in employment as weight. Capital consumption has been taken from the input-output table for 1963 [CBS (1960-1983), Part 4, Table 3]; I have adjusted the classification of the input-output table to mine (see above the subsection on Industrial classification). The number of employees and the number of establishments have been taken from the Census data [CBS (1968-1970, Part 2, Table 23].

Tables C.16 and C.17 give the other data that have been used in Section 8.5. The price-cost ratio is the ratio of the value of gross output and the value of total cost. Total cost consists here of intermediate consumption, capital consumption, indirect taxes less subsidies, compensation of employees, and imputed labour income of self-employed (the product of the wage rate in the industry and the number of self-employed).[2]

The budget/cost shares given in Tables C.16 and C.17 differ from those in Table C.11: the data given in Tables C.16 and C.17 are the shares in total domestic expenditure inclusive expenditure on Public services and Unallocated, whereas the data in Table C.11 are the shares in total expenditure on the goods of the 24 industries given. Because the models of Chapter 8 are logarithmic, this difference in measurement has only consequences for the coefficient of the constant term, but not for the estimates of the other coefficients.

[2] Because time series of employment could not be obtained for the whole of the period 1961-1968, the data of Tables C.6 and C.8 do not include imputed labour income of self-employed.

Table C.5 *Price index numbers of domestic sales by domestic producers (1970 = 100)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	70.79	72.77	79.34	82.08	87.24	91.17	91.81	93.55	98.55	100	100.79	107.89	119.92	114.18	128.12	144.31	144.21	137.42	136.66
2 Meat and dairy	67.84	67.91	73.54	84.88	86.02	89.45	90.81	92.91	98.37	100	102.40	111.34	124.16	123.41	128.91	139.09	142.21	143.54	144.42
3 Other food	80.09	80.41	83.52	87.23	91.34	94.21	94.96	97.01	93.87	100	102.43	103.71	113.84	137.62	136.92	146.92	162.40	156.72	161.91
4 Drink and tobacco	79.42	79.90	80.70	88.77	90.38	104.91	105.31	108.40	100.67	100	103.33	108.33	110.25	115.50	125.00	136.46	139.38	145.63	147.71
5 Textiles	91.14	89.72	91.46	96.76	95.73	97.55	97.47	98.10	98.66	100	103.00	108.58	118.92	135.83	135.58	143.48	150.05	150.83	155.01
6 Clothing and leather	83.36	84.44	84.78	87.57	90.02	95.60	98.12	99.08	97.26	100	107.33	114.35	123.66	135.58	147.07	157.35	166.02	175.96	185.84
7 Paper and printing	74.93	75.45	78.24	82.31	84.78	88.51	92.67	95.26	92.59	100	109.10	113.25	122.99	144.88	162.12	166.82	175.83	177.59	185.58
8 Timber and stone	83.41	85.26	86.39	90.98	93.96	95.45	95.45	96.94	93.90	100	107.71	113.51	121.76	136.71	147.07	156.87	166.50	173.50	181.33
9 Chemical products	96.94	97.01	97.47	100.74	101.75	102.77	102.33	103.51	96.74	100	102.75	106.38	111.60	137.74	146.80	152.54	153.29	152.54	168.03
10 Primary metal products	90.61	89.56	84.67	88.32	91.05	91.54	90.64	91.85	90.23	100	95.75	95.67	109.67	150.58	135.42	139.71	142.53	142.07	147.04
11 Metal products and machinery	82.39	83.38	83.95	87.58	90.52	93.92	95.45	96.86	91.36	100	106.34	110.59	116.12	132.12	145.15	153.76	160.32	165.07	170.36
12 Electrical products	91.86	90.92	90.14	93.43	96.17	101.17	99.06	101.72	97.02	100	101.80	105.30	110.70	120.00	123.60	128.60	131.70	133.00	136.70
13 Transport equipment	81.91	83.79	83.96	86.65	88.99	92.10	94.59	95.91	92.17	100	107.20	112.45	118.30	132.14	146.94	157.08	164.31	169.24	174.32
14 Mineral oil refining	88.82	90.16	90.16	90.78	92.60	94.73	98.23	97.97	92.62	100	108.50	104.00	123.92	185.58	195.08	212.31	207.92	203.53	246.13
15 Mining and quarrying	90.77	90.77	93.40	97.79	95.93	97.28	100.39	102.05	95.87	100	106.47	102.54	117.11	161.22	242.90	299.11	320.48	320.94	373.85
16 Electricity, gas and water	98.04	97.94	98.53	99.21	98.51	102.06	103.90	103.46	95.58	100	106.83	103.08	114.42	131.08	177.67	206.10	220.31	218.68	243.85
17 Construction	63.29	66.07	69.77	75.35	80.17	85.06	88.12	92.44	91.24	100	110.10	120.01	131.05	148.74	163.91	177.68	191.01	205.34	221.76
18 Housing services	50.81	53.60	58.00	61.71	65.91	72.43	77.64	84.01	92.08	100	112.70	128.03	145.95	163.17	180.96	199.35	214.37	226.31	240.79
19 Distribution	74.63	75.60	77.79	82.38	85.68	89.19	96.32	102.00	92.51	100	104.40	109.10	116.74	127.60	139.59	150.06	155.31	163.08	169.60
20 Sea and air transport services	82.49	83.07	88.47	89.00	91.49	91.49	99.82	96.53	94.70	100	102.00	102.00	100.88	119.95	125.95	130.61	134.40	137.76	143.96
21 Other transport & communication	64.43	66.75	69.02	73.99	79.46	83.27	88.60	90.11	94.07	100	109.30	111.27	115.16	124.49	138.31	149.37	158.33	168.62	180.43
22 Banking and insurance	62.98	64.81	69.02	72.40	76.17	82.19	84.41	86.94	93.72	100	110.70	122.32	134.55	149.89	164.73	177.25	190.54	203.88	213.06
23 Health services	42.70	47.40	52.09	57.87	62.09	70.97	79.27	83.95	88.57	100	115.48	137.75	156.78	182.53	217.06	241.87	265.83	288.32	306.29
24 Other services	46.04	48.76	50.86	57.17	62.37	69.29	75.60	80.66	91.07	100	109.40	120.67	132.98	146.54	163.54	179.08	194.66	208.66	220.26
25 Public services	43.45	47.11	51.55	60.34	66.15	72.55	79.59	84.40	92.10	100	112.23	124.17	138.81	160.68	182.01	198.42	211.40	223.65	236.65
26 Capital consumption	71.29	72.14	75.08	80.99	84.06	87.35	88.47	88.66	92.33	100	109.35	119.21	127.14	141.39	156.75	169.66	178.64	187.51	191.56

Table C.6 *Average variable cost of domestic sales (1970 = 100)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	67.80	73.16	79.29	76.18	83.79	92.63	91.68	92.01	93.13	100	102.04	104.35	118.44	123.43	132.21	146.71	151.16	144.02	152.40
2 Meat and dairy	69.13	68.26	74.19	83.54	85.37	90.56	92.96	95.72	99.45	100	104.27	108.47	125.10	123.21	132.87	140.49	145.91	149.10	155.29
3 Other food	78.22	78.81	82.19	86.02	89.88	91.05	90.15	94.31	92.75	100	100.75	101.04	113.27	151.41	141.18	152.16	174.82	169.66	177.27
4 Drink and tobacco	81.03	82.03	81.34	87.54	88.78	102.83	101.13	104.78	96.85	100	98.19	108.57	111.65	124.82	129.37	138.96	146.75	157.11	157.83
5 Textiles	86.24	86.44	88.62	93.39	92.76	93.79	94.93	95.19	95.62	100	102.21	104.82	115.37	134.82	134.49	140.77	152.16	151.07	155.28
6 Clothing and leather	76.86	79.04	78.52	81.38	85.45	91.32	95.54	95.56	94.41	100	102.53	111.38	123.29	137.22	147.10	153.83	164.57	172.39	184.53
7 Paper and printing	73.13	72.93	75.91	79.74	82.75	86.60	90.74	92.75	90.33	100	108.65	110.55	120.20	143.77	161.53	163.30	171.15	169.82	181.57
8 Timber and stone	84.52	86.99	87.77	92.11	95.53	97.46	97.21	99.69	93.27	100	107.42	112.35	121.42	142.62	157.20	166.99	171.82	178.29	192.03
9 Chemical products	100.38	97.16	99.99	102.23	107.06	102.74	104.62	97.01	90.90	100	106.94	103.08	110.32	152.78	169.72	168.47	171.93	171.63	199.13
10 Primary metal products	86.23	84.92	82.60	94.15	99.70	101.19	100.11	102.44	90.37	100	106.22	98.59	111.25	139.84	158.80	156.17	161.00	156.69	168.76
11 Metal products and machinery	83.69	86.25	86.92	88.49	92.12	97.15	98.40	99.68	91.48	100	105.83	110.49	116.19	132.35	147.02	151.22	157.97	165.45	172.89
12 Electrical products	99.03	102.68	101.16	96.61	99.80	104.90	109.88	111.42	91.88	100	103.64	106.46	111.71	118.21	132.04	129.66	134.78	132.07	133.30
13 Transport equipment	78.04	77.43	81.24	87.53	89.28	90.21	93.32	93.73	89.66	100	104.18	112.20	120.57	134.74	141.61	143.13	154.28	164.54	166.18
14 Mineral oil refining	109.73	106.26	98.66	102.11	88.21	99.54	94.13	97.01	85.84	100	110.78	121.07	188.38	227.26	231.58	243.43	265.69	236.53	264.79
15 Mining and quarrying	184.83	189.92	200.84	214.86	212.58	195.62	178.33	155.17	121.76	100	92.20	77.19	56.69	57.22	61.00	64.90	70.80	88.37	106.79
16 Electricity, gas and water	94.44	95.81	97.36	101.88	101.75	105.62	105.44	104.71	91.61	100	109.36	103.82	120.37	143.24	205.78	240.74	254.40	254.39	298.70
17 Construction	58.66	61.99	66.80	71.72	75.80	80.49	81.12	85.09	89.22	100	107.33	115.32	128.62	148.65	163.08	177.06	188.57	200.25	218.64
18 Housing services	48.88	53.28	55.65	59.84	69.16	73.36	76.31	85.43	95.24	100	106.65	110.52	119.80	117.43	100.00	102.94	116.86	147.65	161.27
19 Distribution	73.37	72.13	76.08	81.98	85.62	94.11	102.83	109.85	93.42	100	106.22	111.01	117.62	132.55	150.22	163.13	172.20	179.16	190.45
20 Sea and air transport services	86.18	87.74	92.26	90.26	90.59	95.51	97.90	93.90	97.92	100	101.81	107.32	116.72	127.87	138.08	142.57	145.17	151.34	164.96
21 Other transport & communication	67.04	70.73	71.95	80.37	86.07	93.19	95.15	94.56	93.76	100	111.99	110.02	115.60	128.81	145.39	148.45	152.04	160.64	176.49
22 Banking and insurance	56.62	59.27	65.06	68.75	72.62	77.50	78.34	82.36	91.34	100	110.42	121.05	128.25	143.82	160.37	166.62	177.07	183.11	187.27
23 Health services	37.69	42.47	47.32	52.40	57.47	67.23	75.65	80.63	85.91	100	113.54	139.11	160.45	188.15	224.72	252.86	280.16	301.00	321.43
24 Other services	44.01	46.32	49.30	54.55	60.38	67.10	74.10	80.36	90.71	100	110.66	119.95	134.62	149.54	166.78	183.62	199.52	212.49	225.81

Table C.7 *Average fixed cost (1970 = 100)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	68.35	69.79	79.04	77.25	80.31	88.15	88.08	87.85	91.14	100	105.67	112.70	117.18	131.97	153.47	169.49	182.17	189.09	200.39
2 Meat and dairy	77.71	79.18	83.29	88.16	92.07	98.53	99.69	94.86	96.13	100	106.45	115.92	127.84	144.21	161.91	182.38	195.39	207.18	222.15
3 Other food	64.14	64.41	67.57	67.01	71.47	73.11	74.37	75.01	91.53	100	107.74	117.55	119.98	154.22	166.65	177.82	192.04	199.32	214.23
4 Drink and tobacco	60.71	61.48	57.94	65.18	64.16	75.49	74.72	75.97	93.65	100	106.04	114.26	121.66	142.53	156.67	172.36	188.01	203.69	215.46
5 Textiles	71.90	74.54	74.03	77.05	79.66	80.16	88.23	81.71	84.50	100	104.68	120.32	130.23	147.57	181.07	191.69	202.45	210.90	224.46
6 Clothing and leather	76.13	77.35	77.38	76.42	82.35	86.60	94.51	91.40	93.49	100	110.89	118.85	144.09	169.23	185.34	211.36	231.91	239.27	293.21
7 Paper and printing	72.31	75.68	82.41	81.37	83.02	84.15	89.12	86.82	91.23	100	117.82	126.21	124.80	146.75	180.79	181.96	192.00	195.77	207.43
8 Timber and stone	74.76	77.51	80.79	79.19	82.53	87.35	88.06	86.34	90.65	100	109.77	120.54	125.21	151.50	187.55	195.36	202.23	214.95	243.10
9 Chemical products	85.19	84.98	87.44	84.45	83.83	86.52	92.35	86.88	86.93	100	114.15	121.82	116.64	130.94	180.25	161.83	176.53	187.75	186.04
10 Primary metal products	64.06	79.23	77.21	74.21	79.59	90.26	93.87	98.36	92.36	100	117.87	120.69	126.33	132.80	184.03	176.61	189.43	183.13	174.94
11 Metal products and machinery	66.40	73.03	73.28	71.77	73.10	77.43	86.91	81.46	82.45	100	110.76	123.31	120.65	133.11	162.88	166.94	176.36	190.90	202.04
12 Electrical products	113.67	115.62	125.88	120.42	118.52	129.54	138.07	132.23	113.33	100	122.02	132.12	125.34	137.60	171.25	177.16	185.69	181.73	190.46
13 Transport equipment	94.84	88.02	85.19	86.90	101.71	106.85	113.45	100.01	101.16	100	97.21	108.33	108.85	121.12	138.50	146.88	166.45	190.52	193.74
14 Mineral oil refining	113.64	112.34	116.74	111.24	114.99	126.98	134.97	114.58	100.13	100	108.81	112.46	121.35	125.06	150.45	139.79	146.84	146.50	147.32
15 Mining and quarrying	125.79	120.46	128.41	144.53	158.14	197.02	193.14	172.51	112.82	100	108.67	112.90	92.59	119.79	143.72	160.97	178.83	210.03	244.75
16 Electricity, gas and water	120.27	115.43	112.19	115.08	112.16	116.75	113.03	104.55	101.11	100	109.13	104.82	113.90	132.26	157.55	165.19	176.99	178.53	189.51
17 Construction	53.28	58.70	67.35	65.19	69.93	72.15	87.18	86.18	92.38	100	114.68	125.91	135.37	171.40	201.08	230.14	238.45	259.05	306.07
18 Housing services	56.77	59.78	65.36	70.38	73.95	77.99	79.66	83.31	92.94	100	113.84	128.81	151.28	172.40	190.23	203.25	218.30	236.67	257.57
19 Distribution	67.15	63.98	67.57	72.05	76.44	83.42	88.23	91.23	88.75	100	114.53	124.86	132.47	144.38	167.30	177.42	185.82	194.85	207.43
20 Sea and air transport services	96.81	100.39	100.60	91.40	103.24	97.56	100.06	90.80	99.51	100	101.03	110.78	113.80	123.90	144.46	155.10	152.13	166.61	167.33
21 Other transport & communication	69.58	72.80	74.09	78.67	81.82	89.01	90.37	95.20	97.54	100	116.56	126.02	132.33	147.13	171.39	181.11	185.22	194.92	211.54
22 Banking and insurance	34.30	45.38	53.28	54.87	58.80	64.74	71.26	77.35	90.02	100	119.77	129.26	147.10	168.96	190.34	203.79	231.46	238.25	243.72
23 Health services	44.80	48.13	55.35	62.84	69.79	69.37	79.61	84.06	90.70	100	118.50	137.32	160.81	182.56	218.13	244.50	271.64	296.66	321.53
24 Other services	50.09	53.72	54.99	62.14	66.96	71.90	80.87	84.46	93.49	100	116.02	142.18	158.79	181.11	211.44	229.40	251.45	269.05	286.37

Table C.8 *Average cost of domestic sales (1970 = 100)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	67.82	72.93	79.26	76.24	83.55	92.32	91.43	91.72	93.00	100	102.29	104.93	118.36	124.02	133.68	148.28	153.30	147.14	155.72
2 Meat and dairy	69.24	68.40	74.30	83.60	85.46	90.67	93.05	95.71	99.41	100	104.30	108.56	125.14	123.48	133.24	141.02	146.54	149.83	156.13
3 Other food	77.85	78.43	81.80	85.51	89.39	90.57	89.73	93.79	92.72	100	100.93	101.47	113.45	151.49	141.83	152.82	175.26	170.44	178.24
4 Drink and tobacco	80.02	81.02	80.17	86.42	87.55	101.48	99.82	103.35	96.69	100	98.57	108.85	112.14	125.67	130.66	140.53	148.68	159.29	160.51
5 Textiles	85.76	86.04	88.12	92.84	92.31	93.33	94.71	94.73	95.24	100	102.29	105.34	115.88	135.25	136.08	142.51	153.87	153.13	157.67
6 Clothing and leather	76.85	79.00	78.49	81.26	85.37	91.21	95.52	95.46	94.39	100	102.72	111.55	123.77	137.95	147.98	155.15	166.12	173.93	186.98
7 Paper and printing	73.10	73.03	76.16	79.80	82.76	86.51	90.68	92.53	90.36	100	108.98	111.12	120.37	143.88	162.24	163.98	171.91	170.77	182.51
8 Timber and stone	84.03	86.52	87.43	91.46	94.88	96.96	96.76	99.02	93.14	100	107.54	112.75	121.61	143.05	158.69	168.39	173.32	180.09	194.52
9 Chemical products	99.30	96.31	99.11	100.97	105.41	101.59	103.76	96.30	90.63	100	107.44	104.40	110.76	151.23	170.44	167.99	172.23	172.73	198.20
10 Primary metal products	84.57	84.49	82.20	92.66	98.21	100.37	99.64	102.14	90.51	100	107.02	100.10	112.28	139.33	160.52	157.56	162.94	158.49	169.20
11 Metal products and machinery	83.17	85.85	86.51	87.98	91.54	96.55	98.06	99.12	91.21	100	105.98	110.88	116.33	132.37	147.50	151.70	158.53	166.22	173.76
12 Electrical products	99.40	102.99	101.82	97.24	100.28	105.55	110.63	111.95	92.44	100	104.13	107.14	112.06	118.72	133.08	130.93	136.14	133.40	134.83
13 Transport equipment	78.52	77.73	81.35	87.50	89.64	90.70	93.91	93.91	89.99	100	103.98	112.09	120.23	134.35	141.52	143.24	154.63	165.25	166.93
14 Mineral oil refining	109.91	106.52	99.34	102.47	89.21	100.56	95.66	97.69	86.39	100	110.70	120.73	185.21	222.47	227.43	238.51	260.14	232.11	259.31
15 Mining and quarrying	176.23	179.78	190.26	204.62	204.67	195.82	180.42	157.62	120.51	100	94.51	82.23	61.78	66.14	72.83	78.68	86.31	105.82	126.56
16 Electricity, gas and water	100.36	100.30	100.75	104.89	104.12	108.15	107.16	104.64	93.74	100	109.31	104.05	118.92	140.77	194.85	223.60	236.84	237.18	273.92
17 Construction	58.56	61.93	66.81	71.60	75.70	80.34	81.23	85.11	89.27	100	107.46	115.51	128.74	149.05	163.75	177.99	189.44	201.26	220.11
18 Housing services	53.46	57.09	61.28	65.95	71.98	76.09	78.28	84.13	93.83	100	110.92	121.31	138.27	149.15	150.00	158.18	173.21	198.95	216.81
19 Distribution	73.04	71.65	75.58	81.40	85.09	93.48	101.94	108.68	93.14	100	106.70	111.82	118.48	133.23	151.21	163.96	172.98	180.06	191.43
20 Sea and air transport services	87.65	89.49	93.41	90.42	92.34	95.80	98.19	93.47	98.14	100	101.70	107.80	116.32	127.32	138.97	144.30	146.13	153.44	165.29
21 Other transport & communication	67.41	71.03	72.26	80.12	85.45	92.59	94.46	94.64	94.29	100	112.63	112.25	117.92	131.35	148.96	152.88	156.54	165.29	181.27
22 Banking and insurance	56.36	59.11	64.92	68.60	72.46	77.35	78.26	82.31	91.32	100	110.52	121.15	128.46	144.11	160.71	167.05	177.70	183.75	187.92
23 Health services	38.24	42.91	47.94	53.21	58.42	67.40	75.96	80.90	86.29	100	113.92	138.97	160.48	187.71	224.20	252.21	279.49	300.65	321.43
24 Other services	44.17	46.52	49.45	54.75	60.56	67.23	74.28	80.47	90.78	100	110.80	120.54	135.26	150.38	167.96	184.83	200.90	213.98	227.41

Table C.9 *Capacity utilization*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	1.0000	0.9657	0.8902	0.9328	0.9141	0.8769	0.9060	0.9070	0.9045	0.9264	0.9371	0.9452	0.9691	0.9866	0.9595	0.9479	0.9514	0.9867	1.0000
2 Meat and dairy	1.0000	0.9983	0.9759	0.9225	0.9453	0.9179	0.9211	0.9639	0.9307	0.9535	0.9747	0.9873	0.9733	0.9739	1.0000	0.9985	0.9981	1.0000	0.9843
3 Other food	1.0000	0.9865	0.9578	0.9752	0.9328	0.9329	0.9358	0.9273	0.9385	0.9581	1.0000	0.9819	1.0000	0.8730	0.9059	0.9221	0.8808	0.9081	0.9080
4 Drink and tobacco	0.9326	0.9140	0.9634	0.9243	1.0000	0.8959	0.9466	0.9345	0.9153	0.9219	0.9354	0.9244	1.0000	0.9575	0.9586	0.9452	0.9296	0.9123	0.9485
5 Textiles	0.8363	0.8174	0.8764	0.8822	0.8521	0.8822	0.8057	0.8534	0.8822	0.8272	0.8822	0.8800	0.8770	0.8370	0.7770	0.8030	0.7870	0.7870	0.8200
6 Clothing and leather	0.8935	0.8343	0.8688	0.8935	0.8762	0.8935	0.8208	0.8661	0.8935	0.8703	0.8935	0.8720	0.8660	0.8690	0.8400	0.8550	0.8320	0.8830	0.8580
7 Paper and printing	0.7967	0.8084	0.8269	0.8601	0.8812	0.8986	0.8691	0.8967	0.9270	0.9166	0.8749	0.8834	0.9270	0.9141	0.8189	0.8671	0.8523	0.8810	0.8880
8 Timber and stone	0.8028	0.7730	0.7712	0.8273	0.8277	0.8102	0.8122	0.8257	0.8597	0.8597	0.8523	0.8370	0.8300	0.8160	0.7890	0.7940	0.8300	0.8450	0.8320
9 Chemical products	0.9444	0.8472	0.7668	0.7749	0.7712	0.8011	0.7836	0.8248	0.8500	0.8209	0.8281	0.8530	0.8900	0.8770	0.7370	0.7600	0.7970	0.8170	0.8480
10 Primary metal products	0.9789	0.8182	0.8437	0.8476	0.8387	0.7697	0.7858	0.7923	0.8879	0.8640	0.8691	0.9230	0.9200	0.9200	0.7700	0.7470	0.6930	0.7770	0.8150
11 Metal products and machinery	0.8538	0.7840	0.7523	0.7876	0.7897	0.7725	0.7205	0.7539	0.7952	0.8192	0.8255	0.7870	0.8110	0.8160	0.7820	0.7710	0.7610	0.7550	0.7620
12 Electrical products	1.0000	0.9112	0.8123	0.8824	0.8750	0.8018	0.7383	0.7395	0.8470	0.9498	0.8802	0.8739	0.9420	1.0000	0.9063	0.9439	0.9194	0.9766	1.0000
13 Transport equipment	0.8267	0.8646	0.8599	0.8317	0.6875	0.6934	0.6571	0.7177	0.7747	0.7975	0.8621	0.8430	0.8100	0.7800	0.8100	0.7500	0.8000	0.7730	0.8000
14 Mineral oil refining	0.9975	0.9216	0.8407	0.8599	0.8480	0.7909	0.7431	0.8486	0.9668	1.0000	0.9667	1.0000	0.9434	1.0000	0.8706	0.9480	0.9126	0.9244	0.9817
15 Mining and quarrying	1.0000	0.9736	0.9721	0.9800	0.9834	0.9856	1.0000	0.8542	0.7875	0.7929	0.7963	0.8300	1.0000	0.8481	0.9266	1.0000	0.9993	0.9490	0.8971
16 Electricity, gas and water	1.0000	0.8911	0.8296	0.7774	0.7660	0.7411	0.7423	0.7763	0.8510	0.8974	0.9013	1.0000	0.9729	0.9705	0.9443	0.9774	0.9540	1.0000	0.9950
17 Construction	1.0000	0.9407	0.8845	0.9775	0.9570	0.9564	0.9830	1.0000	0.9594	0.9775	0.9970	1.0000	0.9945	0.9265	0.9087	0.9235	0.9765	1.0000	0.9608
18 Housing services	1.0000	0.9884	0.9761	0.9678	0.9657	0.9659	0.9679	0.9708	0.9721	0.9722	0.9746	0.9801	0.9891	0.9969	1.0000	1.0000	1.0000	1.0000	1.0000
19 Distribution	0.9533	0.9850	0.9861	1.0000	1.0000	0.9595	0.9394	0.9311	0.9423	0.9653	0.9590	0.9613	0.9982	1.0000	0.9564	0.9692	0.9764	0.9801	0.9746
20 Sea and air transport services	1.0000	0.9865	0.9205	0.9727	0.9665	0.9236	0.8673	0.9109	0.9047	1.0000	0.9992	0.9193	0.8878	0.9398	0.8968	0.8961	0.9332	0.8958	0.9250
21 Other transport & communication	1.0000	0.9763	0.9675	0.9680	0.9487	0.9278	0.9252	0.9495	0.9629	0.9632	0.9294	0.9590	0.9940	1.0000	0.9342	0.9465	0.9578	0.9354	0.9177
22 Banking and insurance	1.0000	0.9412	0.8765	0.8652	0.8572	0.8496	0.8548	0.8774	0.8789	0.8905	0.8938	0.8969	0.9360	0.9314	0.9208	0.9403	0.9422	0.9713	1.0000
23 Health services	0.9830	0.9699	0.9226	0.9291	0.9430	0.9181	0.9173	0.9411	1.0000	0.9912	0.9984	0.9976	0.9990	1.0000	0.9713	0.9664	0.9435	0.9344	0.9305
24 Other services	0.9934	0.9770	0.9759	1.0000	0.9768	0.9634	0.9543	0.9567	0.9360	0.9452	0.9553	0.9469	0.9483	0.9676	0.9687	0.9758	0.9738	0.9891	1.0000

Table C.10 *Domestic market share (per mille)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1 Agriculture	803.9	800.2	800.4	807.9	803.1	809.3	819.7	820.9	809.4	802.0	792.6	789.8	784.2	740.5	771.7	773.4	779.2	770.0	764.9	740.3
2 Meat and dairy	929.5	942.6	931.0	891.7	903.1	900.1	900.6	893.6	866.0	870.4	864.1	840.9	810.2	807.9	827.5	802.1	790.4	790.7	785.1	761.9
3 Other food	874.6	869.5	856.7	857.1	863.0	860.6	861.2	849.0	833.2	819.6	826.8	822.2	802.5	790.0	801.6	783.4	774.8	780.1	799.4	788.4
4 Drink and tobacco	955.8	957.0	949.0	942.0	940.3	941.5	920.1	916.4	897.5	882.6	874.3	856.7	836.7	817.7	821.7	825.2	816.9	816.4	793.7	784.8
5 Textiles	667.6	640.3	602.8	577.5	546.9	540.0	539.0	511.9	484.3	444.5	427.6	399.4	370.2	374.5	370.0	333.9	330.2	318.3	300.8	265.8
6 Clothing and leather	835.6	821.6	796.1	774.1	746.0	721.7	724.4	703.2	640.0	588.1	553.5	488.8	447.8	397.3	331.8	273.1	253.2	291.4	277.9	228.3
7 Paper and printing	839.3	852.5	844.4	837.6	831.5	830.9	830.8	822.0	792.5	779.3	785.0	780.4	782.2	750.6	767.4	760.0	768.3	772.6	773.8	759.8
8 Timber and stone	670.4	685.9	685.9	661.0	669.6	679.9	690.0	679.7	655.9	645.0	658.7	643.3	618.7	596.5	610.6	569.1	565.0	562.2	562.1	556.7
9 Chemical products	591.8	594.8	569.8	582.8	568.2	553.0	533.5	517.6	454.1	417.1	399.4	411.8	406.9	441.4	419.6	438.2	440.2	435.6	414.1	405.5
10 Primary metal products	375.8	396.0	391.8	353.7	377.2	354.2	364.8	362.6	332.6	324.4	317.8	308.9	291.0	317.1	320.7	321.9	316.9	315.9	342.8	299.1
11 Metal products and machinery	574.3	568.9	559.7	560.9	567.3	542.3	534.4	545.2	525.4	499.9	498.4	506.3	518.1	500.7	481.8	469.1	475.7	481.9	467.2	468.7
12 Electrical products	426.5	409.6	370.5	399.1	416.8	416.4	395.2	409.3	403.1	402.5	351.9	365.3	376.8	358.9	331.9	316.9	291.3	298.7	339.8	325.5
13 Transport equipment	561.4	552.0	527.6	451.1	436.2	456.9	461.8	460.1	403.1	422.7	380.3	366.6	303.5	375.8	288.2	253.8	278.3	290.2	288.2	265.7
14 Mineral oil refining	659.7	693.3	728.4	736.2	761.1	769.3	737.5	794.2	818.3	782.0	767.5	802.2	710.6	723.2	717.5	720.1	723.1	725.9	692.8	570.7
15 Mining and quarrying	310.4	289.8	276.2	290.6	292.9	293.1	279.8	275.3	256.0	262.0	276.2	284.7	357.1	195.9	298.0	297.0	322.1	324.4	354.5	286.7
16 Electricity, gas and water	997.5	998.2	997.3	999.0	998.7	998.8	999.3	999.7	999.4	999.5	1000.0	999.8	999.7	999.7	999.6	999.8	996.8	996.8	998.1	997.7
17 Construction	999.7	999.5	999.5	999.6	999.7	999.7	999.7	999.7	999.8	999.6	999.5	999.8	999.9	999.9	999.9	999.9	999.9	1000.0	1000.0	999.8
18 Housing services	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
19 Distribution	979.7	984.8	983.8	978.7	981.9	985.5	983.5	976.9	970.4	966.9	973.8	975.1	971.8	962.9	967.4	969.7	971.7	984.5	988.2	987.3
20 Sea and air transport services	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
21 Other transport & communication	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
22 Banking and insurance	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
23 Health services	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
24 Other services	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

Table C.11 *Budget/cost share (aggregate market share) (per mille)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1 Agriculture	87.4	86.4	84.0	81.7	81.2	79.0	78.4	74.5	76.0	72.6	70.7	71.5	73.4	64.8	64.6	63.4	61.2	57.7	55.3	52.8
2 Meat and dairy	41.3	39.9	40.6	40.3	38.5	38.9	38.7	37.4	37.4	32.0	31.8	35.2	34.1	29.6	31.1	30.2	30.9	29.3	28.7	26.2
3 Other food	77.8	78.2	78.5	76.4	73.6	73.8	73.3	69.6	67.7	68.2	68.1	64.5	66.1	63.7	61.1	59.5	61.0	56.4	53.6	52.0
4 Drink and tobacco	18.0	17.9	19.0	18.3	20.0	19.9	21.5	20.6	18.7	17.4	17.4	17.6	17.4	14.9	15.9	15.2	14.5	13.7	13.7	13.5
5 Textiles	42.4	39.8	42.1	41.1	37.4	38.6	33.3	33.7	33.3	29.2	28.1	27.9	25.2	23.6	21.2	21.0	19.2	17.9	17.1	16.1
6 Clothing and leather	25.2	23.9	24.8	24.3	23.0	23.6	20.4	19.9	19.6	17.4	18.2	17.5	15.8	14.8	14.4	14.7	14.1	14.1	13.9	13.5
7 Paper and printing	39.2	39.0	39.9	38.9	39.3	39.6	38.4	38.5	38.4	37.7	36.4	36.1	36.3	37.8	37.0	36.2	35.2	34.0	34.0	34.0
8 Timber and stone	34.7	34.8	34.6	37.8	38.3	36.3	35.8	35.8	36.8	37.0	36.5	36.7	37.1	34.4	31.4	32.7	34.3	31.9	31.7	29.9
9 Chemical products	48.3	48.6	48.2	50.5	49.8	51.2	50.2	50.6	52.9	49.6	47.3	47.3	50.0	60.0	48.7	53.2	49.8	45.9	43.6	48.3
10 Primary metal products	29.9	24.4	23.5	25.7	25.2	24.2	23.0	22.8	26.1	27.7	22.9	21.4	23.8	27.1	20.9	20.8	18.2	17.2	17.0	16.0
11 Metal products and machinery	76.3	73.3	72.6	74.9	75.3	76.5	71.3	71.9	70.4	77.5	76.0	70.4	70.2	70.7	68.5	63.7	65.4	62.7	60.0	58.7
12 Electrical products	36.8	38.8	35.0	34.9	34.6	33.2	30.6	29.9	36.2	41.1	34.9	35.8	35.9	36.5	35.8	32.5	32.0	30.6	32.1	30.2
13 Transport equipment	37.7	38.9	39.3	32.4	31.7	29.4	29.1	30.8	31.7	35.7	40.3	32.5	32.3	31.4	31.1	28.5	33.7	32.8	35.0	34.1
14 Mineral oil refining	19.6	19.9	21.0	20.4	21.6	21.1	21.2	23.4	24.1	22.3	23.6	21.4	18.2	32.0	29.9	32.2	27.7	26.5	28.4	39.7
15 Mining and quarrying	33.0	32.7	32.1	29.1	26.8	25.3	25.6	26.3	28.1	31.3	34.3	34.3	38.6	55.6	56.4	65.7	60.0	57.0	50.0	55.5
16 Electricity, gas and water	19.1	19.4	19.6	18.3	18.7	19.2	20.2	20.8	21.5	22.5	23.3	24.8	24.0	23.7	30.6	33.1	32.9	31.1	31.0	32.0
17 Construction	85.2	86.3	85.4	94.8	97.9	101.4	107.6	109.7	97.9	97.1	99.8	102.2	96.9	85.9	86.8	83.5	89.0	97.4	100.4	96.4
18 Housing services	21.0	21.4	21.8	20.4	20.8	21.6	22.4	22.7	24.0	23.6	24.9	27.2	27.8	26.9	29.0	29.7	31.1	33.4	34.8	35.0
19 Distribution	100.6	104.6	105.8	106.0	108.3	102.9	107.1	108.0	95.6	97.1	96.5	95.1	96.3	89.5	94.2	94.2	95.2	99.5	100.1	97.3
20 Sea and air transport services	1.6	1.9	1.4	1.3	1.2	1.3	1.5	1.6	2.0	2.0	2.1	2.2	2.1	3.0	3.4	3.0	3.2	3.3	3.3	3.5
21 Other transport & communication	36.0	37.1	38.0	37.1	38.5	38.9	40.5	39.9	41.1	39.8	38.7	39.7	38.3	36.4	37.4	37.0	37.5	34.9	35.2	34.8
22 Banking and insurance	22.1	22.8	22.7	23.1	24.1	26.0	27.1	28.0	30.2	30.2	32.2	35.1	36.9	36.1	39.0	38.9	40.2	37.1	40.1	40.8
23 Health services	15.7	17.4	17.8	18.3	19.4	21.0	23.1	23.8	26.2	27.0	29.8	34.4	35.3	35.8	40.6	40.9	41.8	42.7	44.4	43.9
24 Other services	50.9	52.5	52.4	54.1	54.9	57.0	59.7	59.7	63.8	64.0	66.3	69.5	68.1	65.7	71.0	70.1	71.9	92.8	96.5	95.8
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Table C.12 *Average labour cost (1970 = 100)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	96.17	98.12	101.70	97.50	101.67	107.72	104.60	98.57	100.49	100	98.84	104.18	113.98	119.33	133.72	144.40	152.47	155.35	162.60
2 Meat and dairy	53.48	54.65	59.12	69.79	71.53	79.10	82.38	84.02	94.26	100	106.65	117.41	134.48	149.40	156.56	164.42	165.18	165.00	174.52
3 Other food	60.72	62.45	66.26	70.76	75.15	76.88	78.90	84.30	92.67	100	102.87	113.46	122.26	155.65	160.16	167.56	182.70	184.16	190.22
4 Drink and tobacco	76.96	75.33	75.91	86.48	82.27	95.26	89.34	91.67	95.36	100	107.25	118.61	121.04	137.23	144.15	152.20	157.65	166.01	165.00
5 Textiles	74.45	78.42	76.79	82.85	85.86	85.52	91.15	87.83	90.20	100	101.71	105.72	115.36	129.67	146.45	150.19	156.66	154.27	151.88
6 Clothing and leather	64.72	70.66	71.53	74.97	82.23	87.63	96.26	92.76	94.76	100	97.39	107.53	121.41	131.62	138.36	142.79	155.12	162.67	168.44
7 Paper and printing	54.28	56.93	62.07	66.88	72.11	77.35	83.07	84.00	88.90	100	112.48	120.02	128.29	142.02	168.20	166.97	175.22	176.57	183.97
8 Timber and stone	70.62	74.22	75.26	77.31	82.19	87.26	87.79	88.69	94.75	100	108.46	115.60	124.04	141.99	159.31	162.35	162.32	169.26	181.15
9 Chemical products	75.89	76.65	79.72	82.51	85.15	84.69	86.94	83.70	90.84	100	102.40	103.16	107.58	115.50	152.89	136.46	146.38	146.91	139.62
10 Primary metal products	45.08	58.10	58.40	64.04	73.43	81.30	80.55	84.49	88.15	100	107.09	106.74	118.38	129.25	170.53	162.38	167.89	164.71	158.65
11 Metal products and machinery	64.60	68.00	72.68	75.27	79.26	85.41	92.12	90.71	95.14	100	107.67	114.76	121.33	132.62	152.92	154.40	160.21	168.65	171.99
12 Electrical products	79.99	81.54	86.91	84.33	90.90	98.94	104.59	106.77	100.22	100	112.05	113.78	115.64	121.95	140.69	137.06	144.27	137.42	136.32
13 Transport equipment	65.00	62.91	62.32	67.17	84.03	84.91	94.20	89.98	92.36	100	99.53	109.09	119.42	129.93	142.95	150.74	163.16	177.69	174.50
14 Mineral oil refining	116.15	117.12	118.30	114.67	111.22	114.23	120.02	104.41	94.93	100	106.23	114.44	134.40	142.13	172.98	169.19	187.57	188.30	188.57
15 Mining and quarrying	210.35	215.40	227.02	246.45	253.46	237.34	199.33	152.34	126.57	100	84.40	70.30	49.40	48.66	39.62	42.03	44.54	51.47	58.82
16 Electricity, gas and water	86.21	90.49	93.69	107.29	113.20	118.69	119.01	112.42	102.24	100	108.91	104.38	118.94	132.44	151.33	155.38	166.98	165.51	172.11
17 Construction	47.42	51.04	57.73	60.72	65.96	71.48	70.14	74.56	87.87	100	108.92	116.77	134.94	158.31	173.59	187.56	194.44	207.45	229.34
18 Housing services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19 Distribution	49.10	48.41	51.98	57.57	62.26	69.67	75.05	82.51	92.62	100	110.00	116.76	125.51	141.95	161.54	172.16	182.46	191.43	201.88
20 Sea and air transport services	73.10	80.07	86.84	87.27	90.48	92.79	97.41	100.26	106.73	100	104.44	118.33	128.85	131.41	155.46	159.09	165.60	171.30	174.68
21 Other transport & communication	60.18	63.40	66.15	74.89	81.01	87.61	90.24	87.89	91.54	100	116.71	119.21	129.17	144.62	170.92	180.46	187.50	202.73	218.05
22 Banking and insurance	51.28	53.58	58.75	66.39	70.33	75.46	76.81	81.90	89.23	100	114.22	125.94	135.08	153.47	169.50	176.48	186.01	189.25	192.30
23 Health services	33.59	38.04	43.59	49.61	55.25	65.01	75.34	80.79	85.41	100	119.04	144.25	169.71	200.43	239.28	269.82	297.23	321.26	338.88
24 Other services	37.59	38.95	42.27	47.11	52.14	58.57	65.10	71.31	88.05	100	112.41	123.95	141.39	159.04	179.21	198.47	216.66	230.83	245.46

Table C.13 *Aggregate wage rate and aggregate import price index*

	Wage rate	Import price
1961	58.02	62.62
1962	60.64	63.72
1963	64.82	67.71
1964	69.69	72.21
1965	74.30	73.01
1966	81.06	76.60
1967	82.88	76.53
1968	85.63	78.84
1969	93.18	87.24
1970	100	100
1971	109.01	106.68
1972	117.06	107.21
1973	127.47	120.60
1974	142.22	153.73
1975	161.74	157.72
1976	169.37	173.34
1977	179.97	179.77
1978	189.41	184.86
1979	200.56	215.79

Table C.14 *Theil coefficients*[a] *1950, 1963, 1971*

	1950	1963	1971
1. Agriculture	.	16.29[b]	.
2. Meat and dairy	.	8.24	6.71
3. Other food	.	11.19	10.03
4. Drink and tobacco	7.36	6.69	5.92
5. Textiles	8.67	8.40	8.27
6. Clothing and leather	11.53	10.47	9.71
7. Paper and printing	9.68	9.52	9.41
8. Timber and stone	11.54	11.05	10.39
9. Chemical products	7.50	7.79	6.91
10. Primary metal products	4.32	3.83	9.96[c]
11. Metal products and machinery	11.02	10.96	[d]
12. Electrical products	3.98	4.28	3.86
13. Transport equipment	.	7.21	.
14. Mineral oil refining	0.94	1.73	2.15
15. Mining	1.82	2.61	3.18
16. Electricity,gas, and water	6.53	5.84	.
17. Construction	13.65	13.36	.
18. Housing services	-	-	-
19. Distribution	15.71	15.12	.
20. Sea and air transport services	4.08	4.99	.
21. Other transport, comm.	8.99	9.25	.
22. Banking and insurance	.	7.88	.
23. Health services	.	.	.
24. Other services	.	14.16	.

[a] The base of the logarithms is 2.
[b] 1965
[c] Including Metal products and machinery
[d] Included in Primary metal products

Table C.15 *Market-structure variables 1963*

	Theil coefficient	CR4 (%)	CR4 (establishments) (%)	Capital consumption per establishment (Hfl. 1000)
1. Agriculture	16.29[a]	1[a]	.	3
2. Meat and dairy	8.24	21	16	103
3. Other food	11.19	35	26	73
4. Drink and tobacco	6.69	38	30	100
5. Textiles	8.40	31	24	162
6. Clothing and leather	10.47	13	8	17
7. Paper and printing	9.52	22	15	108
8. Timber and stone	11.05	19	17	27
9. Chemical products	7.79	49	38	1281
10. Primary metal products	3.83	90	89	9347
11. Metal products and machinery	10.96	25	21	61
12. Electrical products	4.28	82	63	386
13. Transport equipment	7.21	40	39	238
14. Mineral oil refining	1.73	95	86	13918
15. Mining	2.61	90	46	6163
16. Electricity,gas, and water	5.84	40	.	1090
17. Construction	13.36	5	.	5
18. Housing services	-	-	-	-
19. Distribution	15.12	5	.	40
20. Sea and air transport services	4.90	53	.	4119
21. Other transport, comm.	9.25	47	.	103
22. Banking and insurance	7.88	23	.	8
23. Health services	.	.	.	.
24. Other services	14.16	8	.	4

[a] 1965

Table C.16 *Data for 1963*

	Price-cost ratio	Domestic market share	Budget/ cost share	1 – Export share
	(per mille)			
1. Agriculture	1085.6	800.4	74.4	804.4
2. Meat and dairy	1012.4	931.0	36.0	660.7
3. Other food	1040.8	856.7	69.6	836.4
4. Drink and tobacco	1093.1	949.0	16.9	893.7
5. Textiles	1054.5	602.8	37.3	651.2
6. Clothing and leather	1064.3	796.1	22.0	855.3
7. Paper and printing	1107.4	844.4	35.3	887.1
8. Timber and stone	1114.3	685.9	30.6	897.8
9. Chemical products	1210.8	569.8	42.8	581.9
10. Primary metal products	1199.0	391.8	20.8	516.7
11. Metal products and machinery	1071.0	559.7	64.4	731.8
12. Electrical products	1201.2	370.5	31.0	359.9
13. Transport equipment	1079.3	527.6	34.8	622.0
14. Mineral oil refining	983.8	728.4	18.6	483.1
15. Mining	1079.5	276.2	28.4	754.2
16. Electricity,gas, and water	1243.2	997.3	17.4	997.3
17. Construction	1042.7	995.5[a]	75.7	986.0
19. Distribution	1217.2	983.8	93.8	829.9
20. Sea and air transport services	1047.3	1000	1.3	45.5
21. Other transport and communication	1087.0	1000	33.7	833.1
22. Banking and insurance	1243.0	1000	20.2	912.9
24. Other services	1132.8	1000	46.4	981.4

[a] This value is incorrect; the correct value is 999.5 (see Table C.10). However, the incorrect value has been used in the empirical analysis of Section 8.5.

Table C.17 *Data for 1971*

	Price-cost ratio	Domestic market share	Budget/ cost share	1 – Export share
	(per mille)			
2. Meat and dairy	1011.8	864.1	26.2	549.5
3. Other food	1039.0	826.8	56.1	778.0
4. Drink and tobacco	1161.4	874.3	14.3	852.9
5. Textiles	1017.3	427.6	23.2	527.7
6. Clothing and leather	1024.1	553.5	15.0	694.6
7. Paper and printing	1057.1	785.0	30.0	835.2
8. Timber and stone	1133.9	658.7	30.1	887.3
9. Chemical products	1109.8	399.4	39.0	349.8
10. Primary metal products 11. Metal products and machinery	}1107.6	456.6	81.5	568.1
12. Electrical products	1154.9	351.9	28.8	323.1
14. Mineral oil refining	1038.6	767.5	19.4	478.2
15. Mining	2565.2	276.2	28.2	661.0

Table C.18 *Expenditure on the gross domestic product (mln hfl)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1 Collective consumption	6172	6914	7924	9431	10498	11709	13157	14255	16256	18706	21670	24455	27455	32444	38189	43335	47611	47845	52610	57166
2 Private consumption	25836	28134	31250	35336	39491	42957	46640	50985	58343	65589	73190	82212	93285	105449	120723	138931	153826	164310	179171	192432
3 Increase in stocks	1192	729	581	1841	1308	954	707	555	2440	2916	1800	1094	3022	5510	-442	3148	1782	1541	1825	1500
4 Gross fixed capital formation	10920	11591	12219	15424	16984	19299	21259	24032	24888	29446	33400	34716	38707	41426	43570	46219	54850	57886	63298	66491
5 Exports of goods and services	21282	22584	24550	27996	30802	32632	34783	39016	45826	54090	61870	69405	83405	107537	109482	128474	130740	130740	133338	155057
6 Imports of goods and services	21229	22398	24932	29320	31281	33722	35549	39032	46038	56174	62280	65152	77760	102068	102102	119935	127398	127398	133228	156688
7 (1/5-6) Gross domestic product	44173	47554	51592	60708	67802	73829	80997	89811	101715	114573	129650	146730	168114	190298	209420	240172	261411	274924	297014	315958

Table C.19 *Cost components of the gross domestic product (mln hfl)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1 Compensation of employees	21991	24139	26939	32167	36411	40949	44781	49427	57186	65507	75100	84178	97436	113115	127703	141910	154698	159540	172776	185914
2 Operating surplus	13944	14493	14940	17486	19011	19106	21062	23300	26277	27786	29420	33874	39098	42127	41695	53348	55917	64411	68268	70956
3 Capital consumption	4206	4545	4940	5459	6010	6595	7166	7749	8568	9727	11340	12910	14558	17094	19813	22140	24063	24240	26671	29292
4 Indirect taxes less subsidies	4032	4377	4773	5596	6370	7179	7988	9335	9684	11553	13790	15768	17022	17962	20209	22774	26733	26733	29299	29796
5 (1/4) Gross domestic product	44173	47554	51592	60708	67802	73829	80997	89811	101715	114573	129650	146730	168114	190298	209420	240172	261411	274924	297014	315958

Table C.20 *National accounting aggregates (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Gross domestic product	44173	47554	51592	60708	67802	73829	80997	89811	101715	114573	129650	146730	168114	190298	209420	240172	261411	274924	297014	315958
2	Gross national product	44822	48003	52257	61475	68557	74430	81846	90404	102481	115104	130040	147429	169412	191970	209398	240293	261896	275409	296332	315234
3	Net domestic product	39967	43009	46652	55249	61792	67234	73831	82062	93147	104846	118310	133820	153556	173204	189607	218032	237348	250684	270343	286666
4	Net nat. prod. (= nat. income)	40616	43458	47317	56016	62547	67835	74680	82655	93913	105377	118700	134519	154854	174876	189585	218153	237833	251169	269661	285942
5	Gross dom. prod. (factor cost)	40141	43177	46819	55112	61432	66650	73009	80476	92031	103020	115860	130962	151092	172336	189211	217398	234678	248191	267715	286162
6	Gross nat. prod. (factor cost)	40790	43626	47484	55879	62187	67251	73858	81069	92797	103551	116250	131661	152390	174008	189189	217519	235163	248676	267033	285438
7	Net dom. prod. (factor cost)	35935	38632	41879	49653	55422	60055	65843	72727	83463	93293	104520	118052	136534	155242	169398	195258	210615	223951	241044	256870
8	Net nat. prod. (factor cost)	36584	39081	42544	50420	56177	60656	66692	73320	84229	93824	104910	118751	137832	156914	169376	195379	211100	224436	240362	256146

Table C.21 *Gross output at producers' value (mln hfl)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1 Agriculture	7231	7589	8015	8926	9661	10040	10735	11310	12323	13273	14040	15491	18162	18321	20363	23361	24180	24173	24522	25510
2 Meat and dairy	4727	4920	5490	6126	6655	7095	7544	8267	8770	9490	10300	11615	13197	13856	15693	17148	17781	17802	18614	19043
3 Other food	6801	7207	7710	8707	9169	9944	10577	11232	11756	13400	14910	15290	17938	20941	21145	23393	25863	25039	25834	27390
4 Drink and tobacco	1603	1702	1938	2166	2533	2749	3080	3287	3182	3347	3670	3941	4504	4683	5272	5822	6066	6052	6420	7038
5 Textiles	3358	3328	3737	4084	4026	4346	4029	4393	4678	4398	4700	4817	5105	5704	5057	5468	5383	5250	5280	5296
6 Clothing and leather	2028	2017	2218	2474	2503	2718	2551	2711	2762	2746	2980	2962	3019	3153	3068	3194	3064	3367	3433	3553
7 Paper and printing	3104	3307	3641	4142	4536	5004	5219	5710	5991	6602	7040	7547	8791	10667	10858	12114	12819	13185	14093	15460
8 Timber and stone	2176	2330	2534	3084	3405	3609	3835	4179	4470	5017	5590	6018	6911	7474	7404	8319	9299	9120	9691	9988
9 Chemical products	3971	4269	4532	5451	6223	7207	7745	8839	9563	10308	11120	12572	15631	23651	19975	24495	24322	23498	23843	30191
10 Primary metal products	1668	1552	1711	2057	2345	2321	2476	2680	3191	3777	3890	4295	5090	7243	5841	6829	6791	6892	7294	8308
11 Metal products and machinery	4943	5046	5328	6286	7012	7620	7688	8639	9330	11053	12480	12952	14905	17962	18682	20853	22196	22536	23058	24662
12 Electrical products	3224	3426	3457	4275	4814	4965	5053	5503	6446	7791	7830	8408	9924	11814	11652	13081	13606	13741	15171	16131
13 Transport equipment	2615	2981	3198	3388	3021	3284	3349	3876	4353	5173	6130	6570	7292	8323	8900	9509	9500	10023	9637	10384
14 Mineral oil refining	2765	2967	3043	3337	3762	3679	3972	4825	5562	6549	7800	7923	8881	18516	17018	21271	20520	20699	19991	27513
15 Mining and quarrying	1072	1061	1127	1226	1234	1272	1346	1634	1842	2337	2950	3441	5177	5917	9428	12421	14072	14154	13943	15212
16 Electricity, gas and water	1589	1712	1882	2039	2252	2515	2827	3218	3536	4207	4840	5530	6159	7260	9871	12198	13089	13054	13959	15900
17 Construction	7211	7722	8303	10668	11903	13458	15221	17193	16450	18533	21000	23170	25300	26900	29210	32349	36975	42461	47015	49064
18 Housing services	1748	1888	2087	2275	2503	2837	3140	3508	3960	4421	5130	6015	7097	8197	9342	10912	12419	14045	15636	17356
19 Distribution	9773	10927	12037	13730	15130	16041	17565	19283	19061	22073	23900	26016	30076	34861	37675	42640	46494	51295	55545	59904
20 Sea and air transport services	2859	2948	2988	3271	3451	3429	3449	3682	3679	4417	4660	4262	4661	5698	5807	6093	6576	6823	6861	7873
21 Other transport & communication	3612	3949	4374	5051	5669	6224	6943	7665	8613	9612	10550	11621	13160	15044	16238	18550	20390	19782	21122	23119
22 Banking and insurance	1992	2169	2389	2720	3092	3581	3984	4512	5196	5967	7000	8173	9867	11481	13063	15004	16864	16487	18942	21193
23 Health services	1307	1533	1709	2031	2341	2749	3229	3683	4325	5059	6140	7622	9033	10931	13093	15032	16684	17992	19970	21806
24 Other services	4360	4727	5118	6118	6757	7663	8563	9460	10781	12323	14020	15760	17868	20645	23664	26782	29783	40377	45056	49226
25 Public services	6593	7423	8476	10086	11050	12284	13768	14897	17148	19619	22790	25690	28855	34225	40073	45547	50060	50752	55756	60466
26 Statistical adjustment	-22	-164	-72	-78	118	124	130	167	-	-	-	-	-	-	-	-	-	-	-	-
27 Unallocated	418	487	575	743	869	985	841	1028	1106	1123	1320	1521	1805	2305	2310	2538	2614	1403	1493	1374
28 VAT	-	-	-	-	-	-	-	-	5973	7495	9270	10334	11782	12643	14590	17343	20552	19272	21251	22406
29 Total	92726	99023	107545	124383	136034	147743	158859	175381	194047	220110	246050	269556	310190	368415	395292	452266	487962	509274	543430	595366

Table C.22 *Intermediate consumption (mln hfl)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1 Agriculture	3579	3876	4104	4311	4718	5097	5344	5472	5704	6596	7050	7469	9034	10020	10530	12007	12707	12757	12750	14180
2 Meat and dairy	4248	4462	4993	5541	5993	6505	6979	7889	8418	9106	9600	10593	12452	12538	14395	15984	16933	16904	17812	18665
3 Other food	5184	5464	5901	6724	7019	7457	7829	8393	9085	10532	11610	11690	14214	17286	16689	18550	20822	20091	20533	22249
4 Drink and tobacco	484	526	632	717	815	846	954	1039	1038	1065	1150	1226	1523	1755	1958	2122	2311	2399	2556	2794
5 Textiles	2316	2306	2649	2877	2802	3032	2739	3003	3274	3082	3290	3275	3526	4077	3483	3756	3896	3654	3631	3700
6 Clothing and leather	1296	1283	1386	1543	1566	1718	1556	1657	1768	1804	1930	1933	1999	2160	2133	2211	2134	2294	2324	2469
7 Paper and printing	1976	2053	2246	2535	2762	3032	3145	3444	3610	4033	4240	4352	5165	6519	6585	7311	7716	7628	7965	9071
8 Timber and stone	1121	1195	1293	1586	1730	1792	1863	2051	2149	2436	2680	2830	3286	3794	3818	4409	4863	5104	5394	5762
9 Chemical products	2186	2307	2559	3054	3644	4009	4419	4618	5145	5783	6650	6884	8585	14168	12633	15787	15794	16075	16639	22596
10 Primary metal products	1047	916	1026	1312	1471	1449	1508	1623	1966	2202	2470	2476	2941	4357	3893	4384	4380	4526	4712	5713
11 Metal products and machinery	2857	2946	3007	3437	3844	4190	4044	4598	4860	5824	6450	6546	7545	9555	9805	10832	11602	12500	12942	14214
12 Electrical products	1663	1868	1801	2093	2280	2373	2440	2653	3140	4082	3990	4173	5106	6068	6338	6845	7199	7395	8195	8934
13 Transport equipment	1658	1863	2101	2301	1861	1992	1976	2321	2699	3240	3880	4181	4702	5584	5782	5849	6012	6551	6547	7063
14 Mineral oil refining	2160	2225	2305	2420	2489	2592	2758	3363	3628	4527	5510	5535	6362	15469	13971	18031	17148	17221	15408	20972
15 Mining and quarrying	337	343	374	400	397	392	437	515	461	485	570	559	564	506	660	767	855	921	1137	1338
16 Electricity, gas and water	595	642	706	756	805	895	979	1143	1244	1652	1950	2181	2538	3154	5028	6553	7034	6859	7450	9261
17 Construction	4040	4335	4644	6006	6581	7376	8161	9121	9151	10450	11430	12441	13542	14517	15722	17525	20208	24133	26325	27556
18 Housing services	377	409	427	461	530	568	588	643	690	801	950	1005	1195	1340	1498	1652	1861	1726	1912	2100
19 Distribution	2980	3321	3750	4243	4530	4957	5459	5964	6473	7217	8000	8363	9391	11073	12085	13585	14974	15506	17011	18763
20 Sea and air transport services	1753	1777	1781	1881	1910	1983	1966	1978	2086	2507	2590	2497	2686	3284	3329	3523	3782	3769	3871	4582
21 Other transport & communication	1087	1221	1296	1540	1701	1922	2096	2331	2412	2684	2830	2982	3442	4167	4489	5146	5450	5017	5262	6029
22 Banking and insurance	743	826	927	995	1132	1299	1428	1622	1916	2194	2480	2752	3125	3619	4250	4629	5149	4983	5586	6154
23 Health services	281	333	358	404	462	551	608	688	778	929	990	1266	1440	1716	2059	2399	2676	3245	3504	3979
24 Other services	1274	1406	1508	1773	1988	2218	2483	2723	2918	3166	3520	3770	4185	4772	5356	6080	6621	9859	10868	12117
25 Public services	2174	2406	2867	3160	3121	3280	3661	3788	4128	4959	5590	5889	6215	7569	8971	10387	11459	11514	12775	14435
26 Statistical adjustment	115	4	-9	-15	185	143	122	238	-	-	-	-	-	-	-	-	-	-	-	-
27 Unallocated	418	487	575	743	869	985	841	1028	1106	1123	1320	1521	1805	2305	2310	2538	2614	1403	1493	1374
28 VAT	-	-	-	-	-	-	-	-	506	611	760	932	1085	1251	1505	1756	2107	2190	2500	2752
29 Imputed banking services	604	669	746	877	1027	1261	1479	1664	1979	2447	2920	3505	4423	5494	6597	7476	8244	8126	9314	10586
30 Total	48553	51469	55953	63675	68232	73914	77862	85570	92332	105537	116400	122826	142076	178117	185872	212094	226551	234350	246416	279408

Table C.23 *Gross value added at market prices (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	3652	3713	3911	4615	4943	4943	5391	5838	6619	6677	6990	8022	9128	8301	9833	11354	11473	11416	11772	11330
2	Meat and dairy	479	458	497	585	662	590	565	378	352	384	700	1022	745	1318	1298	1164	848	898	802	378
3	Other food	1617	1743	1809	1983	2150	2487	2748	2839	2671	2868	3300	3600	3724	3655	4456	4843	5041	4948	5301	5141
4	Drink and tobacco	1119	1176	1306	1449	1718	1903	2126	2248	2144	2282	2520	2715	2981	2928	3314	3700	3755	3653	3864	4244
5	Textiles	1042	1022	1088	1207	1224	1314	1290	1390	1404	1316	1410	1542	1579	1627	1574	1712	1487	1596	1649	1596
6	Clothing and leather	732	734	832	931	937	1000	995	1054	994	942	1050	1029	1020	993	935	983	930	1073	1109	1084
7	Paper and printing	1128	1254	1395	1607	1774	1972	2074	2266	2381	2569	2800	3195	3626	4148	4273	4803	5103	5557	6128	6389
8	Timber and stone	1055	1135	1241	1498	1675	1817	1972	2128	2321	2581	2910	3188	3625	3680	3586	3910	4436	4016	4297	4226
9	Chemical products	1785	1962	1973	2397	2579	3198	3326	4221	4418	4525	4470	5688	7046	9483	7342	8708	8528	7423	7204	7595
10	Primary metal products	621	636	685	745	874	872	968	1057	1225	1575	1420	1819	2149	2886	1948	2445	2411	2366	2582	2595
11	Metal products and machinery	2086	2100	2321	2849	3168	3430	3644	4041	4470	5229	6030	6406	7360	8407	8877	10021	10594	10036	10116	10448
12	Electrical products	1561	1558	1656	2182	2534	2592	2613	2850	3306	3709	3840	4235	4818	5746	5314	6236	6407	6346	6976	7197
13	Transport equipment	957	1118	1097	1087	1160	1292	1373	1555	1654	1933	2250	2389	2590	2739	3118	3660	3488	3472	3090	3321
14	Mineral oil refining	605	742	738	917	1273	1087	1214	1462	1934	2022	2290	2388	2519	3047	3047	3240	3372	3478	4583	6541
15	Mining and quarrying	735	718	753	826	837	880	909	1119	1381	1852	2380	2882	4613	5411	8768	11654	13217	13233	12806	13874
16	Electricity, gas and water	994	1070	1176	1283	1447	1620	1848	2075	2292	2555	2890	3349	3621	4106	4843	5645	6055	6195	6509	6639
17	Construction	3171	3387	3659	4662	5322	6082	7060	8072	7299	8083	9570	10729	11758	12383	13488	14824	16767	18328	20690	21508
18	Housing services	1371	1479	1660	1814	1973	2269	2552	2865	3270	3620	4180	5010	5902	6857	7844	9260	10558	12319	13724	15256
19	Distribution	6793	7606	8287	9487	10600	11084	12106	13319	12588	14856	15900	17653	20685	23788	25590	29055	31520	35789	38534	41141
20	Sea and air transport services	1106	1171	1207	1390	1541	1446	1483	1704	1593	1910	2070	1765	1975	2414	2478	2570	2794	3054	2990	3291
21	Other transport & communication	2525	2728	3078	3511	3968	4302	4847	5334	6201	6928	7720	8639	9718	10877	11749	13404	14940	14765	15860	17090
22	Banking and insurance	1249	1343	1462	1725	1960	2282	2556	2890	3280	3773	4520	5421	6742	7862	8813	10375	11715	11504	13356	15039
23	Health services	1026	1200	1351	1627	1879	2198	2621	2995	3547	4130	5150	6356	7593	9215	11034	12633	14008	14747	16466	17827
24	Other services	3086	3321	3610	4345	4769	5445	6080	6737	7863	9157	10500	11990	13683	15873	18308	20702	23162	30518	34188	37109
25	Public services	4419	5017	5609	6926	7929	9004	10107	11109	13020	14660	17200	19801	22640	26656	31102	35160	38601	39238	42981	46031
26	Statistical adjustment	-137	-168	-63	-63	-67	-19	8	-71	-	-	-	-	-	-	-	-	-	-	-	-
27	Imputed banking services	-604	-669	-746	-877	-1027	-1261	-1479	-1664	-1979	-2447	-2920	-3505	-4423	-5494	-6597	-7476	-8244	-8126	-9314	-10586
28	VAT on final expenditure	-	-	-	-	-	-	-	-	5467	6884	8510	9402	10697	11392	13085	15587	18445	17082	18751	19654
29	(1/28) Gross domestic product	44173	47554	51592	60708	67802	73829	80997	89811	101715	114573	129650	146730	168114	190298	209420	240172	261411	274924	297014	315958
30	Paid to the rest of the world	-1095	-1325	-1363	-1485	-1702	-1846	-2114	-2489	-2978	-4172	-4960	-4725	-5922	-8306	-8989	-9265	-9756	-9756	-11610	-15733
31	Received from the rest o/t world	1744	1774	2028	2252	2457	2447	2963	3082	3744	4703	5350	5424	7220	9978	8967	9386	10241	10241	10928	15009
32	(29/31) Gross national product	44822	48003	52257	61475	68557	74430	81846	90404	102481	115104	130040	147429	169412	191970	209398	240293	261896	275409	296332	315234

Table C.24 *Capital consumption (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	292	302	330	353	375	411	441	457	490	570	630	700	770	910	1060	1190	1320	1320	1460	1610
2	Meat and dairy	67	72	78	82	92	100	106	110	112	124	140	160	180	210	250	290	320	320	350	380
3	Other food	133	141	153	164	177	191	205	215	278	324	380	420	450	520	600	670	710	710	780	860
4	Drink and tobacco	29	31	33	38	43	48	53	56	71	80	90	100	120	140	160	180	200	200	220	250
5	Textiles	88	92	101	109	112	120	123	123	134	146	160	180	190	210	230	250	250	250	260	270
6	Clothing and leather	42	42	46	49	52	56	56	57	60	62	70	70	80	90	90	100	100	100	100	120
7	Paper and printing	100	111	129	138	150	161	171	178	200	224	260	290	310	370	420	460	490	490	530	590
8	Timber and stone	83	90	101	114	127	140	150	158	182	211	240	270	300	350	400	440	480	470	510	570
9	Chemical products	192	211	233	263	295	354	409	444	498	598	740	870	960	1170	1360	1490	1620	1620	1790	1960
10	Primary metal products	73	85	95	101	117	132	151	171	192	215	270	310	340	400	460	500	520	520	540	560
11	Metal products and machinery	109	121	127	141	155	172	192	200	226	298	350	390	420	500	580	630	680	680	730	800
12	Electrical products	82	89	99	116	126	139	149	155	164	174	210	240	260	320	380	430	460	460	500	560
13	Transport equipment	84	87	89	93	95	106	112	113	129	137	150	170	180	210	240	260	280	280	300	320
14	Mineral oil refining	88	94	102	112	127	144	157	165	177	196	220	250	260	290	310	320	330	330	340	370
15	Mining and quarrying	100	95	103	119	133	169	171	183	142	155	200	250	280	310	410	500	560	560	630	700
16	Electricity, gas and water	343	355	377	416	451	506	541	572	658	740	870	990	1080	1290	1540	1720	1850	1850	2010	2180
17	Construction	100	113	132	152	171	188	248	264	274	305	360	400	430	510	590	690	760	760	850	970
18	Housing services	539	581	649	716	775	843	889	960	1103	1220	1430	1670	2030	2390	2710	3070	3490	3490	3990	4530
19	Distribution	349	369	417	480	540	600	657	710	735	890	1060	1210	1390	1580	1820	2030	2220	2230	2430	2660
20	Sea and air transport services	415	439	424	420	486	452	448	439	491	560	580	600	610	720	820	900	940	940	1010	1070
21	Other transport & communication	446	496	541	618	674	764	821	939	1029	1110	1310	1530	1740	2030	2300	2560	2750	2750	2930	3230
22	Banking and insurance	10	14	17	19	22	26	31	37	46	55	70	80	100	120	140	160	190	190	210	230
23	Health services	74	84	98	119	142	145	175	199	239	273	340	410	500	590	710	820	920	1020	1140	1270
24	Other services	102	112	119	143	156	171	197	213	238	265	320	400	460	550	660	740	830	880	980	1080
25	Public services	266	319	347	384	417	457	513	631	700	795	890	950	1118	1314	1573	1740	1793	1820	2081	2152
26	Total	4206	4545	4940	5459	6010	6595	7166	7749	8568	9727	11340	12910	14558	17094	19813	22140	24063	24240	26671	29292

Table C.25 *Indirect taxes less subsidies (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	-342	-267	-272	-296	-220	-63	-14	106	126	146	180	193	211	65	209	168	216	216	276	190
2	Meat and dairy	8	-28	-27	-17	-79	-281	-406	-583	-677	-935	-520	-697	-1104	-1016	-1002	-1574	-2008	-2015	-2205	-2783
3	Other food	347	410	409	411	485	551	504	591	198	89	30	-41	-339	-274	-81	6	50	33	-66	-256
4	Drink and tobacco	733	780	853	903	1098	1241	1363	1438	1263	1373	1370	1582	1705	1744	1870	2048	2140	2130	2251	2357
5	Textiles	9	9	12	11	11	11	54	59	-9	1	10	15	19	16	-10	12	9	5	8	8
6	Clothing and leather	27	27	27	30	30	31	72	84	-1	4	-	10	11	8	6	-20	-11	-15	-10	-14
7	Paper and printing	61	67	72	78	86	93	105	120	-7	14	20	47	55	57	56	53	74	36	39	38
8	Timber and stone	79	84	92	107	123	132	164	199	0	11	20	28	34	34	31	29	36	17	16	18
9	Chemical products	121	125	127	149	164	188	189	218	-62	-3	60	92	116	151	74	105	117	51	57	60
10	Primary metal products	64	60	57	65	74	75	109	135	-15	-3	-	16	22	25	26	28	28	13	20	24
11	Metal products and machinery	144	144	159	191	203	223	232	289	-85	-29	-20	39	50	41	45	38	54	25	27	24
12	Electrical products	60	61	60	69	97	101	112	135	-101	-44	-30	27	31	32	29	27	29	-	-	-1
13	Transport equipment	59	55	64	64	83	89	99	117	-26	-13	-20	-18	-38	-64	-77	-91	-70	-43	-115	-145
14	Mineral oil refining	430	486	532	734	712	976	845	1227	1301	1400	1460	1900	2051	2224	2155	2070	2629	2624	2890	2698
15	Mining and quarrying	16	18	16	19	6	-40	-62	-60	-63	-77	-90	-66	-33	-76	14	17	18	18	21	23
16	Electricity, gas and water	38	39	43	46	56	62	73	90	8	8	10	12	39	110	142	168	60	79	43	45
17	Construction	220	242	260	324	341	372	483	575	65	71	80	95	111	109	106	95	113	61	54	64
18	Housing services	11	24	35	48	76	95	124	180	255	219	170	193	149	21	-307	-352	-299	-368	-42	35
19	Distribution	1634	1699	1874	2239	2542	2797	3386	3801	1361	1682	1640	1942	2238	2376	2900	3710	4109	4329	4394	4629
20	Sea and air transport services	2	1	1	1	-	1	1	1	2	2	-	3	4	9	10	8	11	14	13	26
21	Other transport & communication	106	120	124	137	166	180	178	159	80	34	30	-113	-310	-505	-800	-1348	-1487	-1463	-1704	-1760
22	Banking and insurance	31	33	47	54	62	61	51	62	115	140	150	282	354	392	435	545	656	698	844	938
23	Health services	5	5	6	6	7	6	11	13	68	78	80	138	160	196	244	255	342	329	365	403
24	Other services	158	170	190	206	229	259	293	350	111	117	140	133	162	140	134	72	139	1420	1616	1615
25	Public services	11	13	12	17	18	19	22	29	310	384	510	554	627	755	915	1118	1333	1457	1756	1906
26	VAT on final expenditure	-	-	-	-	-	-	-	-	5467	6884	8510	9402	10697	11392	13085	15587	18445	17082	18751	19654
27	Total	4032	4377	4773	5596	6370	7179	7988	9335	9684	11553	13790	15768	17022	17962	20209	22774	26733	26733	29299	29796

Table C.26 *Compensation of employees (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	746	771	771	809	862	912	951	931	981	1035	1070	1175	1360	1494	1677	1841	2006	2006	2178	2372
2	Meat and dairy	309	333	371	435	479	538	587	653	736	831	940	1086	1269	1458	1620	1752	1813	1778	1832	1962
3	Other food	642	697	765	883	949	1024	1109	1232	1435	1652	1850	2067	2338	2676	2940	3219	3444	3256	3474	3681
4	Drink and tobacco	210	217	247	288	315	346	362	386	413	457	520	593	682	770	841	908	958	925	989	1056
5	Textiles	674	716	775	867	893	947	940	978	1058	1080	1150	1170	1245	1365	1376	1449	1431	1421	1397	1342
6	Clothing and leather	482	518	574	649	701	765	770	781	821	837	830	855	910	945	907	912	903	915	930	943
7	Paper and printing	632	703	818	955	1097	1246	1342	1450	1641	1886	2090	2322	2683	3015	3290	3554	3765	3842	4107	4496
8	Timber and stone	615	676	738	873	992	1097	1173	1273	1492	1655	1860	2031	2331	2573	2665	2868	3022	2899	3086	3264
9	Chemical products	657	731	816	987	1151	1331	1479	1643	1999	2297	2550	2830	3401	3964	4431	4826	5160	5117	5335	5603
10	Primary metal products	178	216	249	302	374	412	449	509	635	745	850	950	1104	1349	1477	1593	1597	1579	1664	1740
11	Metal products and machinery	1331	1414	1581	1856	2109	2381	2554	2795	3273	3740	4270	4555	5301	6252	6834	7313	7753	7571	7904	8346
12	Electrical products	775	843	918	1091	1298	1426	1516	1681	1948	2337	2590	2776	3222	3809	4193	4468	4800	4837	5117	5425
13	Transport equipment	611	660	691	763	833	894	987	1079	1250	1454	1630	1817	2096	2391	2629	2832	2913	3035	3094	3187
14	Mineral oil refining	134	146	154	172	183	193	208	224	250	292	320	379	429	491	531	577	628	599	621	673
15	Mining and quarrying	506	514	551	614	645	616	534	489	482	469	470	471	452	381	342	395	422	383	424	462
16	Electricity, gas and water	303	343	388	478	561	634	702	758	820	912	1070	1215	1390	1592	1823	1994	2151	2158	2304	2448
17	Construction	1960	2164	2492	3118	3552	4102	4394	5030	5740	6717	7530	8170	9440	10374	11217	12384	13648	13804	15162	16190
18	Housing services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	408	483	546
19	Distribution	2023	2213	2543	3040	3487	3972	4430	5090	6080	7055	8070	8970	10440	12314	13930	15615	17280	18976	20689	22435
20	Sea and air transport services	554	619	647	709	753	760	771	857	931	990	1060	1133	1221	1350	1560	1632	1809	1889	1917	2062
21	Other transport & communication	1444	1617	1808	2202	2498	2815	3069	3245	3615	4155	4910	5418	6358	7469	8586	9548	10421	10305	11280	12324
22	Banking and insurance	701	775	879	1078	1234	1421	1567	1837	2138	2579	3130	3655	4306	5111	5846	6497	7160	6760	7385	8034
23	Health services	463	554	644	784	938	1134	1382	1596	1878	2278	2850	3594	4403	5405	6499	7551	8400	9112	10079	10928
24	Other services	1899	2014	2269	2689	3013	3455	3933	4461	5560	6573	7690	8649	10160	11980	13875	15880	17739	20004	22181	24422
25	Public services	4142	4685	5250	6525	7494	8528	9572	10449	12010	13481	15800	18297	20895	24587	28614	32302	35475	35961	39144	41973
26	(1/25)Paid by resident producers	21991	24139	26939	32167	36411	40949	44781	49427	57186	65507	75100	84178	97436	113115	127703	141910	154698	159540	172776	185914
27	Paid to the rest of the world	-115	-141	-174	-199	-237	-242	-264	-281	-346	-387	-480	-545	-672	-686	-659	-656	-688	-688	-753	-796
28	Received from the rest o/t world	130	190	214	232	267	277	228	241	310	421	570	714	910	848	747	758	842	842	828	899
29	(26/28) Received by households	22006	24188	26979	32200	36441	40984	44745	49387	57150	65541	75190	84347	97674	113277	127791	142012	154852	159694	172851	186017

Table C.27 *Operating surplus (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	2956	2907	3082	3749	3926	3683	4013	4344	5022	4926	5110	5954	6787	5832	6887	8155	7931	7874	7858	7158
2	Meat and dairy	95	81	75	85	170	233	278	198	181	364	140	473	400	666	430	696	723	815	825	819
3	Other food	495	495	482	525	539	721	930	801	760	803	1040	1154	1275	733	997	948	837	949	1113	856
4	Drink and tobacco	147	148	173	220	262	268	348	368	397	372	540	440	474	274	443	564	457	398	404	581
5	Textiles	271	205	200	220	208	236	173	230	221	89	90	177	125	36	-22	1	-203	-80	-16	-24
6	Clothing and leather	181	147	185	203	154	148	97	132	114	39	150	94	19	-50	-68	-9	-62	73	89	35
7	Paper and printing	335	373	376	436	441	472	456	518	547	445	430	536	578	706	507	736	774	1189	1452	1265
8	Timber and stone	278	285	310	404	433	448	485	498	647	704	790	859	960	723	490	573	898	630	685	374
9	Chemical products	815	895	797	998	969	1325	1249	1916	1983	1633	1120	1896	2569	4198	1477	2287	1631	635	22	-28
10	Primary metal products	306	275	284	277	309	253	259	242	413	618	300	543	683	1112	-15	324	266	254	358	271
11	Metal products and machinery	502	421	454	661	701	654	666	757	1056	1220	1430	1422	1589	1614	1418	2040	2107	1760	1455	1278
12	Electrical products	644	565	579	906	1013	926	836	879	1295	1242	1070	1192	1305	1585	712	1311	1118	1049	1359	1213
13	Transport equipment	203	316	253	167	149	203	175	246	301	355	490	420	352	202	326	659	365	200	-189	-41
14	Mineral oil refining	-47	16	-50	-101	251	-226	4	-154	206	134	290	-141	-221	42	51	273	-215	-75	732	2800
15	Mining and quarrying	113	91	83	74	53	135	266	507	820	1305	1800	2227	3914	4796	8002	10742	12217	12272	11731	12689
16	Electricity, gas and water	310	333	368	343	379	418	532	655	806	895	940	1132	1112	1114	1338	1763	1994	2108	2152	1966
17	Construction	891	868	775	1068	1258	1420	1935	2203	1220	990	1600	2064	1777	1390	1575	1655	2246	3703	4624	4284
18	Housing services	821	874	976	1050	1122	1331	1539	1725	1912	2181	2580	3147	3723	4446	5441	6542	7367	8789	9293	10145
19	Distribution	2787	3325	3453	3728	4031	3715	3633	3718	4412	5229	5130	5531	6617	7518	6940	7700	7911	10254	11021	11417
20	Sea and air transport services	135	112	135	260	302	233	263	407	169	358	430	29	140	335	88	30	34	211	50	133
21	Other transport & communication	529	495	605	554	630	543	779	991	1477	1629	1470	1804	1930	1883	1663	2644	3256	3173	3354	3296
22	Banking and insurance	507	521	519	574	642	774	907	954	981	999	1170	1404	1982	2239	2392	3173	3709	3856	4917	5837
23	Health services	484	557	603	718	792	913	1053	1187	1362	1501	1880	2214	2530	3024	3581	4007	4346	4286	4882	5226
24	Other services	927	1025	1032	1307	1371	1560	1657	1713	1954	2202	2350	2808	2901	3203	3639	4010	4454	8214	9411	9992
25	Public services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Statistical adjustment	-137	-168	-63	-63	-67	-19	8	-71	-	-	-	-	-	-	-	-	-	-	-	-
27	Imputed banking services	-604	-669	-746	-877	-1027	-1261	-1479	-1664	-1979	-2447	-2920	-3505	-4423	-5494	-6597	-7476	-8244	-8126	-9314	-10586
28	(1/27) Operating surplus	13944	14493	14940	17486	19011	19106	21062	23300	26277	27786	29420	33874	39098	42127	41695	53348	55917	64411	68268	70956
29	Paid to the rest of the world	-980	-1184	-1189	-1286	-1465	-1604	-1850	-2208	-2632	-3785	-4480	-4180	-5250	-7620	-8330	-8609	-9068	-9068	-10857	-14937
30	Received from the rest o/t world	1614	1584	1814	2020	2190	2170	2735	2841	3434	4282	4780	4710	6310	9130	8220	8628	9399	9399	10100	14110
31	(28/30) Property income	14578	14893	15565	18220	19736	19672	21947	23933	27079	28283	29720	34404	40158	43637	41585	53367	56248	64742	67511	70129

Table C.28 *Domestic sales by domestic producers (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	5839	6101	6447	7341	7863	8390	8987	9454	10139	10909	11540	12507	14719	14633	16077	18037	19017	18711	19006	19395
2	Meat and dairy	3189	3316	3627	4000	4196	4587	4877	5172	5339	5224	5660	6558	7062	7303	8292	8905	9747	9768	10143	9896
3	Other food	5656	5995	6449	7290	7656	8336	8831	9141	9293	10472	11600	11736	13560	15349	15784	17165	18854	18527	19275	20357
4	Drink and tobacco	1427	1515	1732	1918	2267	2461	2762	2916	2767	2879	3130	3336	3714	3715	4203	4618	4733	4719	4901	5259
5	Textiles	2352	2245	2433	2639	2467	2735	2510	2669	2660	2433	2480	2470	2381	2700	2530	2578	2526	2393	2310	2126
6	Clothing and leather	1748	1732	1897	2094	2073	2235	2071	2168	2066	1916	2070	1890	1806	1799	1543	1474	1422	1725	1737	1534
7	Paper and printing	2737	2935	3230	3630	3943	4320	4467	4891	5018	5509	5880	6237	7260	8651	9158	10125	10783	11049	11816	12843
8	Timber and stone	1934	2103	2275	2779	3091	3239	3452	3764	3980	4476	4960	5223	5873	6269	6185	6854	7718	7559	8020	8277
9	Chemical products	2376	2550	2637	3275	3411	3714	3749	4054	3961	3875	3890	4317	5206	8076	6584	8578	8744	8409	8126	9727
10	Primary metal products	933	851	884	1013	1144	1125	1172	1278	1432	1686	1500	1467	1772	2623	2164	2466	2301	2291	2619	2371
11	Metal products and machinery	3644	3680	3899	4673	5152	5444	5332	6067	6098	7260	7800	7889	9299	10804	10640	10995	12398	12719	12594	13671
12	Electrical products	1306	1403	1244	1548	1738	1811	1692	1894	2405	3103	2530	2892	3463	3993	3826	3788	3716	3851	4901	4874
13	Transport equipment	1759	1896	1989	1625	1666	1761	1882	2189	2108	2826	3160	2635	2506	3604	2891	2663	3736	4004	4539	4496
14	Mineral oil refining	1074	1214	1470	1669	1978	2124	2191	2875	3252	3265	3730	3800	3298	7071	6925	8535	7989	8102	8840	11248
15	Mining and quarrying	851	837	850	940	947	973	1001	1120	1187	1539	1950	2164	3521	3325	5415	7182	7702	7784	7962	7897
16	Electricity, gas and water	1585	1707	1877	2036	2249	2513	2825	3217	3535	4206	4810	5495	6128	7220	9869	12192	13089	13030	13932	15876
17	Construction	7079	7610	8187	10544	11797	13296	15055	16964	16132	18191	20550	22619	24765	26212	27967	30705	35500	40986	45128	47833
18	Housing services	1748	1888	2087	2275	2503	2837	3140	3508	3960	4421	5130	6015	7097	8197	9342	10912	12419	14045	15636	17356
19	Distribution	8194	9082	9989	11549	12822	13303	14740	16327	15288	17593	19360	20526	23916	26308	29364	33608	36874	41239	44451	47708
20	Sea and air transport services	136	165	136	140	148	170	211	255	334	383	430	482	545	925	1082	1101	1276	1382	1478	1742
21	Other transport & communication	2991	3273	3644	4131	4648	5102	5665	6171	6767	7459	7980	8782	9793	11099	12060	13627	14948	14674	15822	17300
22	Banking and insurance	1835	2013	2181	2568	2906	3407	3797	4327	4981	5666	6640	7783	9440	11019	12565	14324	16010	15633	18038	20269
23	Health services	1307	1533	1709	2031	2341	2749	3229	3683	4325	5059	6140	7622	9033	10931	13093	15032	16684	17992	19970	21806
24	Other services	4231	4633	5023	6017	6616	7479	8354	9239	10517	11998	13660	15380	17413	20041	22881	25802	28668	39062	43401	47545
25	Public services	6537	7366	8412	10014	10959	12200	13654	14783	17029	19484	22630	25514	28559	33805	39733	45125	49604	50296	55317	60026
26	Statistical adjustment	76	-28	88	78	306	348	363	255	-	-	-	-	-	-	-	-	-	-	-	-
27	Unallocated	273	368	380	517	529	723	533	752	636	660	840	530	552	516	334	433	436	114	-243	-785
28	VAT	-	-	-	-	-	-	-	-	5863	7358	9070	10087	11453	12303	14240	16977	20119	18839	20816	21960
29	Consumption by non-residents	-942	-1106	-1328	-1399	-1513	-1503	-1455	-1588	-1434	-1732	-2290	-2687	-2990	-3060	-3170	-3260	-3340	-3340	-3357	-3442
30	Export of used capital goods	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-223	-185	-312
31	Total	71875	76877	83448	96935	105903	115879	125087	137545	149638	168118	186830	203269	231144	265431	291577	330541	363673	385340	416993	448853

Table C.29 *Exports (f.o.b.) (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	1392	1488	1568	1585	1798	1650	1748	1856	2184	2364	2500	2984	3443	3688	4286	5324	5163	5462	5516	6115
2	Meat and dairy	1538	1604	1863	2126	2459	2508	2667	3095	3431	4266	4640	5057	6135	6553	7401	8243	8034	8034	8471	9147
3	Other food	1145	1212	1261	1417	1513	1608	1746	2091	2463	2928	3310	3554	4378	5592	5361	6228	7009	6512	6559	7033
4	Drink and tobacco	176	187	206	248	266	288	318	371	415	468	540	605	790	968	1069	1204	1333	1333	1519	1779
5	Textiles	1006	1083	1304	1445	1559	1611	1519	1724	2018	1965	2220	2347	2724	3004	2527	2890	2857	2857	2970	3170
6	Clothing and leather	280	285	321	380	430	483	480	543	696	830	910	1072	1213	1354	1525	1720	1642	1642	1696	2019
7	Paper and printing	367	372	411	512	593	684	752	819	973	1093	1160	1310	1531	2016	1700	1989	2036	2136	2277	2617
8	Timber and stone	242	227	259	305	314	370	383	415	490	541	630	795	1038	1205	1219	1465	1581	1561	1671	1711
9	Chemical products	1595	1719	1895	2176	2812	3493	3996	4785	5602	6433	7230	8255	10425	15575	13391	15917	15578	15089	15717	20464
10	Primary metal products	735	701	827	1044	1201	1196	1304	1402	1759	2091	2390	2828	3318	4620	3677	4363	4490	4601	4675	5937
11	Metal products and machinery	1299	1366	1429	1613	1860	2176	2356	2572	3232	3793	4680	5063	5606	7158	8042	9858	9798	9817	10464	10991
12	Electrical products	1918	2023	2213	2727	3076	3154	3361	3609	4041	4688	5300	5516	6461	7821	7826	9293	9890	9890	10270	11257
13	Transport equipment	856	1085	1209	1763	1355	1523	1467	1687	2245	2347	2970	3935	4786	4719	6009	6846	5764	6019	5098	5888
14	Mineral oil refining	1691	1753	1573	1668	1784	1555	1781	1950	2310	3284	4070	4123	5583	11445	10093	12736	12531	12597	11151	16265
15	Mining and quarrying	221	224	277	286	287	299	345	514	655	798	1000	1277	1656	2592	4013	5239	6370	6370	5981	7315
16	Electricity, gas and water	4	5	5	3	3	2	2	1	1	1	30	35	31	40	2	6	0	24	27	24
17	Construction	132	112	116	124	106	162	166	229	318	342	450	551	535	688	1243	1644	1475	1475	1887	1231
18	Housing services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	Distribution	1579	1845	2048	2181	2308	2738	2825	2956	3773	4480	4540	5490	6160	8553	8311	9032	9620	10056	11094	12196
20	Sea and air transport services	2723	2783	2852	3131	3303	3259	3238	3427	3345	4034	4230	3780	4116	4773	4725	4992	5300	5441	5383	6131
21	Other transport & communication	621	676	730	920	1021	1122	1278	1494	1846	2153	2570	2839	3367	3945	4178	4923	5442	5108	5300	5819
22	Banking and insurance	157	156	208	152	186	174	187	185	215	301	360	390	427	462	498	680	854	854	904	924
23	Health services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Other services	129	94	95	101	141	184	209	221	264	325	360	380	455	604	783	980	1115	1315	1655	1681
25	Public services	56	57	64	72	91	84	114	114	119	135	160	176	296	420	340	422	456	456	439	440
26	Statistical adjustment	-98	-136	-160	-156	-188	-224	-233	-88	-	-	-	-	-	-	-	-	-	-	-	-
27	Unallocated	145	119	195	226	340	262	308	276	470	463	480	991	1253	1789	1976	2105	2178	1289	1736	2159
28	Re-exports	431	438	453	548	671	768	1011	1180	1417	2098	2650	3118	4359	4553	5767	6749	6451	6806	6901	8544
29	VAT	-	-	-	-	-	-	-	-	110	137	200	247	329	340	350	366	433	433	435	446
30	Consumption by non-residents	942	1106	1328	1399	1513	1503	1455	1588	1434	1732	2290	2687	2990	3060	3170	3260	3340	3340	3357	3442
31	Export of used capital goods	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	223	185	312
32	Total	21282	22584	24550	27996	30802	32632	34783	39016	45826	54090	61870	69405	83405	107537	109482	128474	130740	130740	133338	155057

Table C.30 *Indirect taxes less subsidies on domestic sales (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	-292	-254	-279	-294	-183	-82	-10	123	138	140	170	183	209	107	229	193	218	231	282	217
2	Meat and dairy	44	13	16	33	88	53	61	39	-96	-165	50	-36	-29	-39	-51	-199	-105	-164	-147	-103
3	Other food	359	411	429	432	516	581	541	649	279	251	200	139	-110	-182	-2	266	492	336	329	207
4	Drink and tobacco	735	783	855	905	1102	1244	1367	1440	1266	1382	1380	1592	1714	1744	1869	2059	2146	2137	2270	2376
5	Textiles	7	7	8	7	7	7	51	55	-13	-7	-	6	6	5	-2	6	6	2	3	3
6	Clothing and leather	26	25	26	28	28	29	71	82	-4	2	-	6	6	4	3	-9	-5	-7	-5	-5
7	Paper and printing	59	65	70	76	83	90	101	116	-11	5	10	37	41	44	43	46	61	26	28	26
8	Timber and stone	77	82	90	105	121	130	162	197	-3	7	20	24	29	28	25	24	31	14	13	14
9	Chemical products	105	108	105	125	128	139	138	162	-80	-36	20	40	46	35	13	37	43	32	33	33
10	Primary metal products	63	59	56	64	73	74	108	134	-17	-6	-	10	14	15	17	20	18	6	9	9
11	Metal products and machinery	139	140	154	182	197	216	225	281	-94	-45	-40	21	27	21	24	21	30	14	15	14
12	Electrical products	54	55	52	60	86	91	102	123	-114	-60	-50	7	8	10	9	8	9	-	-	-
13	Transport equipment	56	52	60	59	78	84	95	113	-28	-17	-20	-2	-4	-10	-19	-16	-36	-4	-38	-53
14	Mineral oil refining	414	469	515	716	691	955	822	1204	1299	1397	1460	1895	2039	2205	2137	2051	2608	2607	2874	2678
15	Mining and quarrying	14	16	14	17	4	-19	-34	-27	-29	-30	-30	-18	-8	-11	10	11	12	13	15	15
16	Electricity, gas and water	38	39	43	46	56	62	73	90	8	8	10	12	39	109	142	168	60	79	43	45
17	Construction	219	242	260	324	340	371	483	574	64	70	80	93	108	106	101	90	108	59	52	62
18	Housing services	11	24	35	48	76	95	124	180	255	219	170	193	149	21	-307	-352	-299	-368	-42	35
19	Distribution	1605	1674	1848	2211	2509	2761	3329	3743	1280	1593	1550	1842	2168	2347	2973	3818	4188	4341	4355	4729
20	Sea and air transport services	-	-	-	-	-	1	-	-	-	-	-	-	-	1	1	2	2	3	3	6
21	Other transport & communication	96	108	110	120	138	156	131	136	52	-1	10	-130	-328	-514	-797	-1329	-1475	-1453	-1688	-1802
22	Banking and insurance	29	31	45	52	59	59	49	60	113	136	150	276	346	384	430	541	648	659	800	894
23	Health services	5	5	6	6	7	6	11	13	68	78	80	138	160	196	244	255	342	329	365	403
24	Other services	156	169	188	204	227	257	291	347	110	116	140	131	159	138	131	72	135	1415	1611	1610
25	Public services	11	13	12	17	18	19	22	29	310	384	510	554	627	755	915	1118	1333	1444	1742	1892
26	VAT on final expenditure	-	-	-	-	-	-	-	-	5357	6747	8310	9155	10368	11052	12735	15221	18012	16649	18316	19208
27	Consumption by non-residents	-	-	-	-	-	-	-	-	-	-	-	-30	-100	-73	-76	-86	-87	-87	-91	-95
28	Total	4030	4336	4718	5543	6449	7379	8313	9863	10110	12168	14180	16138	17684	18498	20797	24036	28495	28313	31147	32418

Table C.31 *Indirect taxes less subsidies on exports (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	-50	-13	7	-2	-37	19	-4	-17	-12	6	10	10	2	-42	-20	-25	-2	-15	-6	-27
2	Meat and dairy	-36	-41	-43	-50	-167	-334	-467	-622	-581	-770	-570	-661	-1075	-977	-951	-1375	-1903	-1851	-2058	-2680
3	Other food	-12	-1	-20	-21	-31	-30	-37	-58	-81	-162	-170	-180	-229	-92	-79	-260	-442	-303	-395	-463
4	Drink and tobacco	-2	-3	-2	-2	-4	-3	-4	-2	-3	-9	-10	-10	-9	-	1	-11	-6	-7	-19	-19
5	Textiles	2	2	4	4	4	4	3	4	4	8	10	9	13	11	-8	6	3	3	5	5
6	Clothing and leather	1	2	1	2	2	2	1	2	3	2	-	4	5	4	3	-11	-6	-8	-5	-9
7	Paper and printing	2	2	2	2	3	3	4	4	4	9	10	10	14	13	13	7	13	10	11	12
8	Timber and stone	2	2	2	2	2	2	2	2	3	4	-	4	5	6	6	5	5	3	3	4
9	Chemical products	16	17	22	24	36	49	51	56	18	33	40	52	70	116	61	68	74	19	24	27
10	Primary metal products	1	1	1	1	1	1	1	1	2	3	-	6	8	10	9	8	10	7	11	15
11	Metal products and machinery	5	4	5	9	6	7	7	8	9	16	20	18	23	20	21	17	24	11	12	10
12	Electrical products	6	6	8	9	11	10	10	12	13	16	20	20	23	22	20	19	20	-	-	-1
13	Transport equipment	3	3	4	5	5	5	4	4	2	4	-	-16	-34	-54	-58	-75	-34	-39	-77	-92
14	Mineral oil refining	16	17	17	18	21	21	23	23	2	3	-	5	12	19	18	19	21	17	16	20
15	Mining and quarrying	2	2	2	2	2	-21	-28	-33	-34	-47	-60	-48	-25	-65	4	6	6	5	6	8
16	Electricity, gas and water	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
17	Construction	1	-	-	-	1	1	-	1	1	1	-	2	3	3	5	5	5	2	2	2
18	Housing services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	Distribution	29	25	26	28	33	36	57	58	81	89	90	100	70	29	-73	-108	-79	-12	39	-100
20	Sea and air transport services	2	1	1	1	-	-	1	1	2	2	-	3	4	8	9	6	9	11	10	20
21	Other transport & communication	10	12	14	17	28	24	47	23	28	35	20	17	18	9	-3	-19	-12	-10	-16	42
22	Banking and insurance	2	2	2	2	3	2	2	2	2	4	-	6	8	8	5	4	8	39	44	44
23	Health services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Other services	2	1	2	2	2	2	2	3	1	1	-	2	3	2	3	-	4	5	5	5
25	Public services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	14
26	Consumption by non-residents																				
	a VAT	-	-	-	-	-	-	-	-	110	137	200	247	329	340	350	366	433	433	435	446
	b Other indirect taxes	-	-	-	-	-	-	-	-	-	-	-	30	100	73	76	86	87	87	91	95
29	Total	2	41	55	53	-79	-200	-325	-528	-426	-615	-390	-370	-662	-536	-588	-1262	-1762	-1580	-1848	-2622

Table C.32 *Imports (c.i.f.) by industries of origin (mln hfl)*

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1	Agriculture	1424	1523	1608	1745	1928	1977	1977	2063	2388	2693	3020	3328	4050	5128	4757	5285	5389	5589	5843	6805
2	Meat and dairy	242	202	269	486	450	509	538	616	826	778	890	1241	1654	1736	1729	2197	2585	2585	2777	3093
3	Other food	811	900	1079	1215	1215	1350	1423	1626	1860	2305	2430	2538	3337	4080	3906	4745	5481	5221	4837	5463
4	Drink and tobacco	66	68	93	118	144	153	240	266	316	383	450	558	725	828	912	978	1061	1061	1274	1442
5	Textiles	1171	1261	1603	1931	2044	2330	2147	2545	2832	3041	3320	3714	4050	4509	4308	5144	5124	5124	5370	5871
6	Clothing and leather	344	376	486	611	706	862	788	915	1162	1342	1670	1977	2227	2729	3107	3924	4195	4195	4514	5185
7	Paper and printing	524	508	595	704	799	879	910	1059	1314	1560	1610	1755	2021	2875	2776	3198	3252	3252	3454	4060
8	Timber and stone	951	963	1042	1425	1525	1525	1551	1774	2088	2463	2570	2896	3620	4240	3944	5189	5942	5886	6247	6591
9	Chemical products	1639	1737	1991	2344	2592	3002	3278	3778	4762	5415	5850	6165	7588	10220	9108	10999	11120	10895	11497	14261
10	Primary metal products	1550	1298	1372	1851	1889	2051	2041	2247	2873	3511	3220	3282	4318	5650	4583	5194	4961	4961	5020	5555
11	Metal products and machinery	2701	2789	3067	3658	3929	4595	4645	5062	5509	7263	7850	7694	8651	10773	11445	12442	13667	13672	14365	15499
12	Electrical products	1756	2022	2114	2331	2432	2538	2589	2733	3561	4607	4660	5025	5728	7132	7702	8167	9041	9041	9523	10099
13	Transport equipment	1374	1539	1781	1977	2153	2093	2193	2569	3121	3860	5150	4553	5751	5987	7139	7828	9688	9794	11211	12425
14	Mineral oil refining	554	537	548	598	621	637	780	745	722	910	1130	937	1343	2707	2726	3317	3059	3059	3919	8460
15	Mining and quarrying	1891	2051	2228	2295	2286	2347	2577	2948	3450	4335	5110	5436	6340	13648	12758	17001	16212	16212	14498	19652
16	Electricity, gas and water	4	3	5	2	3	3	2	1	2	2	-	1	2	2	4	3	42	42	26	36
17	Construction	2	4	4	4	3	4	4	5	3	8	10	4	3	3	2	2	2	2	2	9
18	Housing services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	Distribution	170	140	165	251	237	196	247	386	466	602	520	525	695	1013	989	1051	1074	649	532	613
20	Sea and air transport services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	Other transport & communication	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Banking and insurance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Health services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Other services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Public services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Statistical adjustment	232	222	256	139	225	158	124	155	-	-	-	-	-	-	-	-	-	-	-	-
27	Unallocated	-191	77	9	113	254	116	542	-103	71	559	730	917	547	1951	1341	140	38	185	665	665
28	Re-exports	431	438	453	548	671	768	1011	1180	1417	2098	2650	3118	4359	4553	5767	6749	6451	6806	6901	8544
29	Exotic agriculture, ore mining	920	767	845	1214	1159	1091	1172	1114	1314	1408	1330	1342	1533	1938	1895	2397	3311	3464	3209	3221
30	Services	2663	2973	3319	3760	4016	4538	4770	5348	5981	7031	8110	8146	9218	10366	11204	13985	15703	15703	17544	19139
31	Total	21229	22398	24932	29320	31281	33722	35549	39032	46038	56174	62280	65152	77760	102068	102102	119935	127398	127398	133228	156688

Table C.33 *Total supply in the domestic market (mln hfl)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1977	1978	1979
1 Agriculture	7263	7624	8055	9086	9791	10367	10964	11517	12527	13602	14560	15835	18769	19761	20834	23322	24406	24300	24849	26200
2 Meat and dairy	3431	3518	3896	4486	4646	5096	5415	5788	6165	6002	6550	7799	8716	9039	10021	11102	12332	12353	12920	12989
3 Other food	6467	6895	7528	8505	8871	9686	10254	10767	11153	12777	14030	14274	16897	19429	19690	21910	24335	23748	24112	25820
4 Drink and tobacco	1493	1583	1825	2036	2411	2614	3002	3182	3083	3262	3580	3894	4439	4543	5115	5596	5794	5780	6175	6701
5 Textiles	3523	3506	4036	4570	4511	5065	4657	5214	5492	5474	5800	6184	6431	7209	6838	7722	7650	7517	7680	7997
6 Clothing and leather	2092	2108	2383	2705	2779	3097	2859	3083	3228	3258	3740	3867	4033	4528	4650	5398	5617	5920	6251	6719
7 Paper and printing	3261	3443	3825	4334	4742	5199	5377	5950	6332	7069	7490	7992	9281	11526	11934	13323	14035	14301	15270	16903
8 Timber and stone	2885	3066	3317	4204	4616	4764	5003	5538	6068	6939	7530	8119	9493	10509	10129	12043	13660	13445	14267	14868
9 Chemical products	4015	4287	4628	5619	6003	6716	7027	7832	8723	9290	9740	10482	12794	18296	15692	19577	19864	19304	19623	23988
10 Primary metal products	2483	2149	2256	2864	3033	3176	3213	3525	4305	5197	4720	4749	6090	8273	6747	7660	7262	7252	7639	7926
11 Metal products and machinery	6345	6469	6966	8331	9081	10039	9977	11129	11607	14523	15650	15583	17950	21577	22085	23437	26065	26391	26959	29170
12 Electrical products	3062	3425	3358	3879	4170	4349	4281	4627	5966	7710	7190	7917	9191	11125	11528	11955	12757	12892	14424	14973
13 Transport equipment	3133	3435	3770	3602	3819	3854	4075	4758	5229	6686	8310	7188	8257	9591	10030	10491	13424	13798	15750	16921
14 Mineral oil refining	1628	1751	2018	2267	2599	2761	2971	3620	3974	4175	4860	4737	4641	9778	9651	11852	11048	11161	12759	19708
15 Mining and quarrying	2742	2888	3078	3235	3233	3320	3578	4068	4637	5874	7060	7600	9861	16973	18173	24183	23914	23996	22460	27549
16 Electricity, gas and water	1589	1710	1882	2038	2252	2516	2827	3218	3537	4208	4810	5496	6130	7222	9873	12195	13131	13072	13958	15912
17 Construction	7081	7614	8191	10548	11800	13300	15059	16969	16135	18199	20560	22623	24768	26215	27969	30707	35502	40988	45130	47842
18 Housing services	1748	1888	2087	2275	2503	2837	3140	3508	3960	4421	5130	6015	7097	8197	9342	10912	12419	14045	15636	17356
19 Distribution	8364	9222	10154	11800	13059	13499	14987	16713	15754	18195	19880	21051	24611	27321	30353	34659	37948	41888	44983	48321
20 Sea and air transport services	136	165	136	140	148	170	211	255	334	383	430	482	545	925	1082	1101	1276	1382	1478	1742
21 Other transport & communication	2991	3273	3644	4131	4648	5102	5665	6171	6767	7459	7980	8782	9793	11099	12060	13627	14948	14674	15822	17300
22 Banking and insurance	1835	2013	2181	2568	2906	3407	3797	4327	4981	5666	6640	7783	9440	11019	12565	14324	16010	15633	18038	20269
23 Health services	1307	1533	1709	2031	2341	2749	3229	3683	4325	5059	6140	7622	9033	10931	13093	15032	16684	17992	19970	21806
24 Other services	4231	4633	5023	6017	6616	7479	8354	9239	10517	11998	13660	15380	17413	20041	22881	25802	28668	39062	43401	47545
25 Public services	6537	7366	8412	10014	10959	12200	13654	14783	17029	19484	22630	25514	28559	33805	39733	45125	49604	50296	55317	60026
26 Statistical adjustment	308	194	344	217	531	506	487	410	-	-	-	-	-	-	-	-	-	-	-	-
27 Unallocated	82	445	389	630	783	839	1075	649	707	1219	1570	1447	1099	2467	1675	573	474	299	422	-120
28 VAT	-	-	-	-	-	-	-	-	5863	7358	9070	10087	11453	12303	14240	16977	20119	18839	20816	21960
29 Consumption by non-residents	-942	-1106	-1328	-1399	-1513	-1503	-1455	-1588	-1434	-1732	-2290	-2687	-2990	-3060	-3170	-3260	-3340	-3340	-3357	-3442
30 Export of used capital goods	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-223	-185	-312
31 Exotic agriculture, ore mining	920	767	845	1214	1159	1091	1172	1114	1314	1408	1330	1342	1533	1938	1895	2397	3311	3464	3209	3221
32 Imported services	2663	2973	3319	3760	4016	4538	4770	5348	5981	7031	8110	8146	9218	10366	11204	13985	15703	15703	17544	19139
33 Total	92673	98837	107927	125707	136513	148833	159625	175397	194259	222194	246460	265303	304545	362946	387912	443727	484620	505932	543320	596997
Total 1-24	83105	88198	95946	111271	120578	131162	139922	154681	164799	187426	206040	221454	255673	305127	322335	367930	398749	420894	449554	496525

Table C.34 *Price index numbers of exports (f.o.b.) (1970 = 100)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	82.87	88.76	98.71	93.45	97.49	99.47	93.53	92.54	97.87	100	102.70	103.81	113.63	113.63	120.74	137.17	139.37	132.26	134.56
2 Meat and dairy	79.49	76.15	82.59	88.12	88.78	94.71	96.08	93.55	98.32	100	102.25	108.25	120.37	125.17	137.08	142.80	141.22	143.90	146.09
3 Other food	77.35	77.58	78.51	82.20	82.86	83.85	84.52	86.21	92.59	100	101.45	102.61	121.48	194.32	159.07	161.17	191.27	192.00	198.65
4 Drink and tobacco	88.99	89.34	88.63	91.29	92.17	93.06	93.95	94.61	98.09	100	103.50	103.75	103.33	106.33	115.33	119.46	122.83	128.30	133.40
5 Textiles	91.58	89.69	90.47	94.72	94.34	94.88	93.85	95.28	97.01	100	101.00	105.00	113.25	130.08	128.58	134.79	139.41	140.69	144.65
6 Clothing and leather	82.54	82.12	82.70	86.09	88.15	92.83	94.22	95.11	96.93	100	104.88	111.72	120.76	130.63	136.40	145.57	152.90	159.62	168.81
7 Paper and printing	85.83	84.71	83.95	86.89	88.02	90.48	90.30	90.30	93.37	100	104.00	102.86	106.76	136.34	141.66	142.51	145.21	144.48	150.26
8 Timber and stone	74.47	77.41	75.92	82.84	85.70	88.63	88.50	88.73	91.49	100	106.07	109.17	117.87	131.45	139.21	146.30	154.69	160.17	165.31
9 Chemical products	110.71	104.08	100.71	102.96	104.08	102.06	101.03	97.94	96.91	100	97.71	99.81	109.24	161.96	156.87	154.95	153.62	148.55	173.57
10 Primary metal products	76.83	75.90	74.35	84.28	91.00	89.62	85.28	84.50	85.14	100	97.33	95.03	106.73	130.07	132.20	136.50	140.40	137.48	145.18
11 Metal products and machinery	78.73	79.55	80.87	83.56	86.39	89.59	90.51	90.72	92.57	100	106.73	110.14	114.36	124.03	135.83	142.06	147.83	152.92	158.11
12 Electrical products	104.71	104.71	103.14	102.62	104.19	104.71	107.85	106.81	101.05	100	101.50	102.40	104.90	110.20	114.10	116.40	118.40	116.90	114.60
13 Transport equipment	73.95	75.35	78.14	81.03	82.33	83.15	84.98	85.66	88.57	100	103.00	108.97	114.86	123.01	128.55	133.18	140.37	143.88	147.48
14 Mineral oil refining	129.91	127.19	123.09	110.93	114.89	100.22	107.55	103.27	96.03	100	122.50	109.42	125.00	280.33	286.92	330.19	325.17	294.32	388.55
15 Mining and quarrying	84.70	83.79	91.95	101.28	101.28	101.28	101.74	102.25	99.36	100	106.00	104.00	107.00	136.00	186.15	219.92	262.79	279.56	313.11
16 Electricity. gas and water	81.03	91.40	95.24	100.00	100.00	100.00	100.00	100.00	100.00	100	95.70	85.17	84.83	104.34	192.83	237.95	236.05	260.28	248.38
17 Construction	59.35	62.44	66.75	71.95	76.63	81.30	83.91	87.35	93.02	100	110.00	120.78	132.37	150.51	162.55	175.23	189.07	206.09	225.67
18 Housing services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19 Distribution	82.70	81.13	83.73	87.50	90.47	94.45	89.92	90.46	93.98	100	103.00	104.85	111.04	130.69	139.19	150.32	162.35	163.97	177.91
20 Sea and air transport services	84.66	85.59	89.95	90.31	93.02	93.95	97.52	96.55	94.52	100	103.00	99.50	111.54	124.70	129.94	133.05	134.39	137.75	151.53
21 Other transport & communication	68.27	67.86	69.96	75.56	79.64	86.01	86.87	88.26	95.06	100	105.50	108.14	116.57	129.86	143.63	157.70	159.28	163.26	179.58
22 Banking and insurance	62.98	64.81	69.02	72.41	76.17	82.19	84.41	86.94	93.72	100	105.00	110.98	119.86	132.93	144.89	155.90	167.60	179.33	187.40
23 Health services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24 Other services	46.05	48.77	50.86	57.17	62.37	69.30	75.60	80.67	91.07	100	106.00	113.00	120.00	132.96	144.93	159.42	172.18	185.84	194.05

Table C.35 *Quantity index numbers of gross output (1970 = 100)*

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 Agriculture	74.95	75.92	73.25	80.17	81.92	81.80	87.84	91.26	94.32	100	104.60	108.97	115.28	120.97	121.17	123.18	127.12	135.46	140.95
2 Meat and dairy	69.53	73.33	75.52	75.01	80.58	81.85	85.75	93.52	93.96	100	106.06	111.31	113.55	117.44	124.52	128.23	132.08	136.24	137.95
3 Other food	64.00	67.56	69.89	75.54	76.44	80.63	85.08	88.47	93.74	100	108.86	110.28	115.76	104.07	111.12	116.29	114.11	120.78	123.90
4 Drink and tobacco	59.71	63.03	71.20	72.87	83.78	79.48	88.66	92.14	94.77	100	106.09	109.40	123.29	122.78	127.66	130.54	132.97	135.01	145.04
5 Textiles	83.83	84.54	93.45	96.89	96.30	102.53	95.49	103.10	108.61	100	104.69	102.47	99.93	97.47	87.00	89.33	84.58	84.44	82.39
6 Clothing and leather	88.98	87.58	95.88	103.42	101.85	104.30	95.57	100.59	103.51	100	101.82	95.00	89.55	85.78	78.32	76.31	69.55	67.41	66.01
7 Paper and printing	61.74	65.48	69.88	75.71	80.66	85.41	85.66	91.53	97.87	100	98.52	102.58	110.89	112.56	103.71	112.86	113.93	120.86	126.98
8 Timber and stone	52.62	55.03	59.25	68.23	72.93	75.96	80.73	86.73	95.15	100	103.62	106.16	113.55	109.49	101.08	106.74	112.49	114.84	113.49
9 Chemical products	37.69	41.52	44.56	52.08	58.85	68.42	74.06	85.46	95.80	100	108.41	119.43	137.63	149.42	126.17	153.97	153.46	159.43	176.18
10 Primary metal products	53.00	49.90	57.23	63.30	68.37	68.02	74.82	80.86	96.69	100	106.54	119.47	125.18	140.10	116.26	131.68	127.68	137.15	148.89
11 Metal products and machinery	55.09	55.60	58.16	65.93	71.15	74.54	74.13	82.39	91.98	100	106.04	106.13	116.82	126.05	119.49	126.64	129.39	128.32	132.87
12 Electrical products	41.46	44.24	45.20	55.36	61.10	61.67	62.02	67.37	83.17	100	98.91	104.40	119.22	133.65	127.53	139.49	142.37	158.12	168.98
13 Transport equipment	64.65	72.15	76.26	78.12	68.18	72.41	72.06	82.47	93.08	100	112.63	114.55	120.71	126.56	126.49	129.21	122.79	114.94	120.56
14 Mineral oil refining	39.51	42.69	44.58	51.37	56.35	57.86	59.35	73.47	90.19	100	103.16	113.42	109.31	118.31	105.13	116.79	114.66	118.41	128.14
15 Mining and quarrying	51.29	50.88	51.75	53.12	54.26	55.34	57.12	68.44	81.20	100	118.74	142.86	195.11	166.96	184.05	200.40	202.03	193.52	184.52
16 Electricity. gas and water	38.54	41.56	45.41	48.85	54.34	58.57	64.68	73.93	87.94	100	107.73	127.63	128.14	131.80	132.09	140.71	141.25	152.14	155.45
17 Construction	61.54	63.12	64.26	76.45	80.17	85.43	93.27	100.44	97.25	100	102.92	104.16	104.15	97.56	96.20	98.30	104.50	107.58	103.91
18 Housing services	77.82	79.67	81.39	83.39	85.90	88.60	91.48	94.45	97.28	100	102.96	106.27	109.99	113.63	116.77	123.81	131.04	138.19	144.16
19 Distribution	58.40	64.80	69.34	74.85	79.38	80.81	83.67	87.44	93.05	100	103.99	108.89	117.90	122.96	122.23	128.56	134.24	139.50	143.44
20 Sea and air transport services	76.55	78.09	75.26	82.06	84.06	82.73	79.95	86.34	88.11	100	102.52	96.72	95.72	103.77	101.36	103.62	110.34	108.25	114.19
21 Other transport & communication	57.75	61.38	65.78	70.77	74.21	77.33	81.85	88.86	95.04	100	101.25	109.38	118.46	124.30	120.90	127.34	133.76	135.42	137.56
22 Banking and insurance	53.01	56.09	58.01	62.96	68.03	73.02	79.10	86.97	92.91	100	106.26	112.53	123.60	129.13	133.73	142.75	149.25	160.26	171.58
23 Health services	60.50	63.93	64.85	69.37	74.53	76.57	80.52	86.72	96.52	100	105.10	109.37	113.89	118.38	119.23	122.85	124.06	126.96	130.50
24 Other services	76.85	78.67	81.66	86.84	87.91	89.75	91.92	95.17	96.07	100	104.08	106.16	109.32	114.60	117.79	121.73	124.56	129.64	134.23

C.3 Data for Part 3

Table C.36 *Input output table 1969 (mln hfl)*

		Agriculture and fishning	Meat and dairy producs	Other food	Drink and tobacco	Textiles	Clothing and leather	Paper and printing	Timber and stone	Chemical products
		1	2	3	4	5	6	7	8	9
1	Agriculture	870	6479	1261	15	10	4	15	24	7
2	Meat and dairy	17	707	172	2	3	9	-	-	16
3	Other food	2987	94	1983	108	8	3	4	-	88
4	Drink and tobacco	7	-	14	29	-	-	-	-	15
5	Textiles	23	6	16	-	777	291	12	55	72
6	Clothing and leather	3	-	2	-	2	193	1	6	1
7	Paper and printing	30	49	228	78	47	26	1661	39	221
8	Timber and stone	43	7	48	51	7	1	8	359	47
9	Chemical products	307	19	57	18	206	42	136	63	836
10	Primary metal products	5	-	1	-	-	-	-	16	8
11	Metal products and machinery	98	147	105	18	16	6	20	61	148
12	Electrical products	9	2	7	2	2	1	2	5	12
13	Transport equipment	23	4	4	-	1	-	-	1	5
14	Mineral oil refining	101	68	117	18	24	12	48	59	342
15	Mining and quarrying	12	8	15	2	2	1	8	132	209
16	Electricity, gas and water	20	36	72	11	43	11	44	67	147
17	Construction	131	19	45	10	25	13	36	37	92
18	Housing services	-	-	-	-	-	-	-	-	-
19	Distribution	282	199	469	113	187	99	183	266	294
20	Sea and air transport services	3	1	3	2	3	3	10	4	9
21	Other transport & communication	57	74	78	19	25	21	132	39	75
22	Banking and insurance	80	15	28	11	19	9	24	24	58
23	Health services	60	-	-	-	-	-	-	-	-
24	Other services	147	60	115	32	54	48	230	75	160
25	Public services	11	13	7	-	1	-	4	5	2
26	Unallocated	-	-	40	5	47	12	60	49	60
27	Consumption by non-residents	-	-	-	-	-	-	-	-	-
28	Imports	378	411	4198	494	1765	963	972	763	2221
29	Capital consumption	490	112	278	71	134	60	200	182	498
30	Indirect taxes	174	54	94	1266	-9	-1	-7	-	-54
31	Subsidies (-) less levies	-48	-731	104	-3	-	-	-	-	-8
32	Wages and salaries	841	594	1176	335	868	682	1326	1217	1623
33	Social contributions employers	140	142	259	78	190	139	315	275	376
34	Operating surplus	5022	181	760	397	221	114	547	647	1983
35	Total	6619	352	2671	2144	1404	994	2381	2321	4418

Table C.36 *(cont.) Input output table 1969 (mln hfl)*

		Primary metal products	Metal products and machinery	Electrical products	Transport equipment	Mineral oil refining	Mining and quarrying	Electricity, gas and water	Construction	Housing services
		10	11	12	13	14	15	16	17	18
1	Agriculture	-	-	-	-	-	3	-	-	-
2	Meat and dairy	-	-	-	-	-	-	-	-	-
3	Other food	-	-	-	-	-	-	-	-	-
4	Drink and tobacco	-	-	1	-	-	-	-	-	-
5	Textiles	1	16	10	22	2	-	1	21	-
6	Clothing and leather	-	1	2	4	1	-	-	-	-
7	Paper and printing	17	100	79	16	11	10	9	87	-
8	Timber and stone	14	44	40	97	4	4	2	2109	-
9	Chemical products	9	87	65	67	147	21	19	323	-
10	Primary metal products	166	540	175	171	3	1	32	127	-
11	Metal products and machinery	50	761	126	481	62	31	35	960	10
12	Electrical products	36	162	95	107	3	8	91	174	-
13	Transport equipment	12	22	9	230	1	3	1	26	-
14	Mineral oil refining	26	48	39	14	1	9	157	230	-
15	Mining and quarrying	24	1	3	1	92	13	527	23	-
16	Electricity, gas and water	72	83	33	27	45	19	29	75	0
17	Construction	16	128	74	52	32	25	50	1205	620
18	Housing services	-	-	-	-	-	-	-	-	-
19	Distribution	133	232	88	104	19	14	20	685	-
20	Sea and air transport services	2	6	6	2	3	3	1	8	-
21	Other transport & communication	17	52	52	22	11	32	14	114	-
22	Banking and insurance	25	45	32	22	11	9	7	65	35
23	Health services	-	-	-	-	-	-	-	-	-
24	Other services	22	73	70	26	24	38	22	198	10
25	Public services	-	13	2	2	1	7	29	8	15
26	Unallocated	42	120	68	49	-	28	52	-	-
27	Consumption by non-residents	-	-	-	-	-	-	-	-	-
28	Imports	1282	2326	2071	1183	3155	183	146	2713	-
29	Capital consumption	192	226	164	129	177	142	658	274	1103
30	Indirect taxes	-15	-85	-101	-24	1301	10	8	65	436
31	Subsidies (-) less levies	-	-	-	-2	-	-73	-	-	-181
32	Wages and salaries	520	2668	1558	1020	195	371	685	4490	-
33	Social contributions employers	115	605	390	230	55	111	135	1250	-
34	Operating surplus	413	1056	1295	301	206	820	806	1220	1912
35	Total	1225	4470	3306	1654	1934	1381	2292	7299	3270

C.3 Data for Part 3

Table C.36 *(cont.) Input output table 1969 (mln hfl)*

		Distribution	Sea and air transport services	Other transport & communication	Banking and insurance	Health services	Other services	Public services	Unallocated
		19	20	21	22	23	24	25	26
1	Agriculture	-	3	-	-	11	45	42	-
2	Meat and dairy	-	8	-	-	42	158	8	15
3	Other food	-	6	-	-	40	152	17	2
4	Drink and tobacco	-	15	-	-	1	319	22	3
5	Textiles	11	9	25	2	16	34	23	-
6	Clothing and leather	-	1	-	-	-	6	8	-
7	Paper and printing	605	12	61	154	31	201	238	16
8	Timber and stone	19	1	9	1	11	35	113	-
9	Chemical products	71	12	77	9	76	90	56	14
10	Primary metal products	1	1	8	-	-	49	13	3
11	Metal products and machinery	94	10	80	41	37	143	229	4
12	Electrical products	13	-	46	1	12	107	100	7
13	Transport equipment	22	141	107	-	-	42	85	1
14	Mineral oil refining	242	102	206	48	49	106	158	8
15	Mining and quarrying	4	-	-	-	-	2	26	2
16	Electricity, gas and water	140	6	109	45	43	124	207	7
17	Construction	109	6	73	45	50	79	563	-
18	Housing services	-	-	-	-	-	-	-	-
19	Distribution	197	19	84	14	47	182	96	-
20	Sea and air transport services	22	23	22	9	2	7	32	38
21	Other transport & communication	3146	191	415	245	35	119	313	65
22	Banking and insurance	128	27	83	783	11	28	48	-
23	Health services	-	-	-	14	18	-	195	9
24	Other services	533	29	322	206	100	227	889	28
25	Public services	19	8	82	8	14	50	-	153
26	Unallocated	-	41	139	39	33	25	57	-
27	Consumption by non-residents	-	-	-	-	-	-	-	-
28	Imports	1097	1415	464	252	99	588	590	731
29	Capital consumption	735	491	1029	46	239	238	700	-
30	Indirect taxes	1342	2	184	115	68	111	310	-
31	Subsidies (-) less levies	19	-	-104	-	-	-	-	-
32	Wages and salaries	5100	773	2968	1726	1521	4661	8999	-
33	Social contributions employers	980	158	647	412	357	899	3011	-
34	Operating surplus	4412	169	1477	981	1362	1954	-	-
35	Total	12588	1593	6201	3280	3547	7863	13020	0

Table C.36 *(cont.) Input output table 1969 (mln hfl)*

		Exports	Private consumption	Collective consumption	Public gross fixed capital formation	Private gross fixed capital formation	Increase in stocks	Imputed banking services	Total
		27	28	29	30	31	32	33	34
1	Agriculture	2184	1193	-	-	81	76	-	12323
2	Meat and dairy	3431	4161	-	-	2	19	-	8770
3	Other food	2463	3735	-	-	10	56	-	11756
4	Drink and tobacco	415	2333	-	-	1	7	-	3182
5	Textiles	2018	987	-	17	5	206	-	4678
6	Clothing and leather	696	1663	-	-	-	172	-	2762
7	Paper and printing	973	898	-	-	4	90	-	5991
8	Timber and stone	490	677	-	54	88	87	-	4470
9	Chemical products	5602	847	-	-	62	225	-	9563
10	Primary metal products	1759	5	-	-	69	38	-	3191
11	Metal products and machinery	3232	552	-	188	1286	299	-	9330
12	Electrical products	4041	407	-	52	572	370	-	6446
13	Transport equipment	2245	319	-	37	854	158	-	4353
14	Mineral oil refining	2310	942	-	-	15	63	-	5562
15	Mining and quarrying	655	98	-	-	-	-18	-	1842
16	Electricity, gas and water	1	1820	-	-	200	-	-	3536
17	Construction	318	520	-	3629	8448	-	-	16450
18	Housing services	-	3960	-	-	-	-	-	3960
19	Distribution	3773	10271	-	47	988	-44	-	19061
20	Sea and air transport services	3345	110	-	-	-	-	-	3679
21	Other transport & communication	1846	1300	-	-	104	-	-	8613
22	Banking and insurance	215	1375	-	-	-	-	1979	5196
23	Health services	-	4029	-	-	-	-	-	4325
24	Other services	264	5764	-	143	872	-	-	10781
25	Public services	119	141	16256	178	-	-	-	17148
26	Unallocated	470	-330	-	-	-	-	-	1106
27	Consumption by non-residents	1434	-1434	-	-	-	-	-	0
28	Imports	1417	8741	-	88	4696	636	-	46038
29	Capital consumption	-	-	-	-	-	-	-	8568
30	Indirect taxes	110	3259	-	514	1584	-	-	10711
31	Subsidies (-) less levies	-	-	-	-	-	-	-	-1027
32	Wages and salaries	-	-	-	-	-	-	-	45917
33	Social contributions employers	-	-	-	-	-	-	-	11269
34	Operating surplus	-	-	-	-	-	-	-1979	26277
35	Total	110	3259	0	514	1584	0	-1979	101715

C.3 Data for Part 3

Table C.37 *Imports 1969 (mln hfl)*

		Agriculture and fishning	Meat and dairy producs	Other food	Drink and tobacco	Textiles	Clothing and leather	Paper and printing	Timber and stone	Chemical products
		1	2	3	4	5	6	7	8	9
1	Agriculture	80	58	1620	19	-	3	36	88	4
2	Meat and dairy	-	206	290	10	11	70	-	1	12
3	Other food	2	3	1317	48	-	-	-	-	76
4	Drink and tobacco	-	-	18	136	-	-	-	-	-
5	Textiles	32	1	8	4	1041	456	16	25	13
6	Clothing and leather	-	-	-	-	1	345	-	2	-
7	Paper and printing	3	42	53	14	10	7	729	9	67
8	Timber and stone	15	12	15	42	7	1	-	373	25
9	Chemical products	152	51	119	42	506	57	83	75	1793
10	Primary metal products	8	2	12	1	1	1	14	62	19
11	Metal products and machinery	39	19	26	10	12	22	31	38	32
12	Electrical products	7	1	3	-	1	-	1	1	3
13	Transport equipment	-	-	-	-	-	-	-	-	-
14	Mineral oil refining	29	14	36	-	4	1	5	17	56
15	Mining and quarrying	6	1	6	-	1	-	19	72	86
16	Electricity, gas and water	-	-	-	-	-	-	-	-	-
17	Construction	-	-	-	-	-	-	-	-	-
18	Housing services	-	-	-	-	-	-	-	-	-
19	Distribution	5	1	2	-	18	-	15	-	8
20	Sea and air transport services	-	-	-	-	-	-	-	-	-
21	Other transport & communication	-	-	-	-	-	-	-	-	-
22	Banking and insurance	-	-	-	-	-	-	-	-	-
23	Health services	-	-	-	-	-	-	-	-	-
24	Other services	-	-	-	-	-	-	-	-	-
25	Public services	-	-	-	-	-	-	-	-	-
26	Unallocated	-	-	-	-	-	-	-	-	-
27	Re-exports	-	-	-	-	-	-	-	-	-
28	Exotic agriculture	-	-	672	168	152	-	-	-	-
29	Ore mining	-	-	-	-	-	-	-	-	-
30	Services	-	-	1	-	-	-	23	-	27
31	Total	378	411	4198	494	1765	963	972	763	2221

Table C.37 *(cont.) Imports 1969 (mln hfl)*

		Primary metal products	Metal products and machinery	Electrical products	Transport equipment	Mineral oil refining	Mining and quarrying	Electricity, gas and water	Construction	Housing services
		10	11	12	13	14	15	16	17	18
1	Agriculture	-	-	-	-	-	1	-	15	-
2	Meat and dairy	-	-	-	-	-	-	-	-	-
3	Other food	-	6	-	-	-	-	-	-	-
4	Drink and tobacco	-	-	-	-	-	-	-	-	-
5	Textiles	1	3	9	-	3	-	1	6	-
6	Clothing and leather	-	-	-	1	-	-	-	-	-
7	Paper and printing	1	8	7	2	3	2	1	13	-
8	Timber and stone	3	11	11	13	-	9	-	1021	-
9	Chemical products	49	86	134	51	125	30	18	287	-
10	Primary metal products	663	934	317	212	2	-	-	410	-
11	Metal products and machinery	15	1013	197	317	20	45	8	407	-
12	Electrical products	4	227	1383	112	2	-	2	212	-
13	Transport equipment	-	-	-	459	-	-	-	-	-
14	Mineral oil refining	52	10	4	2	183	3	20	42	-
15	Mining and quarrying	98	6	5	8	2794	1	94	106	-
16	Electricity, gas and water	-	-	-	-	-	-	2	-	-
17	Construction	-	-	-	-	-	-	-	-	-
18	Housing services	-	-	-	-	-	-	-	-	-
19	Distribution	117	20	-	-	-	-	-	-	-
20	Sea and air transport services	-	-	-	-	-	-	-	-	-
21	Other transport & communication	-	-	-	-	-	-	-	-	-
22	Banking and insurance	-	-	-	-	-	-	-	-	-
23	Health services	-	-	-	-	-	-	-	-	-
24	Other services	-	-	-	-	-	-	-	-	-
25	Public services	-	-	-	-	-	-	-	-	-
26	Unallocated	-	-	-	-	-	-	-	-	-
27	Re-exports	-	-	-	-	-	-	-	-	-
28	Exotic agriculture	-	-	-	-	-	-	-	-	-
29	Ore mining	278	-	3	-	-	-	-	-	-
30	Services	1	2	1	6	23	92	0	194	-
31	Total	1282	2326	2071	1183	3155	183	146	2713	0

C.3 Data for Part 3

Table C.37 *(cont.) Imports 1969 (mln hfl)*

		Distribution	Sea and air transport services	Other transport & communication	Banking and insurance	Health services	Other services	Public services	Unallocated
		19	20	21	22	23	24	25	26
1	Agriculture	-	-	-	-	-	13	-	-
2	Meat and dairy	-	-	-	-	-	6	-	-
3	Other food	-	-	-	-	-	7	-	-
4	Drink and tobacco	-	-	-	-	-	31	-	-
5	Textiles	14	1	4	1	2	3	-	-
6	Clothing and leather	-	-	-	-	-	1	-	-
7	Paper and printing	87	4	5	8	3	7	11	-
8	Timber and stone	1	-	5	-	-	3	-	-
9	Chemical products	125	7	69	10	67	104	46	-
10	Primary metal products	4	-	1	-	4	3	17	-
11	Metal products and machinery	11	22	31	6	9	85	121	-
12	Electrical products	3	-	4	-	5	38	81	-
13	Transport equipment	-	17	-	-	0	237	77	-
14	Mineral oil refining	26	20	65	-	5	8	37	-
15	Mining and quarrying	4	-	4	2	4	16	18	-
16	Electricity, gas and water	-	-	-	-	-	-	-	-
17	Construction	-	-	-	-	-	-	-	-
18	Housing services	-	-	-	-	-	-	-	-
19	Distribution	3	24	-	-	-	12	11	-
20	Sea and air transport services	-	-	-	-	-	-	-	-
21	Other transport & communication	-	-	-	-	-	-	-	-
22	Banking and insurance	-	-	-	-	-	-	-	-
23	Health services	-	-	-	-	-	-	-	-
24	Other services	-	-	-	-	-	-	-	-
25	Public services	-	-	-	-	-	-	-	-
26	Unallocated	-	-	-	-	-	-	21	46
27	Re-exports	-	-	-	-	-	-	-	-
28	Exotic agriculture	-	-	-	-	-	-	-	-
29	Ore mining	-	-	-	-	-	-	-	-
30	Services	819	1320	276	225	-	14	150	685
31	Total	1097	1415	464	252	99	588	590	731

Table C.37 *(cont.) Imports 1969 (mln hfl)*

		Exports	Private consumption	Collective consumption	Public gross fixed capital formation	Private gross fixed capital formation	Increase in stocks	Imputed banking services	Total
		27	28	29	30	31	32	33	34
1	Agriculture	-	402	-	-	-	49	-	2388
2	Meat and dairy	-	209	-	-	-	11	-	826
3	Other food	-	392	-	-	-	9	-	1860
4	Drink and tobacco	-	130	-	-	-	1	-	316
5	Textiles	-	1114	-	-	4	70	-	2832
6	Clothing and leather	-	814	-	-	-	-2	-	1162
7	Paper and printing	-	196	-	-	-	22	-	1314
8	Timber and stone	-	493	-	-	18	10	-	2088
9	Chemical products	-	560	-	-	19	97	-	4762
10	Primary metal products	-	-	-	-	142	44	-	2873
11	Metal products and machinery	-	683	-	34	2182	74	-	5509
12	Electrical products	-	602	-	-	864	5	-	3561
13	Transport equipment	-	860	-	49	1412	10	-	3121
14	Mineral oil refining	-	82	-	-	-	1	-	722
15	Mining and quarrying	-	66	-	-	-	33	-	3450
16	Electricity, gas and water	-	-	-	-	-	-	-	2
17	Construction	-	-	-	3	-	-	-	3
18	Housing services	-	-	-	-	-	-	-	0
19	Distribution	-	18	-	-	55	157	-	466
20	Sea and air transport services	-	-	-	-	-	-	-	0
21	Other transport & communication	-	-	-	-	-	-	-	0
22	Banking and insurance	-	-	-	-	-	-	-	0
23	Health services	-	-	-	-	-	-	-	0
24	Other services	-	-	-	-	-	-	-	0
25	Public services	-	-	-	-	-	-	-	0
26	Unallocated	-	-	-	-	-	4	-	71
27	Re-exports	1417	-	-	-	-	-	-	1417
28	Exotic agriculture	-	-	-	-	-	49	-	1041
29	Ore mining	-	-	-	-	-	-8	-	273
30	Services	-	2120	-	2	-	-	-	5981
31	Total	1417	8741	0	88	4696	636	-	46038

C.3 Data for Part 3

Table C.38 *Indirect taxes less subsidies 1969 (mln hfl)*

		Agriculture and fishning	Meat and dairy producs	Other food	Drink and tobacco	Textiles	Clothing and leather	Paper and printing	Timber and stone	Chemical products
		1	2	3	4	5	6	7	8	9
1	Agriculture	12	91	17	-	-1	-	-	-	-
2	Meat and dairy	-	-55	-61	-	-	-	-	-	-
3	Other food	10	-1	-35	11	-	-	-	-	-25
4	Drink and tobacco	-	-	3	-	-	-	-	-	-
5	Textiles	-	-	-	-	1	1	-	-	-
6	Clothing and leather	-	-	-	-	-	-	-	-	-
7	Paper and printing	-	-	1	-	-	-	8	-	2
8	Timber and stone	-	-	-	-	-	-	-	2	-
9	Chemical products	2	-	-	-	1	-	1	-	5
10	Primary metal products	-	-	-	-	-	-	-	-	-
11	Metal products and machinery	-	1	1	-	-	-	-	-	1
12	Electrical products	-	-	-	-	-	-	-	-	-
13	Transport equipment	-	-	-	-	-	-	-	-	-
14	Mineral oil refining	38	26	40	7	9	6	23	26	30
15	Mining and quarrying	-	-	-	-	-	-	-	1	-11
16	Electricity, gas and water	-	-	-	-	-	-	-	-	1
17	Construction	1	-	-	-	-	-	-	-	-
18	Housing services	-	-	-	-	-	-	-	-	-
19	Distribution	35	45	74	54	30	14	28	16	60
20	Sea and air transport services	-	-	-	-	-	-	-	-	-
21	Other transport & communication	-1	1	-	-1	-	-	-	-2	-1
22	Banking and insurance	2	-	1	-	1	-	-	-	2
23	Health services	-	-	-	-	-	-	-	-	-
24	Other services	1	1	2	-	-	-	3	-	3
25	Public services	-	-	-	-	-	-	-	-	-
26	Unallocated	-	-	-	-	-	-	-	-	-
27	VAT	-	-	-	-	-	-	-	-	-
28	Refund of former sales tax	-	-2	-8	-10	-17	-10	-37	-22	-120
29	Import levies less import subsidies	-	30	288	1	-	-	-	-	-
30	Total	100	137	323	62	24	11	26	21	-53

Table C.38 *(cont.) Indirect taxes less subsidies 1969 (mln hfl)*

		Primary metal products	Metal products and machinery	Electrical products	Transport equipment	Mineral oil refining	Mining and quarrying	Electricity, gas and water	Construction	Housing services
		10	11	12	13	14	15	16	17	18
1	Agriculture	-	-	-	-	-	-	-	-	-
2	Meat and dairy	-	-	-	-	-	-	-	-	-
3	Other food	-	-	-	-	-	-	-	-	-
4	Drink and tobacco	-	-	-	-	-	-	-	-	-
5	Textiles	-	-	-	-	-	-	-	-	-
6	Clothing and leather	-	-	-	-	-	-	-	-	-
7	Paper and printing	-	1	-	-	-	-	-	-	-
8	Timber and stone	-	-	-	1	-	-	-	11	-
9	Chemical products	-	1	-	-	1	-	-	2	-
10	Primary metal products	7	1	-	-	-	-	-	-	-
11	Metal products and machinery	-	2	-	2	-	-	-	3	-
12	Electrical products	-	1	-	1	-	-	-	1	-
13	Transport equipment	-	-	-	1	-	-	-	-	-
14	Mineral oil refining	8	20	23	6	1	4	28	47	-
15	Mining and quarrying	-2	-	-	-	1	-	-4	-1	-
16	Electricity, gas and water	-	-	-	-	-	-	-	-	-
17	Construction	-	-	-	-	-	-	-	4	2
18	Housing services	-	-	-	-	-	-	-	-	-
19	Distribution	12	45	23	35	6	3	5	73	-
20	Sea and air transport services	-	-	-	-	-	-	-	-	-
21	Other transport & communication	-	-	-	-1	-	-1	-	-1	-
22	Banking and insurance	-	1	1	1	-	-	-	2	1
23	Health services	-	-	-	-	-	-	-	-	-
24	Other services	-	-	-	-	-	-	-	-	-
25	Public services	-	-	-	-	-	-	-	-	-
26	Unallocated	-	-	-	-	-	-	-	-	-
27	VAT	-	-	-	-	-	-	-	-	70
28	Refund of former sales tax	-25	-112	-120	-34	-33	-	-	-	-
29	Import levies less import subsidies	-	-	-	-	-	-	-	-	-
30	Total	0	-40	-73	12	-24	6	29	141	73

Table C.38 *(cont.) Indirect taxes less subsidies 1969 (mln hfl)*

		Distribution	Sea and air transport services	Other transport & communication	Banking and insurance	Health services	Other services	Public services	Unallocated
		19	20	21	22	23	24	25	26
1	Agriculture	-	-	-	-	-	1	1	-
2	Meat and dairy	-	-	-	-	-	1	-	-
3	Other food	-	-	-	-	-	2	-	-
4	Drink and tobacco	-	-	-	-	-	120	3	-
5	Textiles	-	-	-	-	-	-	-	-
6	Clothing and leather	-	-	-	-	-	-	-	-
7	Paper and printing	4	-	-	1	-	-	2	-
8	Timber and stone	-	-	-	-	-	-	1	-
9	Chemical products	-	-	-	-	-	-	-	-
10	Primary metal products	-	-	-	-	-	-	-	-
11	Metal products and machinery	-	-	-	-	-	-	-	-
12	Electrical products	-	-	-	-	-	-	-	-
13	Transport equipment	-	-	1	-	-	1	-	-
14	Mineral oil refining	139	19	85	25	28	44	82	-
15	Mining and quarrying	-	-	-	-	-	-	-	-
16	Electricity, gas and water	1	-	-	-	-	-	1	-
17	Construction	-	-	-	-	-	-	2	-
18	Housing services	-	-	-	-	-	-	-	-
19	Distribution	72	5	30	1	5	46	38	-
20	Sea and air transport services	-	-	-	-	-	-	-	-
21	Other transport & communication	39	3	4	-1	-	-2	-4	-
22	Banking and insurance	3	-	2	3	-	-	3	-
23	Health services	-	-	-	-	-	-	-	-
24	Other services	6	-	2	2	1	3	9	-
25	Public services	-	-	-	-	-	-	-	-
26	Unallocated	-	-	-	-	-	-	-	-
27	VAT	-	-	28	63	62	10	273	-
28	Refund of former sales tax	-240	-	-	-	-	-	-	-
29	Import levies less import subsidies	19	-	-	-	-	-	-	-
30	Total	43	27	152	94	96	226	411	0

Table C.38 *(cont.) Indirect taxes less subsidies 1969 (mln hfl)*

		Exports	Private consumption	Collective consumption	Public gross fixed capital formation	Private gross fixed capital formation	Increase in stocks	Imputed banking services	Total
		27	28	29	30	31	32	33	34
1	Agriculture	-12	17	-	-	-	-	-	126
2	Meat and dairy	-581	-9	-	-	-	-	-	-705
3	Other food	-81	37	-	-	-	-	-	-82
4	Drink and tobacco	-3	1149	-	-	-	-	-	1272
5	Textiles	4	2	-	-	-	-	-	8
6	Clothing and leather	3	6	-	-	-	-	-	9
7	Paper and printing	4	7	-	-	-	-	-	30
8	Timber and stone	3	3	-	-	1	-	-	22
9	Chemical products	18	27	-	-	-	-	-	58
10	Primary metal products	2	-	-	-	-	-	-	10
11	Metal products and machinery	9	2	-	1	5	-	-	27
12	Electrical products	13	1	-	-	2	-	-	19
13	Transport equipment	2	2	-	-	1	-	-	8
14	Mineral oil refining	2	568	-	-	-	-	-	1334
15	Mining and quarrying	-34	-13	-	-	-	-	-	-63
16	Electricity, gas and water	-	4	-	-	1	-	-	8
17	Construction	1	2	-	10	43	-	-	65
18	Housing services	-	185	-	-	-	-	-	185
19	Distribution	81	590	-	5	145	6	-	1582
20	Sea and air transport services	2	-	-	-	-	-	-	2
21	Other transport & communication	28	-10	-	-	2	-	-	52
22	Banking and insurance	2	27	-	-	-	-	-	52
23	Health services	-	6	-	-	-	-	-	6
24	Other services	1	50	-	3	14	-	-	101
25	Public services	-	-	37	-	-	-	-	37
26	Unallocated	-	-	-	-	-	-	-	0
27	VAT	110	3259	-	514	1584	-	-	5973
28	Refund of former sales tax	-	-	-	-	-	-	-	-790
29	Import levies less import subsidies	-	-	-	-	-	-	-	338
30	Total	-426	5912	37	533	1798	6	0	9684

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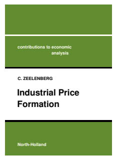

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LIST OF NOTATION†

a	input-output coefficient
b	primary-input coefficient
C	total cost
c	average variable cost
E	Theil coefficient (in Chapter 8); elasticity matrix (in Chapter 9)
e	expenditure function
f	fixed cost
g	revenue function
I	identity matrix
k	mark-up factor (in Chapters 2 and 3)
l	primary cost
M	number of primary inputs
N	number of industries, number of goods
p	price
q	quantity
r	price of primary input
s	value share
u	utility function, utility level (in Chapters 5 and 6 and Appendices A and B); capacity utilization (in Chapters 7 and 8)
v	quantity of primary input
w	value share
x	excess demand
y	income
Δ	marginal cost; (if used as operator) difference operator: $\Delta x_t = x_t - x_{t-1}$
ε	price elasticity; disturbance (in regression equations)
ε^*	compensated price elasticity
η	income elasticity
θ	production-period
ι	$= (1, 1, \ldots, 1)'$: vector with unit elements
μ	marginal budget share
π	Slutsky coefficient
σ	elasticity of substitution
ψ	indirect utility function

† Symbols that have only local significance are not listed, nor is every variant of a symbol (with or without subscript, etc.).

Subscripts and superscripts:

d	identifies domestic variables
F	identifies producer variables
H	identifies consumer variables
h	identifies primary inputs
i	identifies industries
j	identifies industries
m	identifies foreign variables (in Chapters 4-9)
t	identifies time periods
$+$	identifies 'excess variables' (in Chapter 5)
$\hat{}$	(above vector) diagonal matrix: $(\hat{x})_{ii} = x_i$; $(\hat{x})_{ij} = 0$ $(i \neq j)$
$\tilde{}$	relative differential: $\tilde{x} = (\mathrm{d}x)/x$
$\bar{x}$	index: $\bar{x} = (x + \Delta x)/x$
$'$	(prime) transpose of a matrix or vector: $A'_{ij} = (A)_{ji}$
'	derivative

Capital letters are used in Chapter 5 to denote foreign variables.

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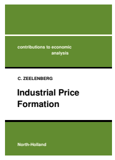

SAMENVATTING (Summary in Dutch)

Probleemstelling en methode

In dit proefschrift worden modellen van de prijsvorming in bedrijfstakken behandeld; de nadruk ligt op prijsvorming in een open economie. Het doel is om te laten zien hoe modellen die zijn gebaseerd op de economische theorie kunnen bijdragen tot een verklaring van prijsvorming; de modellen worden toegepast op gegevens voor Nederland in de periode 1961-1979.

Er zijn verschillende redenen waarom het nuttig is om prijsvorming in bedrijfstakken te bestuderen en hierbij een economische theorie te gebruiken.

Ten eerste kan toepassing van de modellen een antwoord geven op vragen als: zijn de winstmarges in meer geconcentreerde bedrijfstakken hoger dan die in minder geconcentreerde bedrijfstakken?; zijn de prijzen in meer geconcentreerde bedrijfstakken minder flexibel dan die in minder geconcentreerde bedrijfstakken?; leidt sterke buitenlandse concurrentie tot lage winstmarges en lage prijsstijgingen?

Ten tweede zijn veel bestaande modellen van de prijsvorming gebaseerd op ad-hoc argumenten, wat weinig of geen interpretatie van de coëfficiënten toelaat en dus nauwelijks restricties oplevert. Daarentegen laat een economisch-theoretische benadering zien welke variabelen in het model moeten worden opgenomen en maakt een duidelijke interpretatie van de coëfficiënten mogelijk.

Een voorbeeld kan dit wellicht verduidelijken. In veel studies over prijsvorming wordt de winstmarge verklaard uit o.a. het marktaandeel van de binnenlandse producenten; de redenering hierbij is dat een sterke buitenlandse concurrentie (dus een laag binnenlands marktaandeel) tot een lage winstmarge leidt. In Hoofdstuk 6 van dit boek laat ik zien dat een micro-economische theorie inderdaad kan leiden tot de opneming van deze variabele in het model en dat haar coëfficiënt positief is en afhangt van de substitutiemogelijkheden tussen binnenlandse en buitenlandse producten.

Inhoud

Het boek bestaat uit drie delen. In Deel 1 wordt de relatie tussen prijzen en kosten bestudeerd met behulp van een input-output model voor de kosten en een model waarin de prijzen worden bepaald door een opslag op de historische kosten.

In Deel 2 wordt de prijsvorming onder volledige mededinging bestudeerd; de 'law of one price' wordt getoetst en er wordt een algemeen-evenwichtsmodel geconstrueerd en geschat.

In Deel 3 wordt de prijsvorming onder monopolistische mededinging behandeld. Er wordt een theoretische basis gegeven voor een prijsvergelijking die veel gebruikt wordt in de leer van de industriële organisatie; verder bevat dit deel een analyse van de effecten die concentratie heeft op prijsvorming, en een algemeen-evenwichtsmodel van de prijsvorming onder monopolistische mededinging.

Beperkingen

Enkele beperkingen van de analyse in dit boek zijn: 1. de modellen van de Delen 2 en 3 zijn statisch; 2. er wordt verondersteld dat de prijzen of het aanbod van de primaire productiefactoren (arbeid, kapitaal, ingevoerde producten) exogeen zijn; 3. de modellen van de verschillende hoofdstukken worden slechts in zeer beperkte mate met elkaar vergeleken; 4. de toepassing van de modellen is vrijwel steeds beperkt tot een schatting van het uit de theorie afgeleide model, d.w.z. er zijn bijna geen varianten geschat of ad-hoc uitbreidingen aan de modellen gegeven.

Samenvatting van de hoofdstukken

Deel 1

In Deel 1 wordt bestudeerd hoe prijsveranderingen zich door de economie voortplanten doordat de kosten van een bedrijfstak mede bepaald worden door de prijzen van de andere bedrijfstakken. In dit deel wordt verondersteld dat de productietechniek onafhankelijk van de prijzen is en dat de ondernemers hun prijzen vaststellen door een constante procentuele winstmarge op de kosten te leggen.

In Hoofdstuk 2 worden de eigenschappen van een statische en een dynamische versie van het model geanalyseerd.

In Hoofdstuk 3 wordt een versie van het dynamische model toegepast en worden de effecten gesimuleerd van een algemene loonstijging, een algemene stijging van het invoerprijspeil, en een stijging van de prijs van ruwe aardolie.

Deel 2

In Deel 2 wordt bestudeerd hoe de prijzen tot stand komen als er volledige mededinging is.

Hoofdstuk 4 gaat over de 'law of one price,' toegepast op een kleine open economie. Als een binnenlands en een buitenlands product in een perfecte markt verhandeld worden, dan zegt de 'law of one price' dat de prijzen van het binnenlandse product en het buitenlandse product gelijk aan elkaar zijn. De 'law of one price' is getoetst voor 5 goederengroepen; de resultaten laten zien dat de 'law of one price' alleen opgaat voor de groep brandstoffen. Ook zijn de effecten die aggregatie kan hebben op de toetsing geanalyseerd en is een vergelijking gemaakt tussen 'unit values' en prijsindexcijfers.

Een mogelijke verklaring voor het niet opgaan van de 'law of one price' is dat binnenlandse en buitenlandse producten niet volledig substitueerbaar zijn. In Hoofdstuk 5 wordt daarom een model geconstrueerd waarvan de 'law of one price' een speciaal geval is. Er wordt aangetoond dat voor een kleine open economie de prijzen van buitenlandse producten gegeven zijn omdat haar uitvoer klein is ten opzichte van de wereldproductie. Uit de empirische toepassing blijkt dat de prijsvorming beter verklaard wordt door dit model dan door de 'law of one price.'

Deel 3

In Deel 3 wordt prijsvorming onder monopolistische mededinging behandeld.

In Hoofdstuk 6 wordt aangenomen dat de kosten evenredig zijn met de omvang van de productie en er wordt alleen aandacht gegeven aan concurrentie tussen binnenlandse en buitenlandse producenten die een gelijksoortig product (bijvoorbeeld voedingsmiddelen) produceren. Er wordt een relatie afgeleid tussen de winstmarge van een monopolist en zijn aandeel op de binnenlandse markt; er wordt aangetoond dat de winstmarge lager is, naarmate het binnenlandse marktaandeel lager is of de substitutiemogelijkheden tussen het binnenlandse en het buitenlandse product groter zijn. Uit de empirische toepassing blijkt dat de toegenomen buitenlandse concurrentie de winstmarge vooral heeft beïnvloed in de bedrijfstakken Overige voedingsmiddelenindustrie, Textielindustrie en Kleding-, leer- en schoenenindustrie.

In Hoofdstuk 7 wordt ook de concurrentie tussen de producenten van geheel verschillende goederen (bijvoorbeeld voedingsmiddelen en kleding) in de beschouwing betrokken. Ook wordt er een model gemaakt voor de relatie tussen de kosten en de bezettingsgraad. Deze twee veralgemeniseringen leiden tot een model waarin het prijspeil in een bedrijfstak wordt beinvloed door vijf variabelen: 1. de variabele kosten (loonkosten en materiaalkosten); 2. de vaste kosten (kapitaalkosten); 3. de bezettingsgraad; 4. het binnenlandse marktaandeel (het aandeel van de binnenlandse producenten op de markt voor het goed dat zij produceren); 5. het budgetaandeel (het aandeel dat de binnenlandse en de buitenlandse producenten van een goed hebben in de totale binnenlandse bestedingen). Het model is geschat voor 24 bedrijfstakken, die samen de Nederlandse economie omvatten. De empirische resultaten laten zien dat in alle bedrijfstakken (behalve Delfstoffenwinning en Woningbezit) de variabele kosten de belangrijkste factor in de prijsvorming zijn; de vaste kosten en het budgetaandeel zijn belangrijk in ongeveer de helft van de bedrijfstakken; en de bezettingsgraad en het binnenlandse marktaandeel zijn belangrijk in ongeveer een vijfde van de bedrijfstakken.

In Hoofdstuk 8 wordt de relatie tussen concentratie en prijsvorming onderzocht. Verschillende bestaande modellen van deze relatie worden gecombineerd met het model van Hoofdstuk 7. De empirische resultaten laten zien dat er in Nederland geen verband bestaat tussen concentratie en winstmarge. Wel is het zo dat het prijspeil meer reageert op veranderingen in de bezettingsgraad en veranderingen in het budgetaandeel, naarmate de bedrijfstak geconcentreerder is.

In Hoofdstuk 9 worden de modellen per bedrijfstak die in Hoofdstuk 7 zijn ontwikkeld, samengevoegd tot een model dat de prijsvorming in de economie als geheel beschrijft. Voor enkele eenvoudige gevallen wordt theoretisch afgeleid hoe de binnenlandse prijzen reageren op veranderingen in de buitenlandse prijzen, de primaire kosten en het inkomen. Voor de 24 bedrijfstakken die in Hoofdstuk 7 zijn onderscheiden, wordt een empirische analyse gegeven. De resultaten laten zien dat in de meeste bedrijfstakken de primaire kosten en de buitenlandse prijzen ongeveer even belangrijk zijn.

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