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The determinants of investment

Estimation and simulation of international trade linkages in the QUEST model

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SUMMARY

Abbreviations and symbols used

Countries

B	Belgium
DK	Denmark
D	Federal Republic of Germany
GR	Greece
E	Spain
F	France
IRL	Ireland
I	Italy
L	Luxembourg
NL	The Netherlands
P	Portugal
UK	United Kingdom
EUR 10	Total of the Member States of the European Community in 1985
EUR 9	Community in 1985 excluding Greece
EUR 12	Community

Currencies

BFR	Belgian franc
DKR	Danish krone
DM	Deutschmark
DR	Greek drachma
ESC	Portuguese escudo
FF	French franc
HFL	Dutch guilder
IRL	Irish pound (punt)
LFR	Luxembourg franc
LIT	Italian lira
PTA	Spanish peseta
UKL	Pound sterling
ECU	European currency unit
USD	US dollar
SFR	Swiss franc
YEN	Japanese yen
CAD	Canadian dollar
ÖS	Austrian schilling

Other abbreviations

ACP	African, Caribbean and Pacific countries having signed the Lomé Convention
ECSC	European Coal and Steel Community
EDF	European Development Fund
EIB	European Investment Bank
EMCF	European Monetary Cooperation Fund
EMS	European Monetary System
ERDF	European Regional Development Fund
Euratom	European Atomic Energy Community
Eurostat	Statistical Office of the European Communities
GDP (GNP)	Gross domestic (national) product
GFCF	Gross fixed capital formation
LDCs	Less-developed countries
Mio	Million
NCI	New Community Instrument
OCTs	Overseas Countries and Territories
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
SMEs	Small and medium-sized enterprises
SOEC	Statistical Office of the European Communities
toe	Tonne of oil equivalent
:	Not available

The determinants of investment

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This document has been prepared for the Economic Policy Committee and discussed by its members. It has been prepared by officials of the Directorate-General for Economic and Financial Affairs under the direction of Michel Catinat, economic adviser.

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Introduction

Since the first oil shock, the investment ratio has fallen in most European countries. The slowdown in capital accumulation which has taken place over 10 years or so has only recently been reversed. A pertinent question is whether the current recovery of investment will be sufficient to reinforce a rate of growth in the Community which is high enough to reduce unemployment? Will productive capacity be sufficient? The most recent analyses generally show increasing strains on productive capacity; in 1987, according to forecasts of the Commission, [19], capacity utilization should come close to the peak rates observed in the last 25 years in Germany, France, Italy and the United Kingdom, well beyond the average levels for the 1970s. The present and future growth of investment and the support for it are one of the key factors determining Europe's future position.

The purpose of this document is to provide some reflections on the determinants of investment. What are they? What is their relative importance? Is their influence the same in the short or medium term? Are there differences according to country? This is a necessary step in the formulation of any economic policy recommendation. A study has been undertaken which provides some answers to the above questions. It should be clearly understood, however, that the study is confined to the determinants of investment. The policy instruments which can be used to influence these determinants and the budgetary, fiscal and financial rules governing them are not considered at this stage. Such a consideration would require a more general macroeconomic view, including an examination of the room for manœuvre on policy in each European country. In particular it would mean measuring the relative effectiveness of the different policy instruments which may influence the determinants of investment. This might be a logical follow-up to this study, but it is not its present purpose.

In Part I a coherent framework is developed which encompasses the three fundamental determinants of investment: demand, the relative cost of the factors of production (capital and labour) and profits. Accordingly, the determinants of investment vary at the level of each firm, in line with the constraints perceived by the firm on different markets, i.e. the 'accelerator-relative costs-profits' model considered in this paper covers cases in which some firms face sales constraints and others financing ones.

In Part II, econometric estimations are presented using two sets of data. The first is quarterly and contains data for Germany, France, the United Kingdom and the United States; the second is annual and covers Germany, France, Italy, the Netherlands and the United Kingdom. The data relates to fixed capital formation of firms in the market sector (and as a result does not include residential investment, investment in the non-market sector and stockbuilding). The period covered is the 1970s and the beginning of the 1980s (to 1984 for the quarterly data and to 1983 for the annual data). The most recent period is therefore excluded. Two specifications are used, corresponding respectively to two separate technological constraints, the putty-putty and the putty-clay production function.

The robustness of the results is also tested on the basis of an analysis of the stability of investment behaviour over time (Part III). Two groups of tests have been developed. The first examines possible breaks in the general relationship between investment, demand, relative prices and profit (cusum test, cusum of squares test, Chow test, Quandt's likelihood ratio test). The second group of tests focuses on the stability over time between investment and each of its determinants taken separately (moving regressions). As a result of these tests sub-periods of relative stability for each country can be determined. Within each of them, the coefficients of the equations, and therefore investment behaviour, can be considered stable. The econometric estimates carried out on each of these sub-periods then provide elasticities of investment relative to determinants.

Finally, Part IV examines the relative importance of the determinants of investment. Which of the determinants seems most appropriate for stimulating capital accumulation? Are short- and medium-term considerations and the country recommendations the same? In order to answer these questions, two points have been taken into account: first, the elasticity of investment in relation to its determinants, and second, the variability of each of these determinants. The importance of a determinant therefore depends not only on its effectiveness in stimulating investment, but also on the ability to vary it.

I. Determinants of investment: Theoretical basis

The purpose of this section is to describe the theoretical basis for the investment functions which are estimated for a number of Community countries in Part II of this report. These models have been discussed in the recent economic literature on investment and only the main characteristics are covered here.

Econometric studies on private investment show that three factors can play a key role in determining investment: demand, the relative cost of the factors of production, and profits. However, the majority of theoretical approaches justify the introduction of just one of these variables.[1] It is only recently that models which encompass all three factors have been mathematically derived. The derivation used in this study is based on a disequilibrium approach and assumes that the factors influencing investment vary, at the level of each firm, in line with the constraints perceived by the firm on the different markets concerned by the investment decision (goods market, the labour market, and the capital market).

With this approach, an 'accelerator-relative costs-profit' model covers cases in which some firms are constrained by sales outlets and others by their financing potential. The theoretical basis of this model is described below.[2]

A. Accelerator models — relative costs

A.1. Theoretical basis

Disequilibrium theory allows the derivation of a model of investment that includes both demand and relative factor costs. The model describes the investment behaviour of firms which are faced with situations of Keynesian unemployment, i.e. they face a sales constraint and are obliged, therefore, to produce at a below-optimum level. Although firms face a sales constraint, they are not constrained on other markets (labour market, capital goods market, capital market).

Formally, their behaviour may be described in the following way:

$$\text{Minimize } wL + cK \qquad (1)$$

$$\text{subject to} \quad Y = \bar{Y} = F(e^{\alpha t}K, e^{\beta t}L)$$

The firm minimizes its production costs[3] (cost of labour (wL) and the cost of capital (cK), with c representing the user cost of capital) while facing a sales constraint ($\bar{Y}$ is given). Output Y is produced by a two-factor production function F (capital and labour) and technical progress is assumed to affect both capital (neutrality according to Solow) and labour (neutrality according to Harrod). Returns to scale are equal to v, and imply mathematically that the production function is homogeneous of degree v.

$$F(\lambda e^{\alpha t}K, \lambda e^{\beta t}L) = \lambda^{v}Y \qquad (2)$$

The optimum level K^* of capital is given by solving (1).[4]

This leads to (see Annex I for more details):

$$\dot{K}^* = \frac{1}{v}\dot{Y} - \sigma b(\dot{c} - \dot{w}) - \alpha + (\alpha - \beta)b \qquad (3)$$

where:

σ represents the elasticity of substitution $= \dfrac{\delta \ln(K/L)}{\delta \ln(w/c)}$,

b represents wage costs expressed as a proportion of total production costs

$$b = \frac{wL}{wL + cK}, \text{ and}$$

[1] Accelerator models for demand, neo-classical models for relative costs or Tobin models among others for profits.

[2] The model used for the econometric work is a combination of an effective demand model (where firms are rationed in goods markets, but not in the labour market and where consequently the desired capital stock is a function of expected demand and expected relative factor prices) and a model where firms are constrained on capital markets so that profits also play a role. Implicitly such an approach means that neither a simple equilibrium (no constraints) neo-classical model is considered, nor is a disequilibrium approach with either classical unemployment or with repressed inflation. However, it should be remembered that the use of either a neo-classical model or a classical unemployment model, where firms do not face constraints on the goods or the labour market, would imply that the desired level of the capital stock is solely a function of the real cost of labour and the real user cost of capital. Furthermore, as the empirical work in this study relates in general to periods of unemployment the model of repressed inflation was ruled out *a priori*.

[3] Since marketing outlets are given and prices fixed, minimization of production cost is identical mathematically to profit maximization.

[4] Resolution of system (1) also yields the optimum demand for labour. From an econometric viewpoint the demand for capital and for labour should, therefore, be estimated at the same time. In this study, demand for capital has been estimated independently.

$\dot{X}$ designates the rate of variation of variable X:

$$\dot{X} = \frac{dX/dt}{X}$$

Equation (3) can be regarded as the basic equation for any model of the accelerator-relative prices type. Assuming a constant rate of capital depreciation over time,

$$dK/dt = I - \delta K, \qquad (4)$$

equation (3) can then be written in the equivalent form:

$$\frac{I^*}{K} = \frac{1}{v}\dot{Y} - \sigma b\,(\dot{c} - \dot{w}) - \alpha + (\alpha - \beta)b + \delta \qquad (5)$$

In other words, the rate of accumulation I/K is a growing function of the rate of variation of demand, (the coefficient of proportionality being interpreted as being the inverse of the returns to scale) and a decreasing function of the rate of variation of relative prices (user cost of capital/wages per capita). The coefficient of proportionality is constant if both the elasticity of substitution (σ) and wage costs expressed as a proportion of total costs (b) are constant. This is strictly verified only in the case of a Cobb-Douglas function.[1] Similarly, owing to the presence of b, the term $(-\alpha + (\alpha-\beta)b + \delta)$ is constant in that case only. *A priori* its sign is indeterminate; the technical progress incorporated into capital is often presumed negative ($\alpha<0$) whereas the technical progress incorporated into labour is positive ($\beta>0$), the rate of depreciation δ being positive.

After integration and assuming b to be constant, equation (3) becomes:

$$\log K^* = \frac{1}{v}\log Y - \sigma b \log \frac{c}{w} + [(\alpha - \beta)b - \alpha]t + Cte \qquad (6)$$

Written in this form, the equation can provide another starting point for econometric tests.

A.2. Econometric specifications of the accelerator-relative costs model

The basic equation (3), or its variants (5) and (6) cannot be used for direct econometric tests for at least two reasons:

(i) the capital stock K* is a desired stock that may deviate from the level recorded in view of adjustment costs and the time it takes to make investments;

(ii) the determinants ($\dot{Y}$ and $\dot{c}/w$) are expected variables on which investment decision is based today.

The problem of the delay between desired and realized investment is generally solved using a distributed lag function. To simplify an adjustment process of the Koyck type is assumed:

$$K/K_{-1} = (K^*/K_{-1})^{\lambda} \quad \text{or} \quad \dot{K} = \lambda\,\dot{K}^* + (1-\lambda)\dot{K}_{-1} \qquad (7)$$

Similarly, the expected variables have been approximated by way of distributed lag processes:

$$\dot{Y}_e = P(L)\,\dot{Y} \quad (\dot{c}/w)_e = Q(L)(\dot{c}/w) \qquad (8)$$

where P and Q are 'lag operator' polynomials where the sum of coefficients are equal to $1/v$ and $-\sigma b$ respectively.

Two types of equation for investment behaviour result, therefore, depending on assumptions made regarding the production function.

(a) Putty-putty production function

In this case, expectations regarding demand and relative prices lead firms to adjust the entire stock of capital.

Equation (5) with the allowances made for adjustment periods and expectations results in the following econometric specification of the accelerator-relative costs model with a putty-putty production function:

$$\frac{I}{K_{-1}} = (1-\lambda)\left(\frac{I}{K_{-1}}\right)_{-1} + \varphi_1(L)\,\dot{Y} + \varphi_2(L)\left(\frac{\dot{c}}{w}\right) + Cte \qquad (9)$$

The rate of accumulation[2] $\frac{I}{K_{-1}}$ is a linear function of the rate of accumulation in the preceding period (autoregressive model), the rate of change of demand and the relative price of factors of production.

The sum of the coefficients of the polynomial $\varphi_1(L)$ is equal to $\lambda\frac{1}{v}$; and equal to $-\lambda\sigma b$ for the polynomial $\varphi_2(L)$.

[1] Empirically, wage costs expressed as a proportion of total production costs are not constant. Even so, the econometric tests carried out show that the introduction of b as a variable (the explanatory variable becoming $b(\dot{c} - \dot{w})$ instead of $(\dot{c} - \dot{w})$) did not significantly alter the results.

[2] The variable $\dot{K} = \frac{dK/dt}{K}$ in continuous time is written $\frac{\Delta K}{K_{-1}} = \frac{I}{K_{-1}} - \delta$ in discrete time.

(b) Putty-clay production function

In this case the investment decision relates only to new plant and machinery (i.e. the most recent vintage and not total capital stock). The volume of capital incorporated into that vintage is equal to the investment made. The demand to be met is equal to the output achieved with that vintage, i.e. the difference between total output before and after incorporation of the new vintage and net of depreciation $(Y - (1 - \delta)Y_{-1})$.

The basic equation written in form (6) then provides the econometric specification of the accelerator-model with putty-clay production function:

$$\log I = (1 - \lambda) \log I_{-1} + \psi_1 (L) \log [Y - (1 - \delta)Y_{-1}] + \psi_2 (L) \log \frac{c}{w} + \gamma t + Cte \quad (10)$$

where $\gamma = -\alpha + (\alpha - \beta)b$

The autoregressive equation is log-linear and a temporal trend (t) appears. As before, the sums of the coefficients of the polynomials of lag ψ_1 and ψ_2 are interpreted economically as $\lambda \frac{1}{v}$ for ψ_1 (inversely proportional to the returns to scale) and $-\sigma b \lambda$ for ψ_2 (proportional to the elasticity of substitution). However, in this case, these parameters and the share of wage costs in total production costs (b) characterize the marginal production function.

B. Profit models

To the two determinants of investment analysed above (the accelerator phenomenon and the relative price of the factors of production) is added the third factor, profits.

However, the theoretical justification for introducing a profit variable is less sound. Considered simply, two distinct theoretical frameworks allow its inclusion. They are based, respectively, on the concept of a financing constraint and a profitability constraint.

The first of those frameworks relates once again to disequilibrium theory. While some firms face constraints as a result of deficient demand, others may be constrained by a lack of internal and external financing. If it is assumed that external financing (borrowing, recourse to shareholders, etc.) is conditioned by the scope for internal financing (self-financing), then the volume of investment subject to financial constraints is equal to:

$$I_f^* = f\left(\frac{Aut}{P_I}\right)$$

$$\text{or} \quad \frac{I_f^*}{K_{-1}} = g\left(\frac{Aut}{P_I K_{-1}}\right) = g(\pi) \quad (11)$$

where π is the profit ratio, i.e. the ratio of self-financing to capital valued at replacement cost.

It should be noted in this context that the existence of a constraint connected with a balance sheet debt ratio — although used by many authors — is called into question by Malecot and Hamon [14], who consider that the debt ratio is used as a proxy for the firm's risk of bankruptcy anticipated by lenders. According to this approach, it would be better to use a debt ratio which took account of the market's expectations on the future of the firm.

If the share of firms facing a sales constraint is written as θ and their investment as I_d then, for all firms:

$$\frac{I}{K_{-1}} = \theta \frac{I_d}{K_{-1}} + (1-\theta) \frac{I_f}{K_{-1}}$$

$$\text{with} \quad \frac{I_f}{K_{-1}} = (1 - \lambda)\left(\frac{I_f}{K_{-1}}\right)_{-1} + \lambda \frac{I_f^*}{K_{-1}}$$

$$= (1 - \lambda)\left(\frac{I_f}{K_{-1}}\right)_{-1} + \varphi_3(L)g(\pi) \quad (12)$$

Unless it is assumed *a priori* that the proportion θ is constant over time, the value of this parameter should be estimated econometrically (probability that firms are demand constrained) [16]. In this study only estimation of simple equations has been made, without considering the disequilibrium approach. In other words, it has been assumed *a priori* that θ is stable over time while allowing the possibility of testing its validity (cf. Part III on the tests of stability over time).

The second theoretical framework draws on the approach of Tobin and stresses the role of profitability. According to Tobin [21], investment is undertaken if the stock market value of a firm is greater than the replacement value of its capital, the relationship between these two values being denoted by the variable q. This variable q can be interpreted as reflecting the profitability expected by the market.

Recent studies have established a link between Tobin's approach and the neo-classial approach. Some of these studies [7], [22] show that the neo-classical process of maximizing profits leads to the Tobin model if the costs of adjusting the capital stock are introduced into the definition of profits.

Other authors [12] and [10] justify the influence of profitability by means of uncertainty over sales. Here it is assumed that the firm faces uncertain demand (instead of a fixed sales constraint, i.e. certain demand). In this situation, expected profits are maximized in such a way as to simultaneously determine productive capacity and the demand for capital and labour.[1] The productive capacity installed does not necessarily allow the firm to continually satisfy demand, which may then be rationed owing to inadequate supply. Without going into the details of the mathematical formulation, it can be shown that this productive capacity is a decreasing function of the uncertainty of demand and an increasing function of expected profits. Accordingly, the investment decision depends not only on expected demand (accelerator effect) and relative prices but also on the expected rate of profit [10]:

$$\log K^* = \log E(Y) - \sigma \left[\log \frac{c}{p} - \log E(T_u) \right] + \sigma_K \log \frac{\pi^*}{cK^*} - (1 - \sigma)\gamma_K t + Cte \qquad (13)$$

where E(Y) is the mathematical expectation of demand;
p the price of output and c the cost of using capital;
T_u the rate of productive capacity utilization;
π^* expected profit, σ the elasticity of substitution between labour and capital, σ_K the uncertainty regarding sales constraints and γ_K the rate of technical progress in the case of capital.

This second approach, which has still been relatively little used, therefore allows the reconciliation of the accelerator-relative prices model with the profit model.

C. Two specifications of the 'accelerator-relative costs-profit model'

The foregoing theoretical observations, lead to two specifications of the accelerator-relative costs-profit model, the first corresponding to a putty-putty production function and the second to a putty-clay function.

$$\frac{I}{K_{-1}} = A_0 \left(\frac{I}{K_{-1}}\right)_{-1} + A_1(L)\dot{Y} + A_2(L)\left(\frac{\dot{c}}{w}\right) + A_3(L)\pi + A_4 \qquad (14)$$

$$\log I = B_0 \log I_{-1} + B_1(L)\log[Y - (1 - \delta)Y_{-1}] + B_2(L)\log\frac{c}{w} + B_3(L)\log\pi + B_4 . t + B_5 \qquad (15)$$

where[2] $A_0 = 1 - \lambda > 0 \quad B_0 = 1 - \lambda' > 0$

the sums of the coefficients of the lag polynomials with the notation ΣA_i are equal to:

$\Sigma A_1 = \lambda \frac{\theta}{v} > 0$ $\qquad$ v = returns to scale

θ = share of firms facing sales constraints as to marketing outlets

$\Sigma A_2 = -\lambda\theta\sigma b < 0$ $\qquad$ σ = elasticity of substitution

b = wage costs divided by total production costs.

$$\Sigma B_1 = \lambda' \frac{\theta'}{v'} > 0$$

[1] Using standard notation (see [10] for further details), the firm's behaviour can be expressed in the following terms:

$$\max_{K^*, L^*, Y^*} E(\pi) = E(pY - wL - cK^*)$$

$$Y^* = \gamma[\delta(e^{\alpha t}K^*)^{-\rho} + (1 - \delta)(e^{\beta t}L^*)^{-\rho}] - \frac{1}{\rho}$$

long-term production function CES

$\frac{L}{Y} = \frac{L^*}{Y^*}$ short-term production function

$Y = \min(Y^d, Y^*)$ where Y^d is a random variable and represents the demand to be met by the firm.

[2] This interpretation of the parameters corresponds to a disequilibrium approach to investment behaviour.

$\Sigma B_2 = -\lambda'\theta'\sigma' b' < 0$

$A_4 = \theta[-\alpha + (\alpha - \beta)b + \delta]$

α = rate of capital-saving technical progress

$B_4 = \theta'[-\alpha' + (\alpha' - \beta')b']$

β = rate of technical progress incorporated into labour

In general the parameters cannot be identified, although if it is assumed, for example, that returns to scale are constant ($v = 1$), then, $\theta = \Sigma A_1/A_0$ and $\sigma = -\frac{1}{b}\frac{\Sigma A_2}{\Sigma A_1}$

It should be noted that in the long term, the role of profits is different in the two specifications: a shock maintained on profits will disappear in the putty-clay model, whereas it will continue to stimulate investment in the putty-putty model. These two specifications, although traditional, are not immediately comparable although they would be if, in the putty-putty model, the profit ratio appeared in first differences.

II. Econometric results

The two accelerator-relative costs-profit models (equations (14) and (15)) described in Part I, form the basis of the econometric tests. These two specifications correspond to putty-putty and putty-clay production functions.

The econometric estimations have been made using two different sets of data. The first, compiled for the purposes of the Quest model (multi-country Compact model) which is being developed in the Commission's Directorate-General for Economic and Financial Affairs is quarterly. Only four countries are currently included: Germany, France, the United Kingdom and the United States. The period covered differs according to country, from 1965-84 for Germany to 1970-84 for the United Kingdom. The second, developed for the purposes of this study (see box for further details), is annual. It covers a larger number of countries (Germany, France, Italy, the Netherlands and the United Kingdom) but fewer years (generally speaking 1970-83). Therefore, neither of the two data sets, whether annual or quarterly, extends to the most recent period.

The data relates to firms in the market sector and for investment covers only 'productive' investment. As a result, the analysis does not include residential investment, investment in the non-market sector and stock building.

Two underlying principles were observed for the econometric estimations. They concerned:

(i) identical specifications, irrespective of the country concerned, and

(ii) uniform data so as to ensure comparability of results. In particular, the three determinants of investment—demand, relative prices and profit—were included in the equations even though, in some cases, their influence was not statistically significant.

The results presented below correspond to estimates using ordinary least squares. The equations were also estimated by maximum likelihood techniques in order to eliminate the biases of simultaneity occurring between investment and demand (investment being one of the components of demand), and between investment and the profit ratio.[1] The results of these estimates are given in Annex II. On the whole, they do not differ significantly from the least square estimates.

[1] Solely for the putty-putty model. The full model is then written:

$$\frac{I}{K_{-1}} = A_0 \left(\frac{I}{K_{-1}}\right)_{-1} + A_1(L)\dot{Y} + A_2(L)\left(\frac{\dot{c}}{w}\right)$$

$$+ A_3(L)\pi + A_4$$

$Y = I + R$ $\quad$ R = other components of demand

$\pi = \text{profit}/p_k K$

where profit is measured either by the gross operating surplus, or by the aggregate 'value added — wage costs — capital costs'. It should be noted that simultaneous bias only appears where the profit ratio is approximated by variables in which capital intervenes directly, and where the coefficient of π_{-1} in the polynomial $A_3(L)$ is not zero.

Statistical box: Definition of variables used

Annual data is derived from the sectoral data base of the Commission.

uarterly data is drawn from national sources, DIW (W. Germany), Insee (France), CSO (UK), BEA (USA), and is seasonally adjusted.

1. Investment

This variable corresponds to gross enterprise investment at constant prices. In annual equations, it is measured by gross fixed capital formation (GFKF) of the market sector, i.e. excluding GFKF of the non-market sector and housing.

The quarterly investment series refer to private fixed investment in equipment and non-residential construction as defined in the corresponding quarterly accounts.[1]

2. Capital stock

The annual capital stock data for enterprises comprises the capital stock of the market sector excluding the capital stock of structures in the branch 'other market services' which represents the housing capital stock.[2]

The quarterly fixed capital stock data have been derived from the annual data series described above, by statistical interpolation.

3. Demand

Demand is measured by gross value added at factor cost in the 'market' sector for the annual equations. In the quarterly equations, total final demand including exports is used.

4. Relative costs

The definition of the user cost of capital is a simplified version of the Jorgenson formula, which essentially ignores the effect of changing tax rates and depreciation rules.

$$c = p_I (r - \dot{p}_I^e + \delta)$$

with c = user cost of capital
p_I = price index of investment goods
r = nominal interest rate (long term)
$\dot{p}_I^e$ = expected inflation rate on investment goods[3]
δ = depreciation rate ($\delta = 0{,}1$)

For the question of expectations, an adaptive process has been used:

$$\dot{p}_I^e = (1 - \lambda)(\dot{p}_I^e)_{-1} + \lambda(\dot{p}_I)_{-1} \qquad (\lambda = 0{,}66)$$

The wage cost is defined as salary per head and obtained by dividing total wages (including employers contributions) by number of employees. In the quarterly equations this cost is defined for the whole economy, in the annual equations just for the 'market' sector.

5. Profits

Three indicators for the rate of profit are used in the annual equations. The first is the ratio of gross operating surplus to value added at factor cost, with gross operating surplus defined as the difference between value added at factor cost and wage costs. The second is the ratio of 'economic' profit to the capital stock valued at replacement cost. The numerator is obtained by subtracting wage costs and capital costs from value added. The third variable used is the ratio of gross operating surplus to the capital stock valued at replacement cost.[4]

In the quarterly equations, the rate of profit is defined as the ratio of gross company saving to GNP or GDP depending on the country. The definition of profit is therefore narrower than that using gross operating surplus but wider than that using 'economic' profit, in the case of the annual equations.

[1] For the UK an attempt at harmonization has been made by including fixed investment of public enterprises (calculated on the basis of annual data).

[2] Except for France where the data for the capital stock of structures for the branch 'other market services' is not available. Here the capital stock of the market sector is used.

[3] For the annual estimates, a user cost of capital for certain countries has been used in which the price inflation observed for investment goods has been substituted for an expected inflation rate.

[4] The capital stock excludes housing except in the case of France.

A. Estimations based on quarterly data

Tables 1 and 2 give the results of the estimations using quarterly data for the putty-putty and putty-clay models. The lag structures for the explanatory variables have been constrained (Almon method), using polynomials of degree 2 and occasionally of degree 3 (see Tables 1 and 2). At this stage, two periods have generally been estimated — the entire period covered by the data, and the period following the first oil shock (1974/I-1984/IV).

The following comments deal in turn with estimation, economic analysis and the lag profile.

A.1. Estimation

Despite the difficulties usually experienced with investment equations, the econometric results seem reasonable. All coefficients have the correct sign and most of them are significantly different from zero. Over 90 % of the variance of the dependant variable is generally explained, except in the case of the United Kingdom. The assumption of non-autocorrelation of the residuals is acceptable in virtually all cases.[1] The standard error of the regressions, measured either by the standard deviation of the residuals relative to the mean of the explanatory variable in the putty-putty model or by the standard deviation of the residuals for the putty-clay model, lies between 1,3 % and 3,3 %.

The influence of the accelerator variable is significant in all cases, that of the profit and relative price variables less so (approximately half the time). From a statistical viewpoint (significance of the coefficients, $\bar{R}^2$, standard error), the putty-clay model seems to be more satisfactory for all countries than the putty-putty model although both are acceptable. The following analysis therefore covers both estimation forms.

A.2. Economic analysis

The long-term coefficient of the accelerator variable $\frac{\Sigma A_1}{1 - A_0}$ or $\frac{\Sigma B_1}{1 - B_0}$ which can be interpreted in economic terms as the relationship between the share of firms facing sales constraints and the returns to scale, is relatively weak. There is a continuing tendency for demand to decline (except in the United States) if the period following the first oil shock is considered. It would seem more reasonable *a priori* to ascribe this to the relatively large and growing proportion of firms facing financing constraints ($d\theta < 0$) than to very high and increasing returns to scale ($v >> 1$ and $dv > 0$). This assumption seems to be borne out for Germany since the relative variations of the coefficients ΣA_1 and ΣA_2 between the two estimating periods are roughly identical and contrast with those for ΣA_3 (these variations corresponding to that of θ, and that of $1 - \theta$ respectively). However, this interpretation (decline over time in the influence of demand and relative prices with a corresponding increase in the influence of profit) is acceptable only for Germany since the variations in coefficients for the other countries are not compatible with changes in the share of firms facing financing constraints. The influence of all the determinants declines over time in the case of France and increases in the case of the United States. As for the United Kingdom, while the influence of demand seems to decline, that of relative prices and profit increases. These changes cannot, therefore, be interpreted simply as straightforward switches from Keynesian demand deficient situations to situations of financial shortage. The reason for those changes is probably to be found, therefore, in the actual investment behaviour of firms. The statistical analysis of these breaks is discussed in Part III.

A.3. Lag profile

Given the lag structure of the explanatory variable, the full effects of the various determinants of investment appear only gradually. This phenomenon is further accentuated by the auto-regressive nature of the equations estimated. The average time for these determinants to act can, therefore, be interpreted in two ways, those stemming from the lags affecting the explanatory variable itself and those that are due to the auto-regressive variable. Table 3 gives the estimations of these different lags according to their origin.

The average periods referred to are longest in the case of profit:[2] generally speaking, they range between five and 10 quarters, although a figure of 18 quarters is recorded for the United States. They are much shorter and, in many instances, similar in the case of demand and relative

[1] Only first order autocorrelation has been tested. Preliminary tests were also performed to detect autocorrelation risks of the fourth order. They indicate that such autocorrelation may exist in the case of Germany.

[2] Except for the United Kingdom in the case of the putty-putty model. Of the two theoretical justifications for the role of profits, expected profitability and financing constraints (see Part I.A.), the empirical results seem to give greater support for the first mechanism, given the lags involved.

Table 1

Econometric results of the putty-putty quarterly model

$$\frac{I}{K_{-1}} = A_0 \left(\frac{I}{K_{-1}}\right)_{-1} + A_1 (L)\,\dot{Y} + A_2 (L) \left(\frac{\dot{c}}{w}\right) + A_3 (L)\,\pi + A_4$$

Country	Period	A_0	Long-term coefficient $\frac{\Sigma A_1}{1-A_0}$	$\frac{\Sigma A_2}{1-A_0}$	$\frac{\Sigma A_3}{1-A_0}$	A_4	$\bar{R}^2$	$\frac{SER}{\text{LHS mean}}$	h	P (ρ)
FR of Germany	1965/II-1984/IV	0,838*	0,318*	−0,026*	0,053	0,001	0,955	0,028	−0,588	61,4%
	1974/I-1984/IV	0,481*	0,083*	−0,010	0,165*	−0,003	0,695	0,030	—	33,9%
France	1968/III-1984/IV	0,620*	0,229*	−0,008*	0,064*	0,001	0,979	0,019	1,756	59,6%
	1974/I-1984/IV	0,714*	0,206*	−0,006*	0,035	0,002	0,944	0,019	0,212	93,3%
UK	1970/III-1984/IV	0,746*	0,111*	−0,006	0,017	0,003	0,752	0,033	−2,150	3,8%
	1974/I-1984/III	0,600*	0,099*	−0,008*	0,052*	0,002	0,712	0,031	−1,927	17,1%
USA	1967/II-1983/IV	0,938*	0,644*	−0,055	0,072	−0,001	0,945	0,016	0,268	95,9%
	1974/I-1983/IV	0,932*	0,723*	−0,009	0,169*	−0,001	0,965	0,013	−0,145	45,3%

* = coefficient (short term) significant at 5% level.
$\bar{R}^2$ = R^2 corrected SER = standard error of regression;
LHS mean = mean of dependent variable.
h = Durbin's h statistic $h = (1\text{-}0{,}5\ DW)\ (NOB/1\text{-}NOB \cdot s^2(A_0))^{0.5}$
where DW = Durbin-Watson statistic, NOB = number of observations, $s^2(A_0)$ = variance of A_0.
P (ρ) = probability that autocorrelation is absent (probability that ρ is not significantly different from zero in the test
$u_t = \rho u_{t-1} + f(x_t) + \varepsilon_t$ where u_t is the residual $I_t/K_{t-1} = f(x_t) + u_t$).

Lag structure

1st column = max. lag
2nd column = initial lag
3rd column = degree of polynomial
4th column = constraints on polynomial

		A_1				A_2				A_3			
FR of Germany	(1)	5		2	tail	9		2	tail	16	−4	2	tail
	(2)	5		2	tail	12	−3	2	tail	16	−4	2	tail
France	(1)	11		3	tail	6		2	tail	11	−2	2	tail
	(2)	11		3	tail	6		2	tail	8	−2	2	tail
UK	(1)	6		2	tail	12		2	tail	8	−2	2	tail
	(2)	6		2	tail	12	−2	2	tail	8	−2	2	tail
USA	(1)	7		3	tail		−1			6		2	head & tail
	(2)	5		3	tail		−1			14	−6	2	head

prices—generally between three and seven quarters, but 16 quarters in the case of the United States.[1]

These differences show up clearly in Graph 1, which depicts the lag profiles for the putty-putty and putty-clay models.

[1] In the case of the United States, the length of the lags stems primarily from the auto-regressive term.

The length of the lags and the inverted u-shaped profile are the reasons why the average period taken for the profit effect to work through is a long one. For the determinant demand, the lag profile shows a continuous decline, with the major impact taking place quickly. In the case of relative prices, the lag profile is intermediate between that of demand and profit.

Table 2

Econometric results of the putty-clay quarterly model

$$\text{Log I} = B_0 \log I_{-1} + B_1(L)\log[Y-(1-\delta)Y_{-1}] + B_2(L)\log\frac{c}{w} + B_3(L)\log\pi + B_4 t + B_5$$

Country	Period	B_0	Long-term coefficient $\frac{\Sigma B_1}{1-B_0}$	$\frac{\Sigma B_2}{1-B_0}$	$\frac{\Sigma B_3}{1-B_0}$	B_4	B_5	$\bar{R}^2$	SER	h	P(ρ)
FR of Germany	1965/II-1984/IV	0,606*	0,300*	−0,237*	0,800*	0,0025*	1,01*	0,969	0,0290	0,431	44,1%
	1974/I-1984/IV	0,134	0,140*	−0,130*	0,884*	0,0065*	3,32*	0,949	0,0244	−0,325	59,1%
France	1968/III-1984/IV	0,363*	0,174*	−0,070*	0,846*	0,0053*	2,53*	0,985	0,0181	2,227	64,1%
	1974/I-1984/IV	0,489*	0,075*	−0,021	0,331*	0,0039*	1,95*	0,955	0,0182		
UK	1970/III-1984/III	0,264*	0,139*	−0,029	0,166	0,0027*	5,68*	0,896	0,0289		
	1974/I-1984/III	0,164	0,086*	−0,049*	0,325*	0,0039*	6,88*	0,857	0,0270		

See footnotes to Table 1.

Lag structure

		B_1			B_2				B_3			
FR of Germany	(1)	9	2	tail	4		2	tail	14	−5	3	head & tail
	(2)	9	2	tail	4		2	tail	14	−5	3	head & tail
France	(1)	8	2	tail	5		2	tail	13		3	tail
	(2)	8	2	tail	5		2	tail	13		3	tail
UK	(1)	11	2	tail	12	−5	3	head & tail	13	−2	2	tail
	(2)	6	2	tail	12	−2	2	tail	8	−2	2	tail

Table 3

Average periods for the investment determinants to act[1]

Average periods in quarters	Demand			Relative prices			Profit		
	Variable	Autoregr.	Total	Variable	Autoregr.	Total	Variable	Autoregr.	Total
FR of Germany									
putty-putty	1,0	5,2	6,2	2,2	5,2	7,4	9,2	5,2	14,4
putty-clay	2,7	1,5	4,2	0,6	1,5	2,1	4,3	1,5	5,8
France									
putty-putty	2,6	1,6	4,2	2,2	1,6	3,8	5,6	1,6	5,2
putty-clay	2,6	0,6	3,2	2,4	0,6	3,0	7,7	0,6	8,3
United Kingdom									
putty-putty	1,5	3,0	4,5	4,6	3,0	7,6	3,0	3,0	6,0
putty-clay	3,7	0,4	4,1	3,2	0,4	3,6	4,7	0,4	5,1
United States									
putty-putty	1,3	15,2	16,5	1,0	15,2	16,2	2,5	15,2	17,7

The average periods are calculated on the basis of the estimations made for the entire period 1965-84 or 1970-84. The effects attributable to the variable and to the auto-regressive part are explained in footnote 1.

[1] An auto-regressive model of the type

$$(I)\ y = ay_{-1} + \sum_{0}^{T} b_i x_{-i} = ay_{-1} + \sum_{0}^{T} b_i L^i x \text{ is equivalent to}$$

$$(II)\ y = \sum_{j=0}^{\infty} a_j L^j \left(\sum_{i=0}^{T} b_i L^i x \right) = \sum_{j=0}^{\infty} c_j L^j x$$

It can then be shown that:

$$\frac{\sum_{0}^{\infty} c_i \cdot i}{\sum_{0}^{\infty} c_i} = \frac{\sum_{0}^{T} b_i \cdot i}{\sum_{0}^{T} b_i} + \frac{a}{1-a}$$

The average total period is equal to the sum of the average period attributable solely to the explanatory variable and to the average period attributable to the auto-regressive part $\frac{1}{1-a}$.

B. Estimations for the annual data

Estimations using the same specifications as above (putty-putty model or putty-clay model) were carried out for the annual data.

Tables 4 and 5 give the econometric results obtained for the putty-putty and putty-clay models respectively. Given the small number of observations, these tests invariably covered the entire period for which data were available. For that same reason, no attempt has been made to accurately investigate the lag structures affecting the explanatory variables as was possible in the case of quarterly data. By contrast, the choice of the profit indicator was examined more closely than in the case of the quarterly data and the influence of profit was tested using different indicators.

B.1. Estimation

As with the quarterly data, the two investment models are difficult to estimate, and the results obtained thus appear highly satisfactory. Adjusted R^2 lies between 0,73 and 0,93 in the case of the putty-putty model and between 0,62 and 0,96 in the case of the putty-clay model; the standard errors of the estimations range from 3% to 6% for the putty-putty model and from 2% to 4% for the putty-clay model. All the coefficients have the desired sign. The three determinants demand, relative prices and profit are generally significant. This is invariably the case with demand, very often the case with profit but less often for relative prices. These results mirror the conclusions which have appeared in the quarterly tests, and again the putty-clay model appears slightly more satisfactory.

B.2. Alternative indicators of the profit ratio

Three profit variables were used:

(i) variable π represents the ratio of gross operating surplus to value added, in nominal terms;

(ii) variable π' represents the ratio of value added minus wage costs minus cost of use of capital to the value of capital at replacement cost. It approximates an economic profit ratio;

(iii) variable π'' represents the ratio of gross operating surplus to the capital stock valued at replacement cost.

In general, the three profit indicators are not always significant yet yield equally satisfactory results, and the choice of indicator has little effect on the coefficients of the other investment determinants.

Alternative specifications for the role of profit were also tested econometrically. To be more precise, in the putty-clay model a linear (and not a log-linear) influence of the profit ratio was introduced. Once again, this alternative did not significantly affect the influences of the other determinants. For this reason, these alternative results are not given.

B.3. Comparison of the annual and quarterly models

For three countries — Germany, France and the United Kingdom — investment behaviour equations were estimated using both quarterly and annual data. Are the relative influences of the investment determinants identical and independent of the period chosen? To answer this question, the quarterly models were aggregated analytically to produce an annual form and then compared with the estimates of the annual models.

Graph 1: **Lag profiles**
Model putty-putty (PP) = full line
Model putty-clay (PC) = dotted line

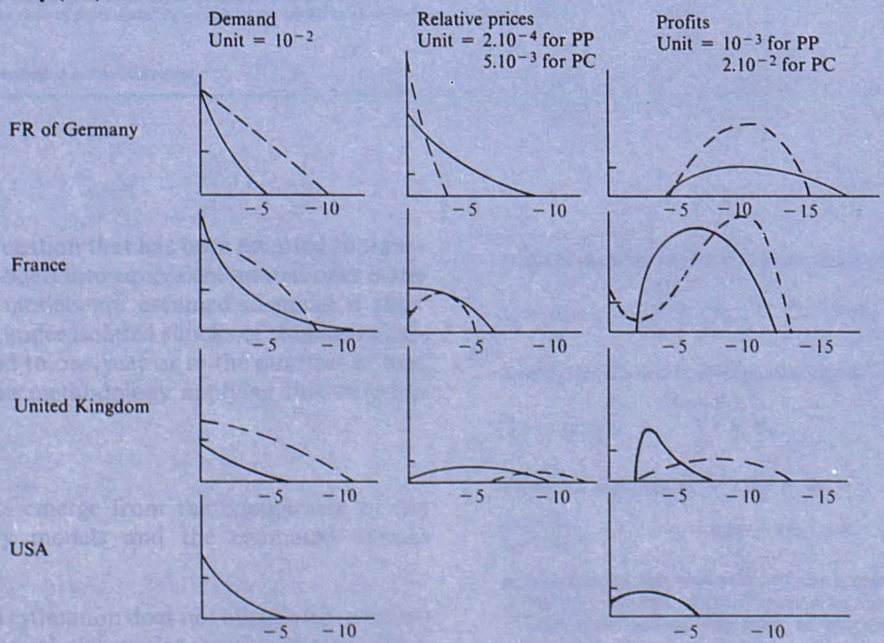


Table 4

Econometric estimates for annual putty-putty model

$$\frac{I}{K_{-1}} = A_0 \left(\frac{I}{K_{-1}}\right)_{-1} + A_1 (L) \dot{Y} + A_2 (L) \left(\frac{\dot{c}}{w}\right) + A_3 (L) \pi + A_4$$

Country	Period	$\frac{I}{K_{-1}}$	Demand $\dot{Y}$	Demand $\dot{Y}_{-1}$	Relative prices $(\dot{c/w})$	Relative prices $(\dot{c/w})_{-1}$	Profit π	Profit π_{-1}	Profit π'	Profit π'_{-1}	Const.	$\bar{R}^2$	DW	SER / LHS mean
FR of Germany	1973-83	0,56 (3,93)		0,052 (1,52)		−0,020 (2,71)		0,42 (3,23)			−0,16 (2,62)	0,78	2,62	3,0%
France I	1973-83		0,13 (3,89)			−0,0032 (−1,21)		0,16 (4,74)			−0,026 (−1,78)	0,93	2,29	2,8%
France II	1972-83		0,17 (3,63)		−0,0081 (−1,99)					0,076 (2,99)	0,044 (26,3)	0,73	1,28	6,3%
Italy	1973-83			0,12 (2,85)		−0,0097 (−2,33)	0,39 (3,73)				−0,13 (−2,55)	0,77	1,93	5,5%
United Kingdom	1972-83		0,059 (4,07)		−0,0028 (−3,93)					0,091 (6,55)	0,049 (59,8)	0,83	2,50	3,8%

The rate of profit π represents the ratio of gross operating surplus to value added.
The rate of profit π' represents an economic profit rate = (value added − wage costs — capital costs) relative to the value of the capital stock at replacement cost.
DW = Durbin-Watson statistic.
SER LHS mean = standard error/mean of dependent variable.
t statistics appear in brackets.

Table 5

Econometric estimates for annual putty-clay model

$$\text{Log I} = B_0 \log I_{-1} + B_1(L)\log[Y-(1-\delta)Y_{-1}] + B_2(L)\log\frac{c}{w} + B_3(L)\log\pi + B_4 t + B_5$$

Country	Period	log I_{-1}	Demand: log[ ]	Demand: log[ ]$_{-1}$	Relative prices: log c/w	Relative prices: log (c/w)$_{-1}$	Profit: logπ	Profit: logπ$_{-1}$	Profit: logπ''	Profit: logπ''$_{-1}$	Time	Const.	$\bar{R}^2$	SER
FR of Germany	I 1971-83	0,80 (7,12)	0,11 (3,43)		−0,25 (−4,29)			1,25 (2,51)			0,0033 (1,1)	1,83 (1,0)	0,96	2,0%
	II 1971-83	0,83 (6,36)	0,14 (4,07)		−0,31 (−4,73)					0,55 (1,72)	0,0075 (1,30)	0,91 (0,46)	0,95	2,3%
France	I 1972-83	0,59 (2,27)	0,28 (2,82)			−0,075 (−1,47)	1,26 (2,53)				0,020 (2,42)	2,36 (0,57)	0,94	2,3%
	II 1972-83	0,58 (2,18)	0,28 (2,76)			−0,081 (−1,48)			0,60 (2,42)		0,028 (2,72)	2,61 (0,62)	0,93	2,4%
Italy	I 1972-83	0,60 (3,25)	0,24 (6,30)			−0,059 (−1,16)		1,73 (2,48)			0,013 (2,68)	2,84 (1,27)	0,89	2,6%
	II 1972-83	0,53 (3,13)	0,19 (4,56)			−0,080 (−1,65)				0,79 (3,05)	0,020 (3,39)	4,05 (1,89)	0,91	2,3%
The Netherlands	1972-83	0,63 (2,13)		0,19 (1,37)		−0,25 (−3,65)		1,14 (1,62)			−0,0005 (−0,10)	2,46 (1,21)	0,72	4,0%
United Kingdom[1]	I 1972-83	0,63 (2,52)	0,13 (4,61)		−0,025 (−1,40)			0,31 (1,62)				0,0008 (0,09)	0,62	2,9%
	II 1972-83	0,53 (2,15)	0,13 (4,56)		−0,028 (−1,59)					0,24 (1,76)		0,0078 (0,88)	0,64	2,9%

The rate of profit π represents the ratio of gross operating surplus to value added.
The rate of profit π'' represents the ratio of gross operating surplus to the capital stock valued at replacement cost.
SER = standard error.
t statistics appear in brackets.

[1] The UK equations have been estimated in first differences.

The principle of aggregation that has been adopted to transform the quarterly models into equivalent annual ones is the following. The two models are assumed identical if their multipliers are equal under isolated shocks of similar magnitude which are limited to one year or to the quarters of that year. The aggregation methodology applying this criterion is developed in [4].[1]

The following points emerge from the comparison of the aggregated quarterly models and the estimated annual models:

1. The direct annual estimation does not adequately capture the lag structures of the explanatory variables. This

[1] It can be demonstrated that a quarterly auto-regressive model of the type

$$y_t = A_0 y_{t-1} + \sum_{0}^{\theta} B_i \; x_{t-i} \qquad \text{i.e.} \quad P(L)\,y_t = Q(L)\,x_t$$

is equivalent to the following annual model:

$$Y_T = a_0\,Y_{T-1} + \sum_{0}^{S+2} b_i\,X_{T-i}$$

where S is such that $4S + 2 \leq \theta < 4S + 6$

$$a_0 = A_0^4 \qquad b_0 = \alpha_0/4 \qquad b_i = \alpha_i/4 - a^4\alpha_{i-1}/4$$

α_i representing the multipliers of the quarterly model aggregated over the four quarters of the i[th] year after the shock. In calculating these multipliers, account was taken of whether the variable was a flow or a stock.

Table 6

Comparison of the aggregated quarterly models and the estimated annual model

Model	Auto-regressive	Demand[1]					Relative prices[1]					Profit[1]					
		0	−1	−2	−3	ΣA_1	0	−1	−2	−3	ΣA_2	0	−1	−2	−3	−4	ΣA_3
putty-putty																	
FR of Germany																	
aggregated	0,49	0,074	0,083	0,005		0,162	−0,0041	−0,0069	−0,0020	−0,0001	−0,013	0	0,010	0,038	0,041	0,017	0,106
estimated	0,56		0,050			0,050		−0,020			−0,020		0,42				0,42
France																	
aggregated	0,15	0,070	0,084	0,032	0,008	0,194	−0,0021	−0,0037	−0,0006		−0,0064	0,009	0,085	0,105	0,024		0,223
estimated	0	0,130				0,130	−0,0030				−0,0030		0,160				0,160
United Kingdom																	
aggregated	0,31	0,031	0,041	0,005		0,077	−0,0004	−0,0018	−0,0016	−0,0003	−0,0041	0,006	0,033	0,008			0,047
estimated	0		0,060			0,060	−0,0030				−0,0030		0,090				0,090
putty-clay																	
FR of Germany																	
aggregated	0,13	0,08	0,14	0,066	0,012	0,30	−0,013	−0,091	−0,013	−0,002	−0,12	0	0,16	1,15	1,43	0,40	3,1
estimated	0,80	0,11				0,11	−0,25				−0,25		1,25				1,25
France																	
aggregated	0,02	0,06	0,09	0,02		0,17	−0,002	−0,045	−0,002		−0,07	0,22	0,53	1,49	1,03	0,05	3,32
estimated	0,59	0,28				0,28		−0,075			−0,075	1,26					1,26
United Kingdom[2]																	
aggregated	0,005	0,04	0,06	0,03		0,14	0	−0,004	−0,018	−0,008	−0,029	0,027	0,227	0,286	0,118		0,66
estimated	0,53	0,13				0,13	−0,028				−0,028		0,24				0,24

[1] coefficient 0 = unlagged; −1 = lagged one year, etc.
ΣA_i = sum of coefficients.
[2] For the UK the annual model has been estimated in first differences.
NB: The aggregation of the quarterly models has been performed from parameters estimated over the entire sample period (first lines of Tables 1 and 2).

difficulty is accentuated by the small number of annual observations available.

2. Even so, the annual estimations generally identify the lag with the greatest influence; the degree of lag of the annual variable corresponds fairly well to the highest coefficient in absolute value in the lag structure of the aggregated quarterly model, except perhaps for profits.

3. There are differences too for the sum of the coefficients. The ratio of that sum between the two models is of the order two to one, in other words the difference may be important to the extent that a coefficient estimated by one method (for example annual) can be equal to a half or twice the coefficient estimated by the other (quarterly). There may be various reasons for these differences: weak significance of certain coefficients, difference of estimating period (see the study of temporal instability in Part III), differences in the basic data and the indicators used for the annual and quarterly equations. Be that as it may, this is not unusual in any econometric exercise, given that the estimated values for the parameters have quite large confidence intervals. This is particularly true of investment equations which are difficult to estimate.[1]

This problem of precision should be borne in mind in the final conclusions.

One improvement that could be made with the annual estimations would be to use the structure of lags observed in the quarterly equations.

[1] There may be a variety of reasons for the difficulty of estimating investment equations: poor statistical quality of the capital series, difficulty of measuring capital costs, instability of investment behaviour, difficult derivation of specifications from theoretical analyses.

III. The stability of investment behaviour over time

A number of indications of instability in investment behaviour have been apparent in the above discussion. A systematic analysis of the stability of the equations over time is set out in this section. The main focus is on the quarterly estimates since the annual estimations have insufficient degrees of freedom to perform the standard stability tests. Two groups of tests have been undertaken. The first group is concerned with possible breaks in the general relationship between investment, demand, relative prices and profits. A full analysis of the results of these tests is given in Annex III. Subsection III.A below gives only a summary of these results.

The second group of tests focuses on the stability of the bilateral relation between investment and each of its determinants. As before, a full analysis of the results is given in Annex IV, and subsection III. B is confined to a summary. Following a short review of possible recent breaks in subsection III.C, conclusions relating to stability over time are set out in subsection III.D.

A. A statistical analysis of the stability of global investment behaviour

This subsection presents the results of stability tests for four countries, Germany, France, the United Kingdom and the United States. The United States have been added for reasons of comparison. Annex III gives a full analysis of the results.

A.1. Methodology

The stability tests have mainly concentrated on the putty-putty investment model. By way of comparison and validation, the tests have also been applied to the putty-clay equations, but the full details are not presented. The estimations already presented (Table 1), which sought to establish whether there was a break at the time of the first oil shock, have not shown any fundamental break in the structure of the lags relating to the variables. For that reason, but also for reasons of simplicity, the search for any break has been directed at the long-term coefficients, i.e. to the long-term and not short-term influence of each of the determinants of investment.

Four stability tests have been performed to investigate the stability of the influence of demand, relative prices and profit on investment. They comprise the Chow test, cusum test, cusum of squares test and Quandt's likelihood ratio test.

A.2. Results and initial tentative conclusions

Examination of these tests allows initial tentative conclusions concerning possible breaks in global investment behaviour. If there are any breaks they should be situated as follows:

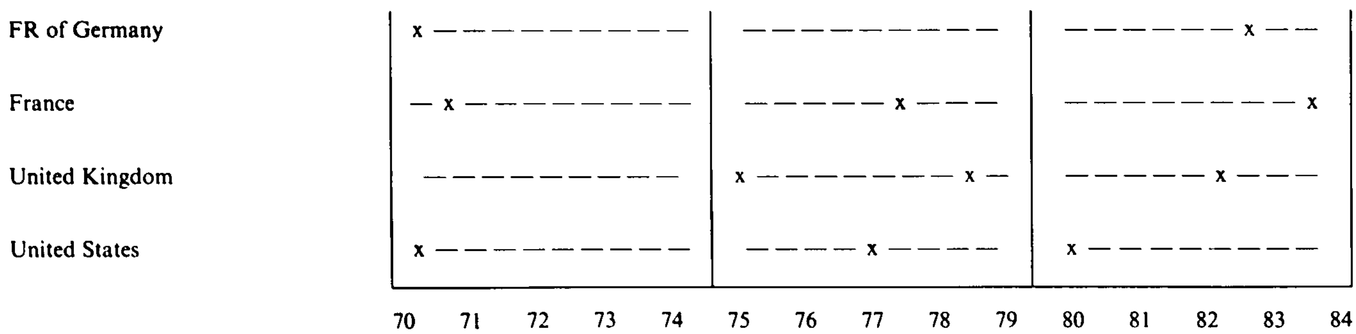
(i) for Germany, two breaks seem possible: in 1970 and, less clearly, in 1983;

(ii) for France, various break points can be discerned: in 1971, during the period 1976-78 and, perhaps, at the beginning of 1984, with the period 1976-78 seeming to correspond to a period of instability and transition;

(iii) for the United Kingdom, the different tests indicate three breaks in investment behaviour: around 1975, in 1978 and lastly at the end of 1982;

(iv) for the United States, there is also evidence of three breaks: in 1970, around 1976-77 and at the beginning of 1980.

The various breaks are summarized in the following diagram:



There appear to be three broad periods in which breaks may have affected investment behaviour:

(i) the beginning of the 1970s;

(ii) the years following the first oil shock, although the breaks occur with varying delays according to the country in question. Whether these breaks result from changes in the choice between factors of production following the increase in the price of energy can not be substantiated in this purely statistical analysis;

(iii) the most recent years, mainly in Europe.

B. The stability over time of individual regression coefficients (moving regressions)

In the previous subsection an indication of possible global breaks in the investment equations has been given. In this subsection the temporal stability of the individual coefficients in the investment equation is examined, and hence the relation between investment and each individual determinant.

B.1. Methodology

As before, the analysis is principally concerned with the quarterly estimates of the putty-putty investment equation, in which the weights of the distributed lags remain fixed. Complementary tests have been made for the putty-clay specification.

The method used to analyse the constancy of individual coefficients is that of moving regressions. It consists of fixing the size of a sample period, for instance 20 quarters (5 years) in this case, and then performing regressions on subsamples of this size while moving through the entire sample period. Observation of the changes in the value of the coefficients then makes it possible to analyse stability over time.

B.2. Results

An analysis of these moving regressions reveals the following (see Annex IV for more details).

For Germany, among the two possible breaks in German investment behaviour that have been indicated, only the first in 1970 seems to be substantiated. The lack of recent data may mean that it is difficult to identify the latter break in 1983 using moving regressions. There is evidence, therefore, of relatively stable coefficients throughout the post-1970 period. Compared with the preceding period (the 1960s), the 1970 break results in a lower demand elasticity, a weaker influence of relative prices, a more important role for profits and an increase in the speed with which investment responds to each determinant.

For France, a comparison of the moving regressions with the results of the preceding section reinforces their validity. Three possible breaks had been detected: 1971, 1976-78 and 1984. The moving regressions lead to similar conclusions but also allow an examination of which determinants are responsible for the breaks. The first break in 1971 seems to have been solely due to profit, whose role seems to have strengthened. The particularly marked break in the years 1976-78 was due to all the determinants and resulted in a weakening of their influence. Investment behaviour seems to have become more self-reinforcing (increase in the weight of the autoregressive variable and therefore less sensitive to variations in demand, relative prices and profit). Finally, the last break at the end of 1984, which was brief and concentrated on the last quarter of 1984, was probably due to a strenthening of demand at the expense of relative prices. However, is this change significant and will it be permanent? This point will be discussed in the following chapters.

The picture which emerges for the United Kingdom is broadly in line with the breaks suggested in the previous subsection. Periods of stability seem to be 1972-75, 1975-78 and 1978-84, the last period possibly including a break at the beginning of 1983. Throughout these periods the roles of demand and relative prices seem to have increased. The role of profits has gained importance until 1978, but its influence has more recently weakened. The 'inertia' of investment behaviour as indicated by the mean lag has increased during the 1975-84 period.

The situation for the United States is not easy to analyse because of extremely high values for the coefficients of the lagged dependent variable. The results for the long-term elasticities therefore have to be viewed in abstraction from these extreme values. The conclusions drawn from the moving regressions partly reinforce those from the preceding subsection, except for the 1980 break which emerged more clearly in the earlier tests. The post-1978 period is characterized in the United States, by a decline in the role of profits, counterbalanced by an increase in the influence of demand and relative prices.

C. Break in investment behaviour in the recent period

The analysis of the two previous sections (III.A and III.B) suggests that breaks may have occurred for each of the four countries in the 1980s. Given the importance which such behavioural changes could have for current economic policy, specific attention has been paid to the latest period.

To avoid interference from previous breaks (mostly during 1977-78), the stability tests previously used were undertaken for the period following 1977-78. These tests covered both the overall stability of investment behaviour (Chow test) and the specific stability of each of the determinants (Chow test using dummy variables, due to the limited number of observations in the latter period).

For Germany, France and the United States, the three suspected breaks[1] (1983/III, 1984/II and 1980/II respectively) were clearly rejected. No break in investment behaviour whether general or specific to certain determinants appears to have occurred in the recent period (disregarding 1985 and 1986 for which no comparable data was available).

In the United Kingdom, by contrast, a break (based on a Chow test at a 5 % significance level) seems likely to have occurred in the fourth quarter of 1982, caused it seems by a simultaneous strengthening of the influence of demand and relative prices, with the role of profit not being affected.

D. Conclusions and estimations for stable periods

The previous sections have presented the tests of global stability and stability of individual deteminants of investment behaviour over the period 1970-84 for three European countries and the United States.

Following this, econometric estimations have been made for the three European countries over each sub-period of stability. The estimation results are given in Table 7. In each case the estimation for the total sample period is presented, followed by those for the 'stable' sub-periods. The starting dates and end dates of these periods have been determined on the basis of the evidence of subsections III.A, III.B and III.C, supplemented with additional Chow tests in some cases. In general, several quarters have been omitted between the end date and start date of two consecutive periods to cope with break points that are not precisely determined. In the case of France eight quarters have been omitted due to the transitional period 1976-78. The weights of the distributed lags remained fixed for each country irrespective of the sub-period.

[1] In any case, some reservations existed concerning these breaks, because of their brief character.

In Germany, the only break in investment behaviour appears to be during the late 1960s (second half of 1969). Before and after this break, the relative effect of the accelerator and profits has stayed approximately the same but both were at a lower level in the latter period.

This reduction cannot be interpreted, on macroeconomic grounds, as changes in the share of firms which are demand-constrained, but as actual changes in investment behaviour at microeconomic level. The influence of relative prices is insignificant for each stable sub-period.[2] The final change to note, although it is not easy to interpret, is the decrease (in absolute value) of the constant c_4. This coefficient reflects a depreciation rate (assumed constant) and a combination of capital and labour-saving technical progress. The decrease in the constant c_4 after the year 1970 could then be the consequence of lower capital productivity.

As noted earlier, the period 1976-78 is highly unstable for France, and therefore the two 'stable' periods lie either side of this period. In fact, the relationship remains highly unstable after 1978, and the coefficients of relative prices and profit are insignificant at a 5% level. In the latter period, the influence of all investment determinants weakens, whereas the 'inertia' of investment strengthens (increase in the mean lag), implying a much less dynamic response to the different determinants than for the 1968-76 period.

In the United Kingdom, frequent changes in investment behaviour can be observed. The negative autocorrelation which is detectable in the estimation for the complete sample period, clearly appears in the first two sub-periods, where negative coefficients for the lagged dependent variable are obtained. For these two periods, therefore, the results should be interpreted very cautiously. In addition, there is an increase in the accelerator and profit coefficients paralleled by a decrease in the constant i.e. the same phenomenon as for Germany but in the opposite direction. Moreover, these two periods appear to be the main source of the poor statistical quality of the overall relationship. As shown in the previous section, the final period 1978/IV-1984/III contains a significant break after 1982/IV for the demand and relative price coefficients. The demand influence increases sharply (the coefficient almost doubles), while the relative price effect changes from an insignificant positive value to a very strong significant negative value. On the basis of its long-term coefficient, the relative price role in the United Kingdom for the most recent period is relatively important, more so than for Germany or France.

[2] However, it is significant when tested for the whole period. It can be regarded as a perverse econometric effect of the 1970-break so the profit variable swamps the effect of the relative price variable in the two subsamples.

Table 7

The putty-putty investment equation for stable periods

$$\frac{I}{K_{-1}} = c_0\left(\frac{I}{K_{-1}}\right)_{-1} + (1-c_0)\left[c_1 f(L)\dot{Y} + c_2 g(L)\left(\frac{\dot{c}}{w}\right) + c_3 h(L)\pi\right] + c_4$$

Country	Period	c_0	Long-term coefficients c_1	c_2	c_3	c_4	$\bar{R}^2$	SER / LHS mean	DW	h	P(p)
FR of Germany	1965/II-1984/IV	$0{,}838^3$	$0{,}318^3$	$-0{,}026^2$	0,053	$0{,}001^2$	0,957	0,028	2,117	−0,560	0,586
	1965/II-1969/II	$0{,}783^3$	$0{,}442^2$	0,034	$0{,}796^1$	−0,025	0,943	0,025	2,347	−0,766	0,512
	1970/I-1984/IV	$0{,}551^3$	$0{,}107^3$	−0,004	$0{,}167^3$	$-0{,}003^1$	0,962	0,025	1,792	1,223	0,228
France	1968/III-1984/IV	$0{,}620^3$	$0{,}229^3$	$-0{,}008^3$	$0{,}064^3$	$0{,}001^3$	0,980	0,018	1,667	1,443	0,744
	1968/III-1976/III	$0{,}465^3$	$0{,}195^3$	$-0{,}005^2$	$0{,}104^3$	0,00001	0,972	0,013	2,213	−0,648	0,651
	1978/III-1984/IV	$0{,}860^3$	$0{,}157^1$	−0,003	0,076	0,0004	0,930	0,015	1,836	0,507	0,813
United Kingdom	1970/III-1984/III	$0{,}746^3$	$0{,}111^3$	−0,006	0,017	$0{,}003^2$	0,752	0,032	2,448	$-1{,}997^2$	0,049
	1972/I-1975/I	−0,210	$0{,}035^2$	−0,005	0,005	$0{,}016^2$	0,381	0,026	2,332	−1,843	0,327
	1975/IV-1978/I	−0,200	$0{,}062^2$	$-0{,}010^1$	$0{,}066^2$	0,004	0,625	0,019	2,361	−0,728	0,993
	1978/IV-1982/III	$0{,}504^2$	0,037	0,008	0,014	$0{,}005^3$	0,870	0,020	2,387	$-4{,}327^3$	0,108
	1982/IV-1984/III[4]		0,067	$-0{,}011^2$							

[1] = significant at 10%.
[2] = significant at 5%.
[3] = significant at 1%. (The significance pertains to the short-term coefficients.)
[4] Tested with dummy variables. Only the modified coefficients are given. A Chow-test revealed a significant break for these two coefficients at a significance level of 5%.
Note: For a description of the column headings, see Table 1.

IV. Relative importance of the determinants of investment

The intention of the econometric work that is presented in this paper is to try to measure the relative influence of the various determinants of investment. To stimulate investment, for example, is it more effective to promote a general upturn in activity or to act on the relative prices of the factors of production, or to improve the financial situation of firms? Are the short- and medium-term recommendations the same?

The econometric and statistical work described establishes a basis for attempting to answer these questions. Quantitative estimates have been produced of the elasticities of investment (or of capital) with respect to each determinant. However, comparisons of the annual and quarterly models (see the chapter on aggregation) and the analysis of the stability of investment behaviour over time (Part III) have also given an indication of the accuracy of the findings, which is not particularly high, but not entirely unexpected. This is due not only to the probabilistic nature of the econometric methods used, but also to the usual difficulties which econometricians encounter in testing investment equations. (See Chapter II.B.3 for more details.)

Nevertheless, it is possible to make some fairly reliable conclusions as to the relative influence of the determinants of investment and to derive some relatively secure economic policy recommendations concerning the means of boosting investment. These recommendations, however, are limited to the three determinants through which economic policy could act to achieve a maximum effect. Defining the instruments to be used and the conditions governing them (whether budgetary, fiscal or financial) belongs to another area of analysis. This would require a more macroeconomic view and a consideration of the room for manœuvre in each European country. It would also mean measuring the relative effectiveness of the different policy instruments, taking into account not only their direct effect — often simultaneous — on the three determinants of investment, but also their indirect effect.

The following section describes the methodology used for measuring the relative influences of the three determinants and then sets out the principal conclusions.

A. Methodology

The method chosen to determine the relative influence of the determinants of investment essentially consists of carrying out dynamic simulations of the econometrically estimated equations. Each of the determinants is increased in turn by a given proportion; starting from a given year, and for five consecutive years, the level of demand is increased by x% $\left(\frac{\delta y}{y} = x\right)$, the level of the ratio of relative prices[1] by y% $\left(\frac{\delta(w/c)}{w/c} = y\right)$, and the profit ratio by z percentage points ($\delta\pi = z$). The simulations then show the sensitivity of investment $\frac{\delta I}{I}$ to each of these changes.

Two stages can be identified in the presentation of these simulation results.

As a first stage, the simulation results are used to calculate the required relative change for each determinant to induce a given relative change in investment, after five years. The main advantage of this method is to allow a comparison of alternative shocks having equivalent effects on investment. The drawback is that it provides no assessment concerning the feasibility of these shocks in terms of economic policy, nor any criterion of comparability regarding the scale of these shocks. Yet some method of comparison is necessary in order to measure the relative weight of the influences of the various determinants. Therefore, in a second stage, the following comparability rule has been defined; the shocks are comparable if they are proportionate to the 'variability' observed in the past of each of the corresponding determinants. In economic policy terms, this means implicitly that a determinant can be manipulated as a policy lever in proportion to its variability in the past and *a contrario* a determinant which has varied little over the past is liable to be difficult to modify by the usual economic policy instruments.

$x = \sigma(\lvert \dot{Y} \rvert)$	σ = standard deviation
$y = \sigma(\lvert \dot{c/w} \rvert)^1$	m = average
$z = m(\lvert \Delta\pi \rvert)$	$\lvert \; \rvert$ = absolute value

Such a standardization makes it possible to compare the simulations directly and to deduce the relative influences of the determinants of investment.

[1] In this part relative prices are designated as the ratio of wages to the user cost of capital in order that an increase gives rise, as it does for the other determinants, to an increase in investment.

The results and analysis of the simulations are presented below. They have only been carried out on the putty-clay models estimated in annual and quarterly forms.

The method can provide no more than orders of magnitude. The variables included in the investment equation are not directly comparable to economic policy instruments. As a result, their past variability already includes the effects of certain economic policies and therefore does not simply measure the ease with which they can be manipulated in the future.

In order to corroborate this approach, an additional graphical method has also been developed, which presents the relative influences of the determinants in a visual manner.

A single graph shows the trend over time of the variable which is explained (investment) and the respective contributions of the explanatory variables (its determinants). For the putty-clay model, the graph shows the changes over time of $\log I_t$, of $\widehat{\log I_t}$ (estimated value of $\log I_t$), of the contribution of demand, $\widehat{B_1}(L) \log [Y_t - (1 - \delta) Y_{t-1}]$, of the contribution of relative prices $\widehat{B_2}(L) \log c_t/w_t$ and of the contribution of profit $\widehat{B_3}(L) \log \pi_t$ where $\widehat{B_i}(L)$ designates the estimated value of $B_i(L)$.

These graphs need, however, to be interpreted cautiously. Firstly, they provide information which is qualitative rather than quantitative. Secondly, they show only the part of the change in investment which is explained by that of its determinants. The relative contribution of the determinants is therefore proportional to their relative variability and not to their relative level with respect to the vertical axis.

These graphs are shown only for the putty-clay model estimated in annual form.

[1] Certain atypical observations for which the rate of variation of c/w was exceptional and of which the frequency of appearance was slight were ignored in order to avoid an artificial upward bias in the value of y.

B. Results

B.1. Preliminary analysis

The initial simulations involve the levels of demand and relative prices increasing by 1% (x = y = 1%) and the profit rate by one percentage point (z = 0,01). These increases have been maintained in the years following the shock.[2] Table 8 gives the results of the simulations. The shock which is necessary on each variable to ensure a 1% increase in the level of investment after five years has then been calculated.

Three important and general conclusions can be drawn:

1. The influence of demand is particularly marked in the short-term. Its impact is greatest in the year in which its increase occurs (except in the Netherlands, although this result would seem to require cautious treatment). It then declines steadily over time to stabilize at a positive level. This phenomenon simply reflects the well-known acceleration effect. A growth in productive capacity necessitates, in the short-term, a more than proportionate increase in investment. In the long-term, the additional residual investment which appears in the simulations simply corresponds to replacement investment, i.e. the growth of capital necessary to satisfy the additional demand entails an increase in investment which in the long term replaces fully depreciated equipment.
2. The influence of profit is more structural in nature. It therefore has its full impact in the medium and the long term.
3. The influence of relative prices, although more difficult to estimate, also seems to be more structural in nature.

If the annual shocks on each determinant to increase investment by 1% after five years are examined (see Table 8a), it seems that the largest variation exists in the case of relative prices. Depending on the country considered the required shock varies between 1,2 and 17,7% (annual case) and between 4,3 and 42% (quarterly case). In comparison the equivalent shocks for demand are of the order of 1 — 2% and 3,3 — 7,5% respectively and for profit 0,1 — 0,6% and 0,1 — 0,9% respectively.

B.2. The effect relative to the determinants of investment

The second stage in measuring relative influence consists of carrying out standardized simulations. The standardization coefficients chosen to ensure the comparability of the influences on investment are given in Table 9.

[2] Form of shock.

Table 8

Sensitivity of investment to its determinants

Putty-clay models estimated on annual (A) and quarterly (Q) data

Percentage effect on investment of an increase		of 1% on demand					of 1% on relative prices[1]					of 1 point on profit rate				
Effect after:		Years					Years					Years				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
FR of Germany	A	0,80	0,75	0,71	0,68	0,66	0,25	0,45	0,61	0,74	0,84	0	2,75	5,09	6,98	8,43
	Q	1,10	0,79	0,38	0,31	0,30	0,19	0,23	0,23	0,24	0,24	0	0,68	3,75	6,16	6,39
France	A	2,05	1,49	1,16	0,97	0,85	0	0,07	0,12	0,14	0,16	2,81	4,46	5,59	6,24	6,62
	Q	0,72	0,40	0,18	0,17	0,17	0,05	0,07	0,07	0,07	0,07	0,73	2,75	7,03	8,75	9,45
United Kingdom	A	1,22	0,90	0,70	0,58	0,50	0,025	0,041	0,051	0,057	0,061	0	0,77	1,27	1,56	1,73
	Q	0,68	0,51	0,17	0,14	0,14	0	0,009	0,027	0,029	0,029	0,11	0,52	1,00	1,13	1,08
Italy	A	1,52	1,15	0,93	0,79	0,71	0	0,059	0,095	0,12	0,13	0	3,50	5,61	6,98	7,81
The Netherlands	A	0	1,54	1,16	0,93	0,78	0	0,25	0,41	0,51	0,57	0	2,65	4,36	5,32	5,87
of an increase:[2]		of x% on demand					of y% on relative prices					of z points on profit rate				
FR of Germany	A	1,19	1,13	1,07	1,03	1,00	0,30	0,54	0,73	0,88	1,00	0	0,33	0,61	0,83	1,00
	Q	2,49	2,65	1,50	1,05	1,00	0,56	0,94	0,99	1,00	1,00	0	0,04	0,38	0,83	1,00
France	A	2,39	1,74	1,36	1,13	1,00	0	0,46	0,74	0,90	1,00	0,43	0,68	0,85	0,94	1,00
	Q	2,68	2,44	1,12	1,01	1,00	0,32	0,95	1,00	1,00	1,00	0,06	0,19	0,59	0,90	1,00
United Kingdom	A	2,39	1,78	1,39	1,15	1,00	0,41	0,67	0,83	0,94	1,00	0	0,43	0,71	0,90	1,00
	Q	2,63	2,63	1,67	1,02	1,00	0	0,12	0,74	1,00	1,00	0,03	0,32	0,76	1,01	1,00
Italy	A	2,11	1,60	1,29	1,11	1,00	0	0,46	0,74	0,90	1,00	0	0,47	0,73	0,89	1,00
The Netherlands	A	0	1,98	1,49	1,19	1,00	0	0,44	0,71	0,88	0,99	0	0,45	0,73	0,91	1,00

[1] In this case, the ratio of wages to user cost of capital.
[2] The increases on each of the determinants taken separately was calculated so as to induce a 1% relative increase in investment at the end of five years. These increases (x% on demand, y% on relative prices and z percentage points on the profit rate) are given in Table 8a.

Table 8a

Shocks necessary to increase investment by 1% at the end of five years

Scale of the annual shock to be given for five years on		Demand (x%)	Relative prices (y%)	Profit rate (z% points)
FR of Germany	A	1,52	1,18	0,122
	Q	3,32	4,35	0,155
France	A	1,17	6,40	0,154
	Q	5,90	15,20	0,107
United Kingdom	A	2,04	17,70	0,57
	Q	7,48	42,00	0,910
Italy	A	1,40	8,10	0,13
The Netherlands	A	1,29	1,74	0,17

Table 9

Standardization coefficients

A = annual data; B = quarterly data

	Demand[1]		Relative prices[1]		Profit[2]	
	A	B	A	B	A	B
FR of Germany	1,79	1,01	2,91	4,43	0,62	1,45
France	1,98	1,58	7,44	6,42	0,72	0,48
United Kingdom	3,12	1,14	34,9	13,6	1,49	1,05
Italy	2,38		8,25		1,01	
The Netherlands	1,58		5,48		0,87	

[1] Relative change as percentage.
[2] Absolute change in percentage points.

The variability of the three determinants of investment is therefore greatest for relative prices, less for demand and least for the profit ratio, irrespective of the country analysed. The countries in which the variability of the determinants is greatest are the United Kingdom and Italy, in that order.

By applying these coefficients, the relative effects of the determinants of investment have been calculated using the method described above and the results are shown in Table 10. Appreciable differences emerge according to the simulations considered, annual or quarterly. These differences are due not only to the standardization coefficients but also to the elasticities, obtained from the annual and quarterly data. Nevertheless, relatively robust conclusions can be drawn which are generally corroborated by the graphical representation of the contributions.

Federal Republic of Germany

In the short term, the acceleration effect is predominant although it is weaker than for the other countries using annual data. In the long term, the predominant role played by profit is clearly shown, the five-year effects for the annual or quarterly putty-clay are similar and substantial. This conclusion appears sound because the profit variable coefficient is relatively accurate and no instability is observable for this parameter since the beginning of the 1970s.[1] The influence of relative prices seems less clear. It is weaker than the influence of demand in the short term, and than the influence of profits in the long term but is relatively higher than in most of the other countries.

It would therefore seem reasonable to draw the following conclusion for Germany: predominance of medium/long term profit, relative moderate short term influence of demand and a moderate influence from relative prices.

1 This was in fact tested only on the putty-putty model but the additional analysis carried out on the putty-clay model (which not presented extensively) has confirmed this assessment.

France

The analysis of the simulations for France also shows that the demand and profit effects are predominant. In the short term, the accelerator effect is appreciable, particularly for the annual data. This result may, however, be due to the simultaneity bias inherent in the ordinary least squares method (see Annex II). Even though a break occurred in the period 1977-78,[1] it only slightly lessened the impact of demand (see Table 10). However, the accelerator effect is relatively short term and after five years, the impact of demand is markedly weaker. As is the case for all countries, the influence of profit is predominant in the medium term. Finally, the impact of relative prices is clearly slight. In addition to the graphical evidence (low variability of the contribution of relative prices), there are two further arguments to support this view: a weak medium term impact in the simulations and a declining relative price coefficient (becoming insignificant) following the behavioural break in the years 1977 and 1978 (see Table 7).

To sum up, there is a relatively appreciable accelerator effect in France, predominant in the short term but temporary, profit plays a determining role in the medium term and relative prices have a negligible impact.

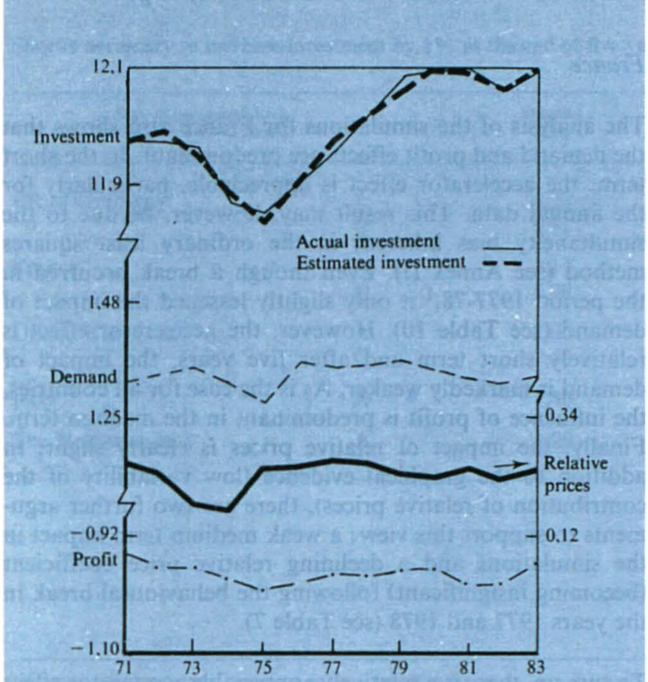
Table 10

Relative importance of the determinants of investment
Putty-clay models estimated on the basis of annual data (A) and on the basis of quarterly data (Q)

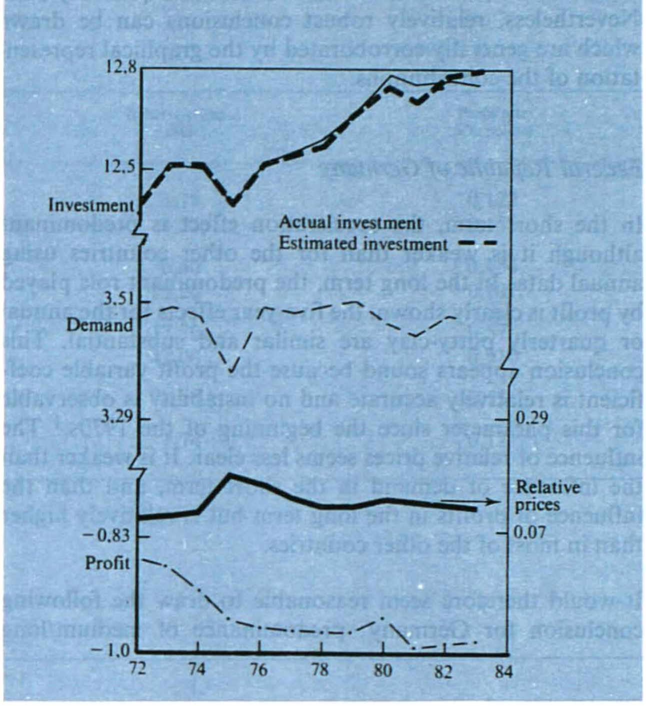
Relative changes in investment (as %) due to an increase in:		Demand[1]			Relative prices[1]			Profit ratio[1]		
Effect after:		1 year	2 years	5 years	1 year	2 years	5 years	1 year	2 years	5 years
FR of Germany	A	1,43	1,35	1,18	0,73	1,32	2,46	0	1,70	5,21
	Q	1,11	0,80	0,30	0,82	1,00	1,04	0	0,98	9,27
France	A	4,05	2,95	1,69	0	0,55	1,20	2,03	3,22	4,77
	Q	1,14	0,64	0,10	0,32	0,45	0,45	0,35	1,32	4,54
United Kingdom	A	3,79	2,81	1,55	0,88	1,43	2,15	0	1,15	2,57
	Q	0,78	0,58	0,16	0	0,14	0,41	0,11	0,55	1,13
Italy	A	3,62	2,74	1,70	0	0,49	1,07	0	3,55	7,92
The Netherlands	A	0	2,43	1,23	0	1,38	3,14	0	2,30	5,09

1 The extent of the initial shocks on demand, relative prices and the profit ratio is standardized (see Table 9).

Graph 2: **Relative contributions — FR of Germany**



Graph 3: **Relative contributions — France**

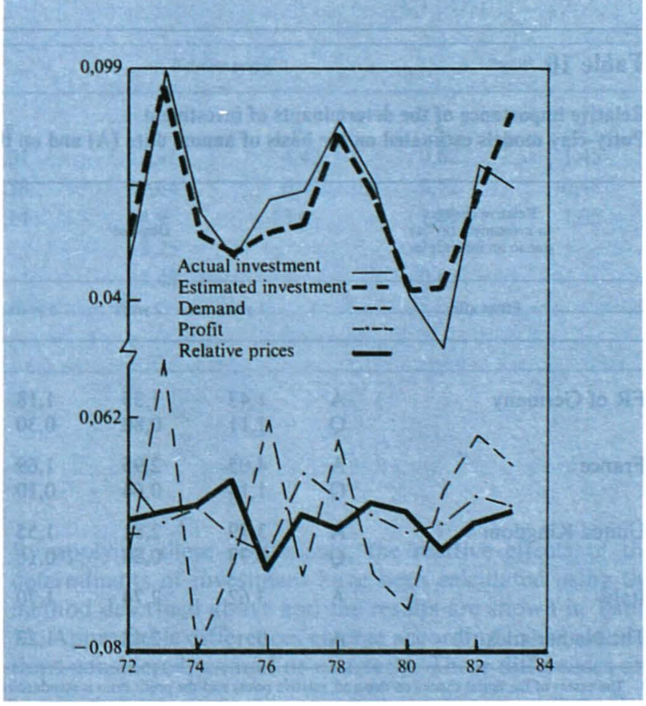


United Kingdom

The poor statistical quality of the econometric estimates for the United Kingdom should first be noted. The tests undertaken showed considerable instability in investment behaviour from 1972 to 1978 and even up to 1982. Over these different periods, some estimated coefficients have signs which are incompatible with theory (see Table 7). The conclusions drawn should therefore be treated with great caution.

The role of the accelerator is predominant in the short term but temporary as is the case for France, there is a progressive effect due to profits but less marked than Germany and France, and relative prices are important in the medium term.[1] On the basis of the econometric significance of coefficients, however, only the influence of demand is certain. The impact of profit is significant only for certain periods and is not so in the most recent period (see Table 7) or for the annual tests of the putty-clay model (see Table 5). The same applies to relative prices.

Graph 4: **Relative contributions — United Kingdom**



[1] This result can chiefly be explained by the scale of the standardization coefficient allocated to relative prices. This reflects a particularly high past variability for this variable for the United Kingdom.

The analysis of the graph also shows a high contribution from demand, and a relatively high contribution from relative prices (which is close to the contribution from profits).

The only reliable conclusion that can be drawn for the United Kingdom therefore seems to be the central role played by demand in the short term. The influence of the other determinants is more uncertain. The profit effect, although predominant in the medium term, is relatively less marked than in the case of the other countries and is also uncertain. Doubts also remain about the relatively important medium-term role played by relative prices.

Italy

The analysis of the simulations for Italy clearly shows that the demand and profit effects are dominant. The picture is in all respects close to that for France. Moreover, the graphs confirm this assessment.

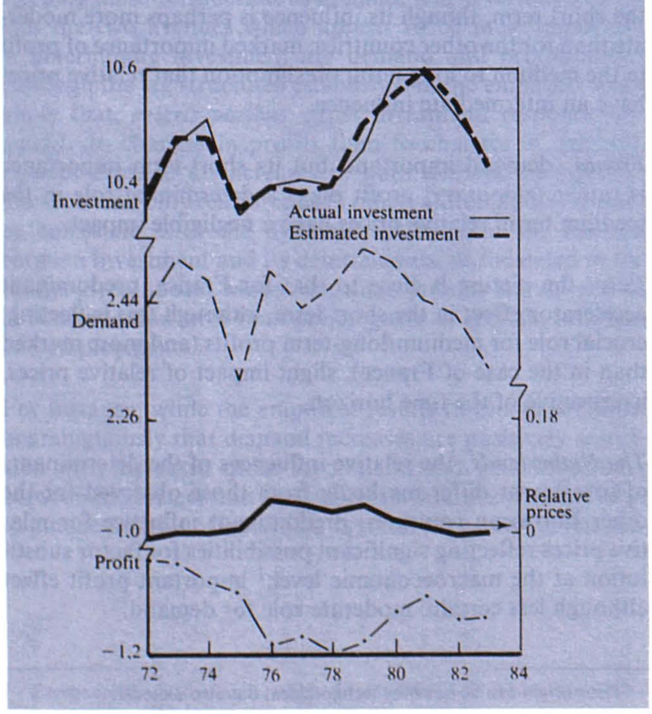
The conclusions made for France can therefore be repeated: predominance of the accelerator effect in the short term although fleeting, crucial role for medium/long-term profits although more marked than in the case of France and the slight impact of relative prices, irrespective of the time horizon.

The Netherlands

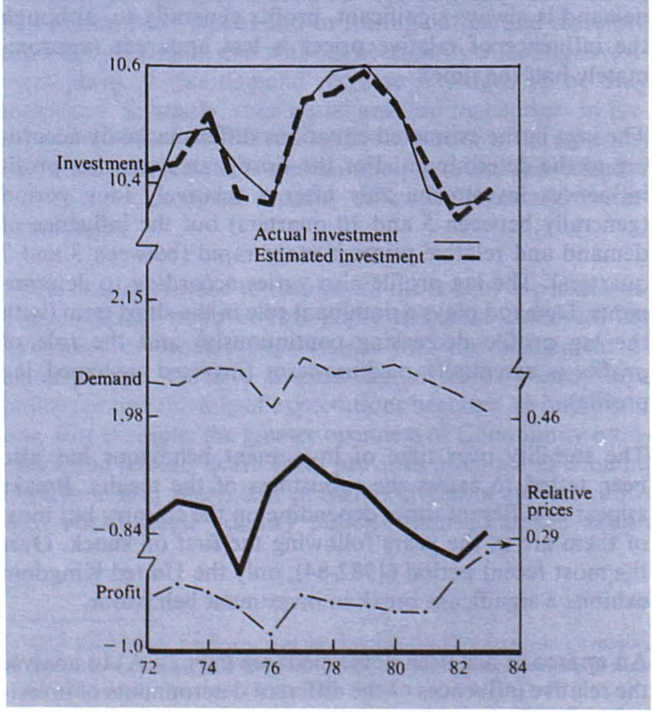
The relative influences of the determinants of investment in the Netherlands differ markedly from those observed for the other European countries. The predominance of the effect of relative prices is clearly shown, followed by profits. The role played by demand is relatively slight. More precisely, the accelerator phenomenon is relatively inevident, witness the absence of an effect after one year (which casts doubt on the results). By contrast, the influences of relative prices and profit gradually increase and become predominant in the medium term. Moreover, the effect of relative prices is highly significant, whereas the profit impact is only just so (see Table 5).

The substantial contribution of relative prices (see Graph 6) reinforces this assessment.

Graph 5: Relative contributions — Italy



Graph 6: Relative contributions — The Netherlands



The predominant influence of relative prices on investment behaviour in the Netherlands seems to be the main conclusion that can be drawn. It reflects considerable substitution possibilities between factors of production. The profit impact is also appreciable, although more uncertain. Finally, the role played by demand appears to be moderate.

Conclusions

The aim of this article was to define the role of the main determinants of investment and to measure their relative influence in the short and medium term and according to the country considered.

Disequilibrium theory has been used to provide a coherent framework covering the three main determinants of investment: demand, the relative cost of the production factors (labour and capital) and profits. The resultant equations relating to investment behaviour have been estimated econometrically, using both putty-putty and putty-clay specifications, and quarterly and annual data. The quarterly data cover Germany, France, the United Kingdom and the United States, and the annual data include Italy and the Netherlands in addition to the same three European countries. The period of analysis covers the 1970s and the early 1980s (up to 1984 for the quarterly data, and 1983 for the annual data). The econometric results are relatively good despite the expected estimation problems. The influence of demand is always significant, profits generally so, although the influence of relative prices is less apparent (approximately half the time).

The lags in the estimated equations differ markedly according to the determinant. For the European countries, profit influences investment only after a relatively long period (generally between 5 and 10 quarters) but the influence of demand and relative prices is more rapid (between 3 and 7 quarters). The lag profile also varies according to determinants. Demand plays a dominant role in the short term (with the lag profile decreasing continuously) and the role of profits is essentially medium-term (inverted u-shaped lag profile).

The stability over time of investment behaviour has also been tested to assess the robustness of the results. Breaks appear at different times depending on the country but most of them are in the years following the first oil shock. Over the most recent period (1982-84), only the United Kingdom exhibits a significant break in investment behaviour.

An approach has been developed (see Part IV.A) to analyse the relative influences of the different determinants of investment. Two aspects have been taken into consideration, namely the elasticity of investment relative to its determinants and the variability of each of the determinants. Furthermore it has been assumed that the variability of a determinant in the past is an indicator of the ability to influence it using economic policy. During the period considered, relative prices have fluctuated the most, followed by demand, and lastly profits.

Three general conclusions can be drawn from this analysis:

(i) the influence of demand is especially important in the short term. Its impact is greatest in the year in which it increases. It then declines steadily over the period. This phenomenon merely reflects the accelerator effect;

(ii) the influence of profit is more structural in nature. It does not, therefore, achieve its full effect until the medium to long term for the five EEC countries analysed. This influence seems, therefore, to stem more from the role of expected profit than the self-financing constraint in the short term;

(iii) the influence of relative prices, although more difficult to estimate, also seems to be more structural in nature.

With a degree of caution appropriate to the precision of the results, the following conclusions can be drawn for the different European countries analysed.

Federal Republic of Germany: predominance of demand in the short term, though its influence is perhaps more moderate than for the other countries; marked importance of profit in the medium to long term; presumption that relative prices have an intermediate influence.

France: demand important, but its short-term importance is rather temporary; profit plays a determining role in the medium term; relative prices have a negligible impact.

Italy: the picture is close to that for France; predominant accelerator effect in the short term, although this is fleeting, crucial role for medium/long-term profits (and more marked than in the case of France), slight impact of relative prices, irrespective of the time horizon.

The Netherlands: the relative influences of the determinants of investment differ markedly from those observed for the other European countries; predominant influence for relative prices reflecting significant possibilities for factor substitution at the macroeconomic level;[1] important profit effect although less certain; moderate role for demand.

[1] Their origin can be not only technological but also sectoral.

United Kingdom: the extreme instability of investment behaviour and the poor statistical quality of the econometric estimates make the conclusions uncertain; central role for demand (this result seems fairly robust); dominant role for profit in the medium term but relatively less clear than for the other countries (and also uncertain); presumption that relative prices have a relatively important role in the medium term (but also not very robust).

Thus far, we have drawn conclusions about the relative importance of the determinants of investment, the lag profile, the stability of their influence throughout the last two decades and the extent to which behavioural differences exist between the Community countries considered. A logical next step would be to infer some robust policy recommendations designed to promote gross investment.

In doing so, it should once more be stressed that investment growth *per se* generally is not considered to be a final policy goal, nor are its determinants (as defined here) considered as policy instruments. Policy goals are rather set in terms of growth, employment and inflation, while policy instruments are supposed to be more directly controllable variables than demand, relative prices and profits. Moreover, any individual policy instrument is likely to influence (directly and indirectly) all three determinants simultaneously, and not always in the same direction. Additionally, there are strong linkages between them, such as between demand and profits.

Keeping these considerations in mind, it is nevertheless clear that the two avenues which appear to be most important in determining investment are demand and profitability,[1] although the lag structures established in the empirical work imply that, *ceteris paribus*, gross investment responds less quickly to changes in profits than to changes in demand. Policies directed at increases in both demand and profits therefore can only reinforce each other, although they should be consistent with the dynamic structure of the relation between investment and its determinants, as indicated in the results given above. Moreover, these policies should not be in contradiction with final policy goals as growth, inflation and employment.

For instance, while the empirical results in this paper show unambiguously that demand increases are positively associated with increased gross investment, and with little delay between the former and the latter, it would seem inadvisable to pursue policies of unbridled demand expansion to encourage investment and presumably employment. Particularly in circumstances where rates of capacity utilization appear to be high, some sectors might not be able to adjust their productive capacity quickly enough to demand increases and this could lead to a deterioration of external balance due to increased imports and to inflationary pressure. Similarly, a singular concentration on policies which only improve profits, although associated with eventual strong responses from investment (in accordance with this paper), runs the risk that investment plans are not implemented if doubts remain about whether demand (from sources other than domestic profits) will also improve. Investment would then not be directed towards increasing productive capacity[2] and thereby employment, but rather towards rationalization and modernization. For these reasons, a strategy aimed at increasing productive capacity upon which employment creation depends has to focus on *both* expected and actual demand and profitability.

Where exactly are Community countries at the present moment? In general for the Community, output in manufacturing industry has recovered from 1984 onwards (although real GDP began to increase moderately from 1982), profitability has recovered from 1982-84 (depending on the country), with increases in gross fixed capital formation occurring from 1984 [19]. Clearly a number of other factors have to be considered to convey a true picture of the present situation.

For example, increased demand will normally be satisfied by running down stocks and/or raising output and therefore capacity utilization, and without necessarily affecting investment plans, if this demand increase is judged to be only transitory. Secondly, substantial and lasting changes in factor prices other than those considered here (e.g. the oil price) can effect depreciation and scrapping rates, the effective capital stock, reported capacity utilization rates and investment plans.

These examples serve to emphasize the role of expectations. The empirical work in this paper has used elaborate lag structures to capture expectations and the adjustment of actual capital stock to desired capital stock. Clearly in a policy context the role of expectations becomes an important one. For example, the greater openness of Community economies and lessons learnt from previous attempts at demand expansion may mean that potential investors are less confident about single country policies than concerted action

[1] Except for the Netherlands, where there is also a role for relative prices.

[2] One must note, however, that investment directed towards increasing productive capacity also involves rationalization and modernization since it incorporates the most recent technology.

(even though the immediate effect on domestic demand may be the same) because of the risk that policies are reversed. With profitability restored, present policies should therefore, next to maintaining these levels of profitability, offer entrepreneurs expectations of sustained growth in demand.

To proceed from here to policy prescriptions entails the consideration of policy instruments themselves, and the margin for manœuvre all within a macroeconomic context, notwithstanding the question of expectations. Such a consideration is beyond the scope of the present study.

Annex I: *Derivation of the demand for capital in an effective demand model*

The firm is supposed to minimize its production costs subject to a sales constraint.

$$\text{Min } wL + cK \quad (1)$$

$$\text{subject to } Y = F(e^{\alpha t}K, e^{\beta t}L) \quad (2)$$

The production function F is homogeneous of degree v

$$F(\lambda e^{\alpha t}K, \lambda e^{\beta t}L) = \lambda^{v}Y \quad (3)$$

The first-order optimality conditions are:

$$\frac{F'_L}{F'_K} = \frac{w}{c} \quad (4)$$

where F'_L and F'_K represent the derivatives of F with respect to the variables L and K respectively

Differenciating (2):

$$dY = \alpha F'_K K dt + \beta F'_L L\, dt + F'_K dK + F'_L dL \quad (5)$$

Equation (5) can be written:

$$\text{dln}Y = \frac{1}{Y}(\alpha F'_K K + \beta F'_L L)dt + F'_K \frac{K}{Y}\text{dln}K + F'_L \frac{L}{Y}\text{dln}L \quad (6)$$

or

$$\text{dln}Y = \frac{1}{Y}(\alpha F'_K K + \beta F'_L L)dt + \frac{1}{Y}(F'_K K + F'_L L)\text{dln}K + F'_L \frac{L}{Y}(\text{dln}L - \text{dln}K) \quad (7)$$

Using the Euler theorem:

$$F'_K K + F'_L L = v\,Y \quad (8)$$

and the fact that the equilibrium condition is

$$\text{dln}(K/L) = -\sigma\,\text{dln}(c/w) \quad (9)$$

equation (7) becomes:

$$\text{dln}Y = \frac{1}{Y}(\alpha F'_K K + \beta F'_L L)dt + v\,\text{dln}K + \sigma F'_L \frac{L}{Y}\text{dln}(c/w) \quad (10)$$

$$\text{Defining } b = \frac{wL}{wL + cK} = \frac{F'_L L}{F'_L L + F'_K K} = \frac{F'_L L}{vY} \quad (11)$$

equation (10) can be written:

$$\dot{Y} = v(\alpha(1-b) + \beta b) + v\,\dot{K} + vb\sigma(\dot{c} - \dot{w}) \quad (12)$$

and thus

$$\dot{K} = \frac{1}{v}\dot{Y} - b\,\sigma(\dot{c} - \dot{w}) - (\alpha(1-b) + \beta b) \quad (13)$$

Annex II: *Comparison of estimations carried out by ordinary least squares (OLS) and by maximum likelihood (FIML)*

The estimation of investment equations by ordinary least squares leads to biased estimation (simultaneous equation), for the specification of both the putty-putty model and the putty-clay model. *A priori*, two sources of bias are liable to appear:

(i) investment is one of the components of demand and so the estimate of the demand coefficient obtained by ordinary least squares is biased;

(ii) capital can also lead to biased estimation if it appears in the calculation of the profit ratio. This link may be direct as in the case of the putty-putty model in which capital appears explicitly in the variable I/K; this bias needs to be corrected whenever the profit variable is directly defined in terms of the capital stock. This will be the case if the profit ratio is defined as the ratio between (value added minus wage cost minus user cost of capital) and the value of capital at replacement cost or as the ratio between the gross operating surplus and the value of capital at replacement cost. But this link can also be indirect, e.g. investment and the profit ratio are linked via capital through the capital accumulation equation:

$$K = K_{-1} + I - \delta K_{-1}$$

$$\pi = \text{function of } K$$

In practice, however, this indirect bias does not appear in the equations tested, either because the profit ratio is not defined directly in terms of capital, or because the profit ratio occurs only with a lag (zero value of the contemporaneous term of the lagged polynomial), or both.

In all cases of possible bias, equations were re-estimated by maximum likelihood methods.

Putty-putty model

$$\frac{I}{K_{-1}} = A_0\left(\frac{I}{K_{-1}}\right)_{-1} + A_1(L)\dot{Y} + A_2(L)\left(\frac{\dot{c}}{w}\right)$$

$$+ A_3(L)\,\pi + A_4$$

$Y = I + R$ $\quad$ R = other components of demand

$$\pi = \frac{pQ - wN - p_K K}{p_K K}$$

or

$$\pi = \frac{pQ - wN}{p_K K}$$

equations defining profit

pQ = value added in value

wN = wage bill

$p_K K$ = value of capital at replacement cost

It should be noted that the biased estimation via capital will not appear unless the coefficient of $\pi - 1$ (first lagged term of the polynomial $a_3(L)$) is non zero. In practice given that the definition of the profit ratio does not systematically use capital (particularly for the quarterly estimates), the bias due to profit has been corrected only for United Kingdom annual data.

Putty-clay model

$$\text{Log } I = B_0 \log I_{-1} + B_1(L)\log[Y - (1-\delta) Y_{-1}]$$

$$+ B_2(L)\log \frac{c}{w} + B_3(L)\log \pi + B_4.t + B_5$$

$Y = I + R$ $\quad$ R = other components of demand

Results

The values of the coefficients, estimated by ordinary least squares or by maximum likelihood, are shown in the Tables below.[1] A comparison of these values does not, however, give a precise evaluation of the bias in estimation except where variances of the estimates are low, which is generally the case for the demand term, and also for the profit term (see putty-putty model on annual data for the United Kingdom). In any case, only an analytical evaluation of these biases would permit a really satisfactory measurement, and no such evaluation has been made.

1. Tests on quarterly data[2]

The comparisons of the ordinary least squares and maximum likelihood estimates are set out in Table II-1 for the putty-putty model and in Table II-2 for the putty-clay model.

For the two models, estimation by maximum likelihood leads to a reduction in the estimated value of the demand coefficient, in both the short and long term. The decline in the long term coefficient is generally between 10 and 20%, except for France (2 to 5%) and for the United Kingdom (30% for the putty-putty model). It, therefore, roughly corresponds to the share of investment in final demand. The estimates of the other coefficients are not greatly affected, except perhaps for the United Kingdom due to the poor statistical quality of the estimates.

[1] For the sake of simplicity, the lag structure obtained by ordinary least squares has been retained in the estimation by maximum likelihood.

[2] It should be remembered that for the quarterly estimates it is only the coefficient of demand which is biased.

Table II.1

Comparison of OLS and FIML estimates — Putty-putty model on quarterly data

(1) $I/K_{-1} = A_0.I_{-1}/K_{-2} + A_1(L)\dot{Y} + A_2(L)(\dot{c/w}) + A_3(L).\pi + A_4$

(2) $Y = I + R$ R = other components of demand (excluding investment)

Country	Period		A_0	ΣA_1	ΣA_2	ΣA_3	A_4	$\frac{\Sigma A_1}{1-A_0}$	$\frac{\Sigma A_2}{1-A_0}$	$\frac{\Sigma A_3}{1-A_0}$	$\bar{R}^2$	SER / LHS mean	DW
FR of Germany	1965/II-1984/IV	OLS	0,838 (0,042)	0,052 (0,008)	−0,004 (0,002)	0,009 (0,007)	0,001 (0,001)	0,318	−0,026	0,053	0,957	0,028	2,117
		FIML	0,845 (0,041)	0,041 (0,007)	−0,004 (0,002)	0,010 (0,007)	0,001 (0,001)	0,265	−0,027	0,061	0,956	0,028	2,145
France	1968/III-1984/IV	OLS	0,620 (0,043)	0,087 (0,008)	−0,003 (0,001)	0,024 (0,008)	0,001 (0,001)	0,229	−0,008	0,064	0,980	0,018	1,667
		FIML	0,651 (0,043)	0,076 (0,008)	−0,002 (0,001)	0,025 (0,008)	0,001 (0,001)	0,217	−0,007	0,073	0,980	0,019	1,722
United Kingdom	1970/III-1984/III	OLS	0,746 (0,069)	0,028 (0,019)	−0,002 (0,001)	0,004 (0,004)	0,003 (0,001)	0,111	−0,006	0,017	0,766	0,032	2,448
		FIML	0,776 (0,066)	0,018 (0,008)	−0,001 (0,001)	0,002 (0,004)	0,003 (0,001)	0,079	−0,004	0,010	0,760	0,033	2,504
United States	1967/II-1983/IV	OLS	0,938 (0,031)	0,040 (0,004)	−0,0003 (0,0004)	0,004 (0,004)	−0,0001 (0,0006)	0,644	−0,005	0,072	0,947	0,015	1,938
		FIML	0,932 (0,030)	0,037 (0,004)	−0,002 (0,0004)	0,006 (0,004)	−0,0001 (0,0006)	0,538	−0,003	0,082	0,946	0,015	1,935

In brackets, the estimated standard deviation of the coefficients.

Table II.2

Comparison of OLS and FIML estimates — Putty-clay model on quarterly data

(1) $\text{Log } I = B_0 \log I_{-1} + B_1(L)\log[Y-(1-\delta)Y_{-1}] + B_2(L)\log\frac{c}{w} + B_3(L)\log\pi + B_4.t + B_5$

(2) $I = Y + R$ R = other components of demand

Country	Period		B_0	ΣB_1	ΣB_2	ΣB_3	B_4	B_5	$\frac{\Sigma B_1}{1-B_0}$	$\frac{\Sigma B_2}{1-B_0}$	$\frac{\Sigma B_3}{1-B_0}$	$\bar{R}^2$	SER	DW
FR of Germany	1965/II-1984/IV	OLS	0,6057 (0,059)	0,1184 (0,018)	−0,0933 (0,025)	0,3157 (0,865)	0,0025 (0,001)	1,0103 (0,217)	0,300	−0,237	0,801	0,9704	0,0284	1,94
		FIML	0,6446 (0,049)	0,0937 (0,017)	−0,0880 (0,024)	0,3005 (0,068)	0,0024 (0,0004)	0,9427 (0,149)	0,264	−0,248	0,845	0,9696	0,0287	2,00
France	1968/III-1984/IV	OLS	0,3633 (0,058)	0,1108 (0,014)	−0,0451 (0,010)	0,5387 (0,076)	0,0053 (0,001)	2,5260 (0,275)	0,174	−0,071	0,846	0,9861	0,0175	1,56
		FIML	0,3721 (0,055)	0,1073 (0,013)	−0,0441 (0,010)	0,5285 (0,072)	0,0053 (0,0005)	2,4921 (0,260)	0,171	−0,070	0,842	0,8861	0,0175	1,58
United Kingdom	1970/III-1984/III	OLS	0,2638 (0,120)	0,1021 (0,024)	−0,0213 (0,013)	0,1220 (0,062)	0,0027 (0,001)	5,6838 (0,991)	0,139	−0,029	0,166	0,9019	0,0280	2,01
		FIML	0,2777 (0,030)	0,0857 (0,023)	−0,0264 (0,016)	0,1106 (0,058)	0,0026 (0,0008)	5,6391 (0,186)	0,119	−0,036	0,153	0,9007	0,0282	2,01

In brackets, the estimated standard deviation of the coefficients.

2. Tests on annual data (Tables II.3, 4 and 5)

The same conclusions emerge from a comparison of the estimated coefficients from ordinary least squares and maximum likelihood methods. There is a decline of between 10% and 15% in the long-term coefficient of demand (except for France—see below), a small change in the coefficients of the other variables and a slight deterioration in the standard error of the regression using maximum likelihood.

However, unlike the quarterly results, the estimates for France differ markedly. The long-term coefficient of demand is roughly halved, the other coefficients are affected and the influence of relative prices becomes quite insignificant. As a result, the role of the accelerator effect for France (see Part IV) needs to be qualified. Judging from the estimation by maximum likelihood, the relative influence of short-term demand is not, for France, markedly greater than for the other countries.

Table II.3

Comparison of OLS and FIML estimations for the putty-putty model (annual data)

(1) $$\frac{I}{K_{-1}} = A_0\left(\frac{I}{K_{-1}}\right)_{-1} + A_1(L)\dot{Y} + A_2(L)\frac{\dot{c}}{w} + A_3(L)\pi + A_4$$

(2) $Y = I + R$ R = other components of demand (excluding investment)

Country		A_0	ΣA_1	ΣA_2	ΣA_3	A_4	$\bar{R}^2$	SER / LHS mean	DW
France	OLS	0	0,13 (3,89)	−0,0032 (−1,21)	0,16 (4,74)	−0,026 (−1,78)	0,93	2,8 %	2,29
	FIML	0	0,087 (2,74)	−0,0057 (−0,23)	0,19 (5,61)	−0,039 (−2,66)	0,91	3,1 %	2,32
United Kingdom	OLS	0	0,059 (4,07)	−0,0028 (−3,93)	0,091 (6,55)	0,049 (59,8)	0,83	3,8 %	2,50
	FIML	0	0,052 (4,20)	−0,0027 (−4,61)	0,090 (7,49)	0,049 (70,2)	0,82	3,8 %	2,34

t statistics appear in brackets.
For the other countries no biased estimation appears (the demand variable is lagged by one year — see Table 4).

Table II.4

Comparison of OLS and FIML estimations for the putty-clay model (annual data)

$$(1)\quad \text{Log } I = B_0 \log I_{-1} + B_1(L)\log[Y-(1-\delta)Y_{-1}] + B_2(L)\log\frac{c}{w} + B_3(L)\log\pi + B_4.t + B_5$$

$$(2)\quad Y = I + R \qquad R = \text{other components of demand}$$

Country		B_0	ΣB_1	ΣB_2	ΣB_3	B_4	B_5	$\frac{\Sigma B_1}{1-B_0}$	$\frac{\Sigma B_2}{1-B_0}$	$\frac{\Sigma B_3}{1-B_0}$	$\bar{R}^2$	SER
FR of Germany	OLS	0,80 (7,12)	0,11 (3,43)	−0,25 (−4,29)	1,25 (2,51)	0,0033 (1,1)	1,83 (1,0)	0,55	−1,25	6,25	0,96	2,0%
	FIML	0,79 (9,46)	0,10 (4,09)	−0,25 (−5,74)	1,35 (3,65)	0,0037 (1,67)	2,20 (1,66)	0,48	−1,19	6,43	0,98	2,0%
France	OLS	0,59 (2,27)	0,28 (2,82)	−0,075 (−1,47)	1,26 (2,53)	0,020 (2,42)	2,36 (0,57)	0,68	−0,18	3,07	0,94	2,3%
	FIML	0,39 (1,83)	0,165 (1,93)	−0,030 (−0,70)	1,01 (2,55)	0,023 (3,56)	6,23 (1,81)	0,27	−0,05	1,66	0,96	2,6%
Italy	OLS	0,60 (3,25)	0,24 (6,30)	−0,059 (−1,16)	1,73 (2,48)	0,013 (2,68)	2,84 (1,27)	0,60	−0,15	4,325	0,89	2,6%
	FIML	0,57 (4,31)	0,22 (8,22)	−0,067 (−1,81)	1,82 (3,64)	0,014 (3,91)	3,38 (2,11)	0,51	−0,16	4,23	0,94	2,7%
United Kingdom	OLS	0,63 (2,52)	0,13 (4,61)	−0,025 (−1,40)	0,31 (1,62)	—	0,0008 (0,09)	0,35	−0,07	0,84	0,62	2,9%
	FIML	0,58 (3,00)	0,12 (5,48)	−0,024 (−1,72)	0,30 (2,01)	—	0,0016 (0,23)	0,29	−0,06	0,71	0,62	3,0%

t statistics appear in brackets.

Table II.5

Comparison of the dynamic simulations of the putty-clay models estimated on annual data by ordinary least squares and by maximum likelihood

Relative changes in I (as %) due to an increase of		1% in demand			1% in relative prices			1 point in the profit ratio		
Effect after:		1 year	2 years	5 years	1 year	2 years	5 years	1 year	2 years	5 years
FR of Germany	OLS	0,80	0,75	0,66	0,25	0,45	0,84	0	2,75	8,43
	FIML	0,71	0,66	0,56	0,25	0,45	0,82	0	2,97	8,93
France	OLS	2,05	1,49	0,85	0	0,07	0,16	2,81	4,46	6,62
	FIML	1,21	0,63	0,29	0	0,03	0,05	2,25	3,09	3,74
Italy	OLS	1,52	1,15	0,71	0	0,06	0,13	0	3,50	7,81
	FIML	1,41	1,03	0,61	0	0,07	0,14	0	3,70	7,88
United Kingdom	OLS	1,22	0,90	0,50	0,02	0,04	0,06	0	0,77	1,73
	FIML	1,11	0,77	0,38	0,02	0,04	0,05	0	0,74	1,52

Annex III: *A statistical analysis of the stability of global investment behaviour*

1. Methodology

This annex presents the results of stability tests for four countries: Germany, France, the United Kingdom and the United States. The United States have been added for reasons of comparison.

The stability tests have chiefly been done for the putty-putty investment model.[1] The first estimations set out in Part II (Table 1), which sought to establish whether there was a break at the time of the first oil shock, have not shown any fundamental break in the structure of the lags relating to the variables. For that reason, but also for reasons of simplicity, the search for any break has been directed at the long-term coefficients, i.e. to the long-term and not short-term influence of each of the determinants of investment.

From a technical point of view, we have therefore fixed the weights of the distributed lags for each of the three explanatory variables (demand, relative prices, profits). Using this fixed distributed lag structure, the stability tests have been performed. The fact that the lag structure has been maintained the same, does not imply that the individual long-run coefficients were not allowed to change: only their dynamic distribution over time was forced to be the same throughout all estimations. In Table III.1 we present the fixed distributed lag weights for the three explanatory variables in the four countries.

Four stability tests have been performed to investigate the stability of the influence of demand, relative prices and profit on investment: the Chow test, cusum test, cusum of squares test and Quandt's likelihood ratio test.

The cusum test [2]

The cusum test of recursive residuals provides a graphical test for constancy of the regression coefficients over time. It is particularly suitable when the departure from constancy is systematic rather than haphazard. Strictly speaking, the test is only applicable to regression equations without stochastic explanatory variables, such as the lagged dependent variable in our equations; nevertheless it may be used as a crude indicator. The test is based on the use of recursive residuals. If their plot crosses one of the symmetrical significance lines, this is an indication of a significant departure from constancy of the regression coefficients, due to the fact that the cumulative sum of the recursive residuals becomes consistently more positive or negative over time. The date at which to identify the break usually lies not at the point where the significance line is crossed, but at the point where the trend line starts.

The cusum of squares test [2]

The cusum of squares test uses squared recursive residuals instead of the level of the recursive residuals, as in the cusum test. As for the latter test, it is actually not suited for equations containing lagged dependant variables. The test is a complement to the cusum test since it tests for haphazard rather than systematic departure from constancy of the regression coefficients. As for the cusum test, a crossing of the significance lines indicates instability of the regression coefficients, although the point in time where this happens usually occurs earlier.

The Chow test [3]

The Chow statistic tests for stability of (a subset of) the regression coefficients over two (or more) time intervals.

The Chow test is based on the calculation of a statistic which is F-distributed if no break occurs. The null hypothesis of stable coefficients is then rejected if the value of the Chow-statistic is higher than the threshold corresponding to the chosen confidence interval of 95%, for instance.

In our particular case we have appplied the Chow tests to all coefficients of the investment equation simultaneously, and we have tested for two sub-periods of the complete sample period for each country only. This choice for the parameters of the Chow test has been made on practical grounds: otherwise the number of tests would have increased substantially. What has been varied, therefore, is the breakpoint which divides the sample period into two sub-periods. For each country we have calculated Chow-statistics for as many breakpoints as possible, i.e. for all possible quarters (except for the extreme quarters for which one of the sub-periods did not offer sufficient observations).

Quandt's likelihood ratio test [17], [18]

This test is comparable to the Chow test as used for our analysis (change in all coefficients for two distinct time intervals): it tests whether regression coefficients change

[1] Preliminary tests have also been performed on the putty-clay model. They are not presented exhaustively. Reference will be made to them only for purposes of comparison.

Table III.1

Distributed lag weights kept constant throughout the stability tests

	Lag (in quarters) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean lag (in quarters)
1. Demand																	
FR of Germany	42	28	17	9	3	—	—	—	—	—	—	—	—	—	—	—	1,0
France	27	20	14	10	7	5	4	4	4	3	2	—	—	—	—	—	2,6
United Kingdom	31	25	19	13	8	4	—	—	—	—	—	—	—	—	—	—	1,5
United States	39	25	16	9	6	3	2	—	—	—	—	—	—	—	—	—	1,3
2. Relative prices																	
FR of Germany	25	21	17	13	10	7	5	3	1	—	—	—	—	—	—	—	2,2
France	19	21	20	18	14	8	—	—	—	—	—	—	—	—	—	—	2,2
United Kingdom	4	8	11	13	14	14	13	11	8	5	—	—	—	—	—	—	4,6
United States	0	100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1,0
3. Profit																	
FR of Germany	—	—	—	1	5	7	9	10	11	11	11	10	9	8	5	3	9,2
France	—	—	9	12	14	14	14	13	11	8	5	—	—	—	—	—	5,6
United Kingdom	—	—	42	28	17	9	3	0	—	—	—	—	—	—	—	—	3,0
United States	11	18	21	21	18	11	—	—	—	—	—	—	—	—	—	—	2,5

Source: Estimates of equation (14) in Table 1.

significantly from one time period to another. For the likelihood ratio test, the maximum likelihood under the hypothesis that the observations in two consecutive time segments come from the same regressions is divided by the likelihood that these observations come from two different regressions. The smaller the (log of the) likelihood ratio is, the more likely is the hypothesis that the observations come from two different regressions. By changing the time point which separates the two consecutive time segments, it may be seen when a (local) minimum for the (log) likelihood ratio occurs. This minimum could correspond to a break in the regression relationship. Moreover, it may also be seen whether this break point is attained gradually or rather more instantaneously.

2. Test results

In Figures I.1 to I.4 we present each time the four graphical tests discussed above for the four countries: FR of Germany, France, the United Kingdom and the United States.

(i) Part (a) of each figure presents the cusum tests. The vertical lines in this figure indicate fixed time intervals. The symmetrical lines which form a topped horizontal cone indicate the significance: if these lines are crossed by the cusums' line, there is a significant break; the significance level is indicated in the heading of the figure. The lead which is indicated below the figure pertains to the number of quarters for which the recursive residuals are calculated. The recursion is always forward.

(ii) Part (b) presents the graph for the cusums of squares. It is similar to part (a), except for the significance lines, which are now parallel straight lines. The recursion is always forward, and the lead holds the same explanation as for part (a).

(iii) Part (c) presents the cumulative densities for the Chow tests. If a cumulative density for a time point t_0 lies above, say, the 95% line, this implies that at a significance level of 5%, all regression coefficients for the time period $[1, t_0]$ are significantly different from those for the period $[t_0 + 1, T]$ (with T observations).

(iv) Part (d) of each figure gives the (log of) the likelihood ratio. A (local) minimum for this graph may be identified with a break point between the corresponding two consecutive time segments. The lead is zero unless otherwise indicated.

Before discussing the figures, several caveats are in order. First, it should be kept in mind that the cusum and cusum of squares tests can only be regarded approximately as valid tests since the regression equations on which they are based contain a lagged dependant variable. Secondly, the equations contain distributed lags of the explanatory variables (which may smooth the breaks and complicate their precise determination). Finally, there might be a bias in the results since we have kept fixed the weights of the distributed lags of the explanatory variables throughout the tests.

Federal Republic of Germany

The results for Germany are given in Figure I.1. The cusum tests indicate two possible significant break points: the first occurring in 1975/IV and the second in 1983/IV.[1] However, in the first case, the departure from zero is trendwise and takes about 5 years to 'mature'. The actual break would therefore have to be situated around 1970. The evidence is less clear for the second break. These breaks are not significant according to the cusum of squares tests, which indicate that they are progressive rather than sudden. The Chow test indicates significant break points at a level of 5% for the whole period 1965-79, and therefore cannot but confirm the 1970 break point. The steadily rising cumulative density after 1981, with a peak in 1983, also points to the more recent break at the end of 1983. The latter break is also quite clearly suggested by Quandt's likelihood ratio, reaching an

[1] For the putty-clay model, the cusum test also indicates a possible break around 1976, but also in 1979.

Figure I.1.a. **Cusums for Germany**

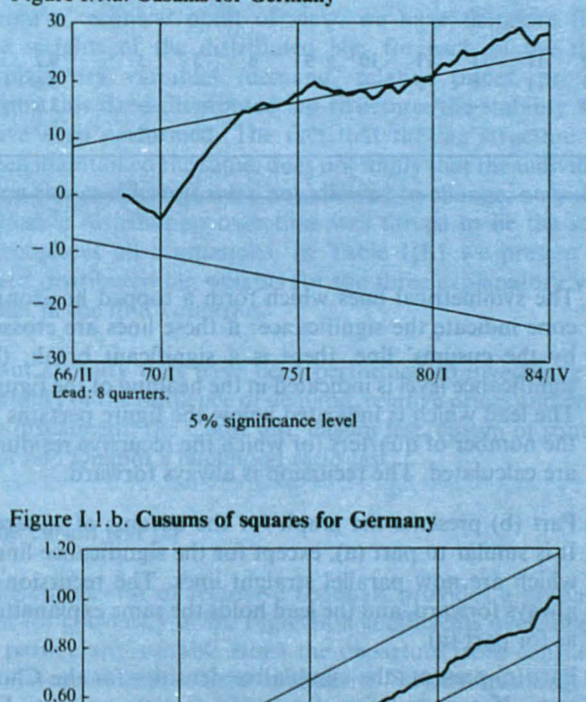


Figure I.1.b. **Cusums of squares for Germany**

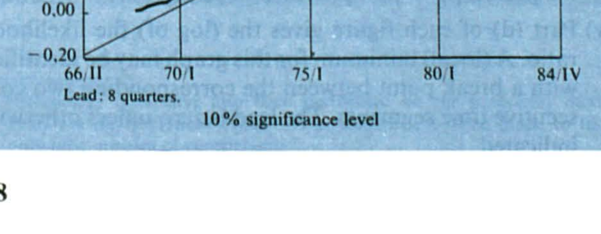


Figure I.1.c. **Cumulative densities of Chow tests for Germany**

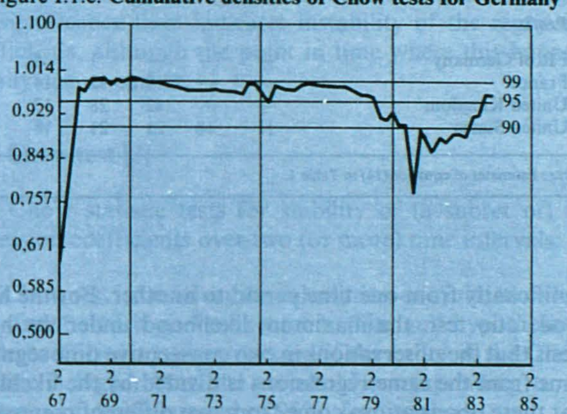
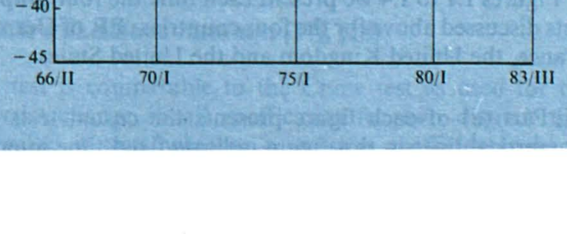


Figure I.1.d. **Quandt likelihood ratios for Germany**



absolute minimum in 1983/III (the last available test point). Furthermore, this test indicates several local minima around and before 1970 — which is broadly in line, though not too outspoken, with the possibility of a break around 1970.

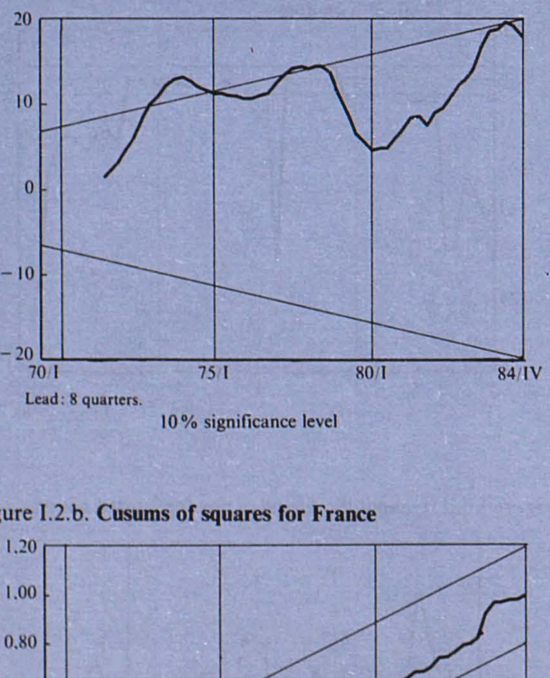
Keeping in mind the caveats mentioned above, the evidence for Germany on the basis of the global investment equation therefore indicates two possible structural changes: one which is actually to be located in 1970, and the second, more recently, towards the end of 1983. This last turning point has however to be regarded with caution given the scarcity of data after this date with a sample period ending in 1984/IV.

France

Figure I.2 presents the results for France. Over the sample period under consideration (1968/III-1984/IV), there are signs of multiple breaks and/or transitional periods in the stability of investment behaviour. The cusum test shows three crossings of the significance line around the first oil shock in 1973/74, in the course of 1977 and, as for Germany, at the end of the sample period, in the beginning of 1984.[1] Of these three turning points, the first and the last are the

[1] In the case of the putty-clay model, the cusum test confirms the 1977 break, and situates the most recent break around 1982.

Figure I.2.a. **Cusums for France**



Lead: 8 quarters.

10 % significance level

Figure I.2.c. **Cumulative densities of Chow tests for France**

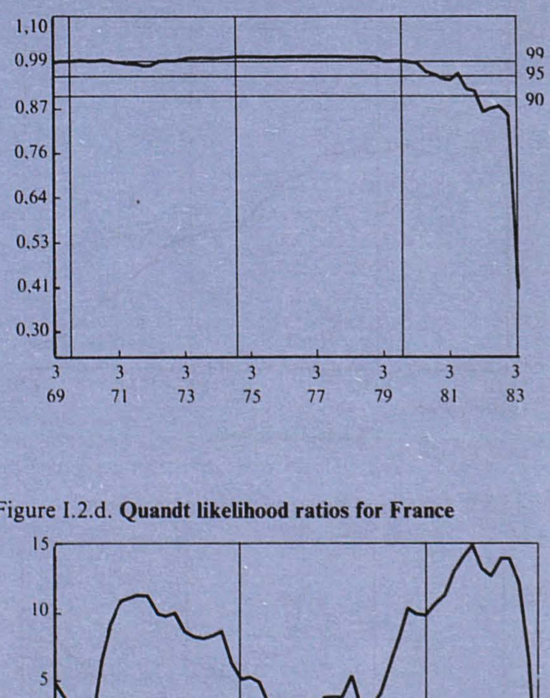
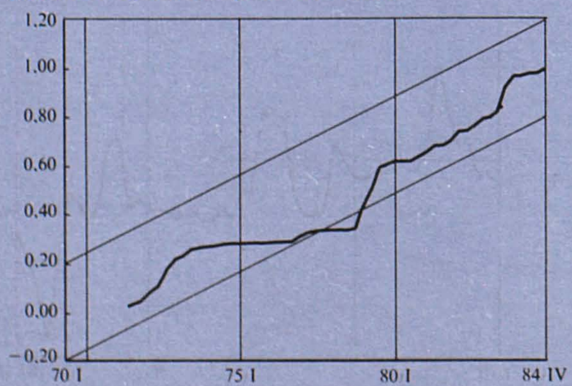


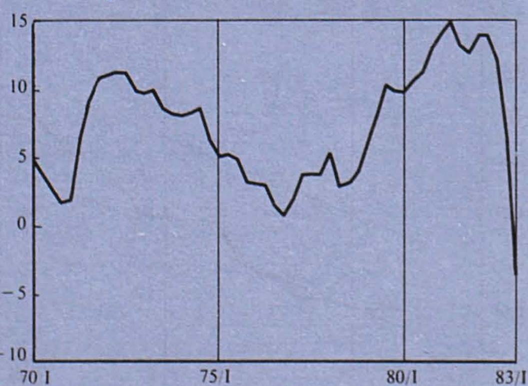
Figure I.2.b. **Cusums of squares for France**



Lead: 8 quarters.

10 % significance level

Figure I.2.d. **Quandt likelihood ratios for France**



Lead: 2 quarters.

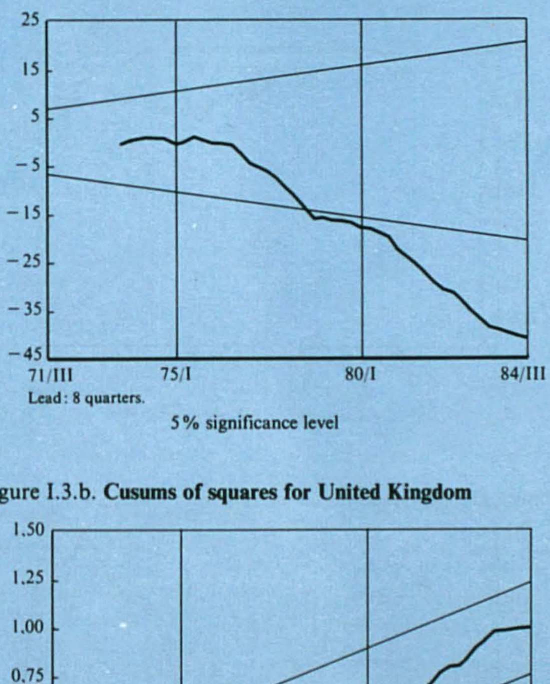
result of a trendwise departure from coefficient constancy, while the 1977 turning point seems more haphazard. Taking account of the starting points of the trend movements, the actual breaks would have to be located in 1971, around 1976-78, and between 1982 and 1984. This picture is confirmed in the cusum of squares test; the first and third breaks are hardly visible, but the 1977 turning point is the only one which is significant in this test. Although slightly visible, the cumulative density for the Chow test reaches a local maximum (above 0,99) in 1976/IV, confirming the second break point. The evidence for a break at the end of the period is not visible. The 1971 break is visible in the Quandt likelihood ratio test, although it appears from a local minimum. The 1976-78 break is very clear however, and is attained quite gradually. Furthermore, there is a tendency towards a minimum in the beginning of 1983, but the sample period does not allow us to see any further.

The evidence for France very clearly points to multiple breaks in investment behaviour over time: in 1971, around 1976-78, and possibly in the beginning of 1984. To judge from the cusum and cusum of squares tests, the 1977 break seems to differ from the other two. More light on this will be shed in Annex IV where we discuss the results of moving regressions.

United Kingdom

As for France, the test results for the United Kingdom in Figure I.3 point at the occurrence of multiple breaks in investment behaviour. Between 1975/II and 1978/III, the cusum test shows a trendwise departure from constancy of the regression coefficients. Starting in the end of 1980, or already in 1978, a new trendwise departure from constancy can be observed until the beginning of 1982 or even one

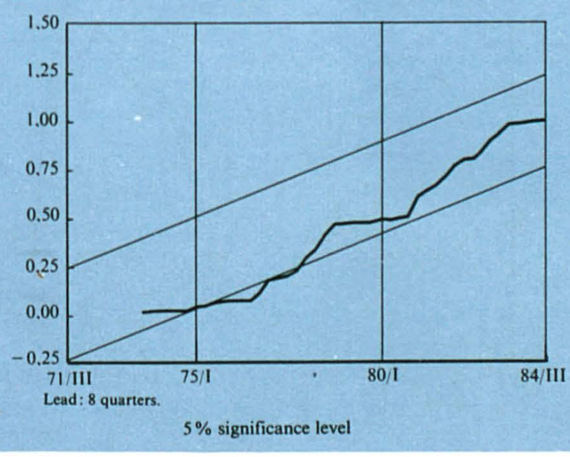
Figure I.3.a. **Cusums for United Kingdom**



Lead: 8 quarters.

5% significance level

Figure I.3.b. **Cusums of squares for United Kingdom**



Lead: 8 quarters.

5% significance level

Figure I.3.c. **Cumulative densities of Chow tests for United Kingdom**

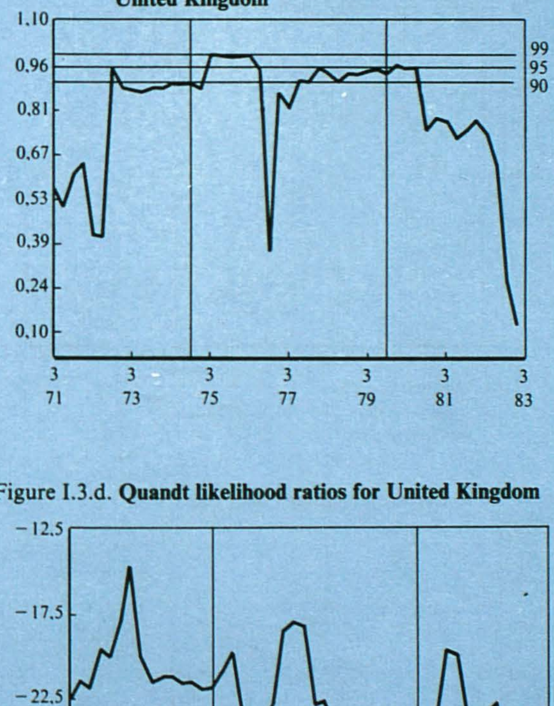
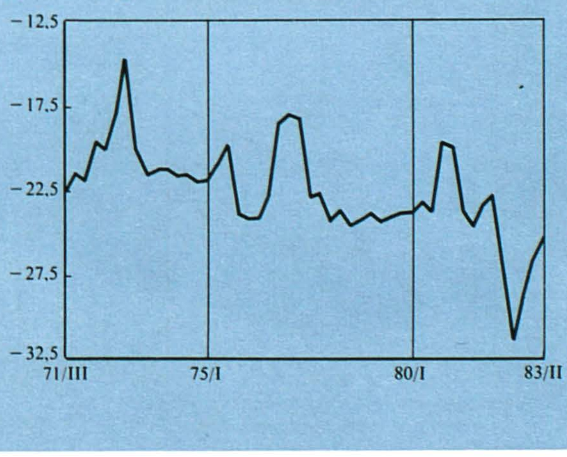


Figure I.3.d. **Quandt likelihood ratios for United Kingdom**



year further. The cusum test therefore points towards possible breaks in 1975, 1978 and in 1982-83.[1] The cusum of squares graph exactly mimics the three trends described above, but since this test is designed to point at sudden breaks, the crossing of the significance lines happens at other points in time than the break indicated by the cusum test. The 1975 and 1978 breaks are not rejected by an absolute and local maximum of the cumulative density of the Chow test in 1975/III and 1978/II, being practically significant at a 1% and 5% level respectively. Although there is a local maximum for the cumulative density of the Chow test in 1982/II, it is not significant and does not really support the 1982/83 break. To judge from the Quandt likelihood ratios, however, the latter break is strongly confirmed by an absolute minimum in 1982/III. Local minima in the first quarters of 1978 confirm the break for this year, whereas the 1975 break occurs in 1975/IV.

Summarizing, the evidence on the possible occurrence of breaks in the investment behaviour in the United Kingdom is convergent and pointing to three breaks: one around 1975, another in 1978, and the last one situated at the end of 1982.

United States

In Figure I.4 we give the stability tests for the global investment behaviour of the last country in our comparison, the United States.

The evidence from the cusum and cusum of squares tests seems to be complementary to that from the Chow and

[1] For the putty-clay model these breaks seem to be situated around 1978 and 1981.

Figure I.4.a. **Cusums for United States**

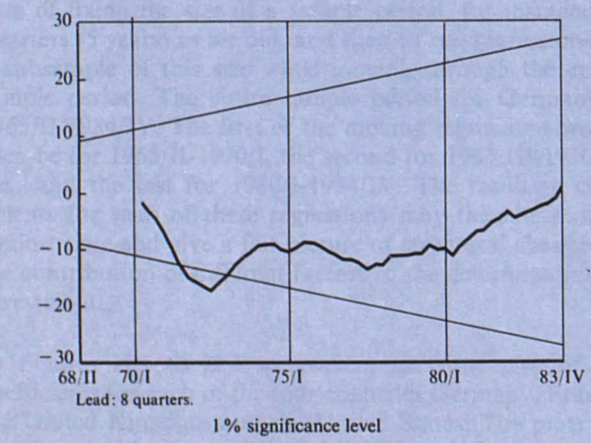


Figure I.4.c. **Cumulative densities of Chow tests for United States**

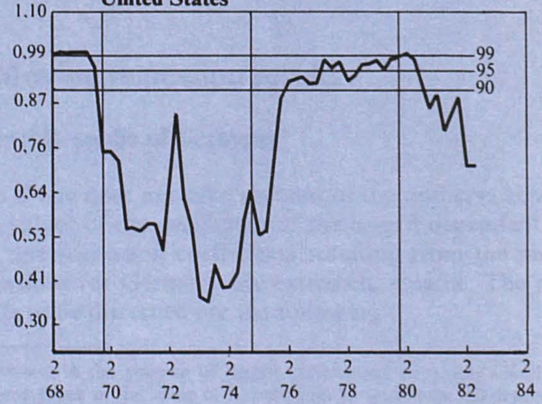


Figure I.4.b. **Cusums of squares for United States**

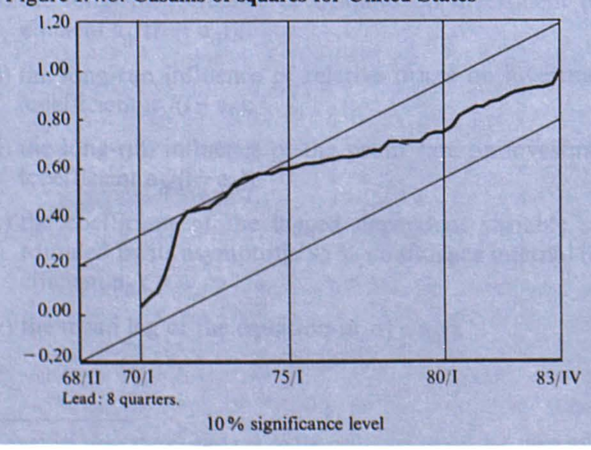
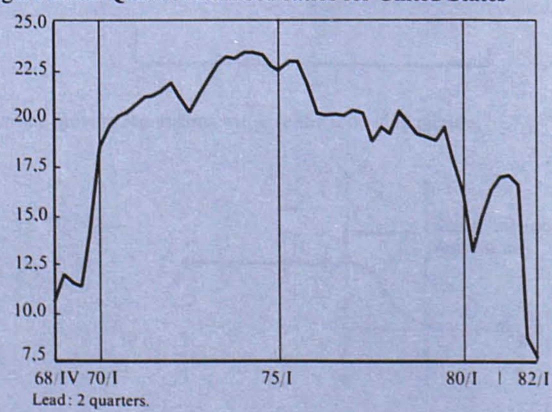


Figure I.4.d. **Quandt likelihood ratios for United States**



Quandt tests and vice versa. The former tests clearly indicate a break in 1970/II, which becomes significant in 1972-73. Next to this significant break, the cusum tests point at a slight departure from constancy of the regression coefficients for the period 1976-77, suggesting a break point at the beginning of 1976. This indication, however, is not significant for this test. If we next look at the cumulative densities for the Chow test to see if these possible break points are confirmed, we note a (local) maximum for periods ending before 1969/III; the point 1970/II, though a local maximum, is not significant, however; a local maximum at 1977/IV which is significant at 5% and an absolute maximum at 1980/II which is significant at 1%. These three (local) maxima appear as local minima for the Quandt test, which moreover shows an absolute minimum in 1982/I.

The general picture for the United States is therefore that of breaks in 1970, in 1976-77 and in the beginning of 1980. Nothing can be said about a possible break in 1982.

Annex IV: *The stability over time of investment behaviour (moving regressions)*

In Annex III, we have obtained an idea about possible global breaks in the investment equation. In this Annex we look in more detail at the stability over time of the individual coefficients in the investment equation, and therefore at the relationships between investments and each of its determinants individually.

1. Methodology

As in the previous Annex, the analysis is concerned with the quarterly estimates of the putty-putty investment equation,[1] where we keep the weights of the distributed lags fixed throughout the estimations.

The method we have used to analyse the constancy of individual coefficients is that of moving regressions. It consists of fixing the size of a sample period, for instance 20 quarters (5 years) as we did, and then to run regressions on a subsample of this size while moving through the entire sample period. The entire sample period for Germany is 1965/II-1984/IV. The first of the moving regressions would then be for 1965/II-1970/I, the second for 1965/III-1970/II, etc., and the last for 1980/I-1984/IV. The resulting coefficients for each of these regressions may then be plotted against time and give a fair picture of structural changes in the contribution of different factors to the determination of investment.

In Figures II.1 to II.4 we present the time plot of the coefficients for each of the four countries Germany, France, the United Kingdom and the United States. The plots are based on moving regressions of 20 quarters (5 years). Each figure gives respectively the evolution of:

(i) the long-run influence of demand on investment (coefficient $a_1/(1 - a_0)$);

(ii) the long-run influence of relative prices on investment (coefficient $a_2/(1-a_0)$;

(iii) the long-run influence of the profit rate on investment (coefficient $a_3/(1-a_0)$);

(iv) the coefficient of the lagged dependent variable surrounded by its asymptotic 95 % confidence internal (coefficient a_0);

(v) the mean lag of the equation ($a_0/(1-a_0)$).

[1] Analyses were also carried out on the putty-clay model, but these will be presented only by way of comparison.

The plotted values for each quarter correspond to the 20 quarter period which ends at this particular quarter. In each of the figures, the horizontal straight line indicates the value of the regression over the complete sample period.

Before we discuss the country results, the same caveat is in order as for global results of the previous section, concerning the timing of the turning points. The appearance of lagged explanatory variables in the investment equation plus the fact that an important change in investment behaviour will only show up in the moving regressions several quarters after it has started to become effective[2] complicate the precise determination of the individual turning points.

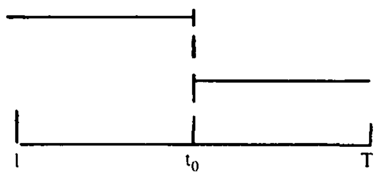
The graphs have been scaled such that the units of the y-axis are proportional to the average of the considered coefficient.[3] Therefore their variability can be directly compared from one coefficient to the next.

2. Moving regression results

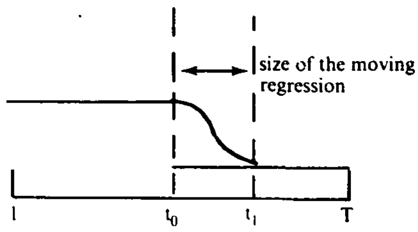
Federal Republic of Germany

Even if one does not take account of the outliers caused by high values of the coefficient of the lagged dependent variable, the regression coefficients resulting from the moving regressions for Germany are extremely volatile. The major trends to be discerned are the following.

[2] Suppose, in the absence of lagged explanatory variables, a well-determined break in the value of a coefficient between two consecutive subperiods:



Then the moving regressions will give the following picture:



[3] Exceptions are the graphs for the coefficient of relative prices where the units of the y-axis are proportional to the average of the coefficients in absolute value.

Figure II.1.a. **Moving regressions: long-term demand coefficients for Germany**

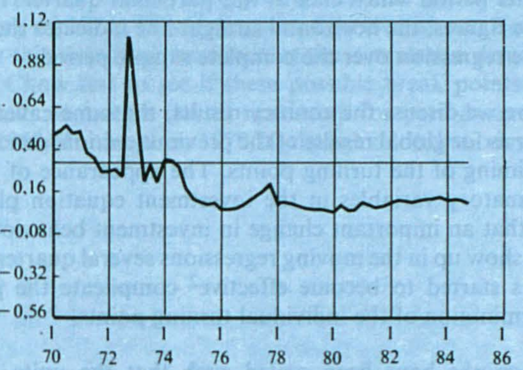


Figure II.1.b. **Moving regressions: long-term relative price coefficients for Germany**

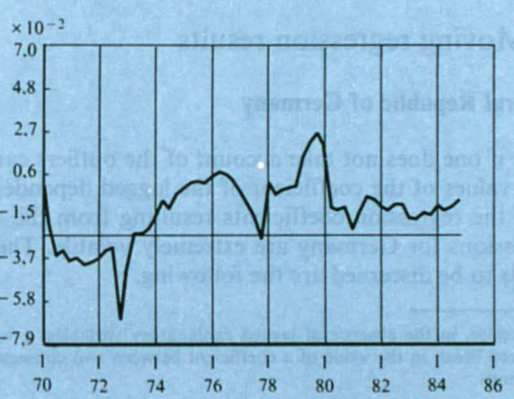


Figure II.1.c. **Moving regressions: long-term profit coefficients for Germany**

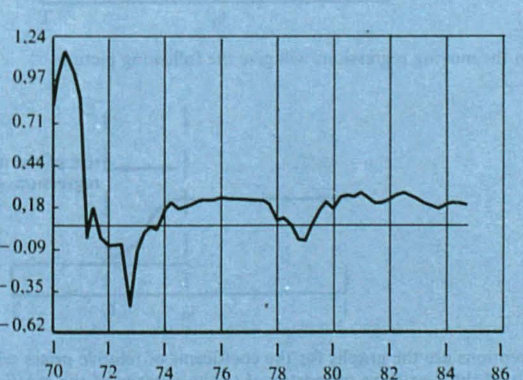


Figure II.1.d. **Moving regressions: coefficients of lagged dependent variable for Germany**

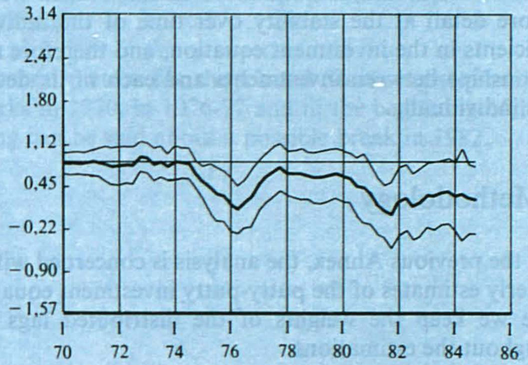
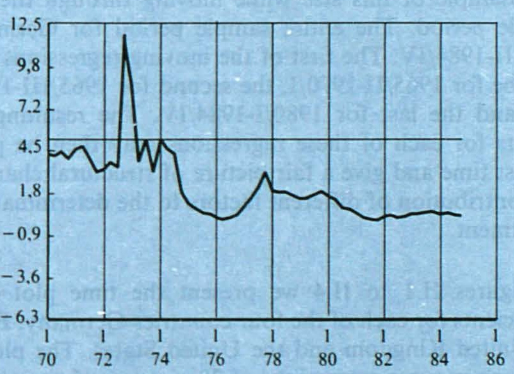


Figure II.1.e. **Moving regressions: autoregressive mean lags for Germany**



Demand: starting from a high level around 0.50 the coefficients gradually decline until the point 1975, attaining a level around 0.10 that remains relatively stable until the end of the sample period. Taking account of the size of the moving regressions sample, the demand coefficient therefore confirms the 1970 break which was conjectured in Annex III. The 1983 break which was also suspected does not show any apparent influence on the demand coefficient, however.

Relative prices: this coefficient is the most volatile for Germany. Several times, its sign becomes positive which is theoretically unacceptable. As for demand, the graph shows progressive changes in the coefficient values between the points 1970 and 1975, which can be regarded as the consequence of a break around the year 1970. The period 1975-84 is relatively more stable, although volatile in absolute terms, implies a 'stable' relationship between relative prices and investment from 1970-84. Also here the end of the sample period does not show significant changes.

Profit: the profit coefficient shows very high values until the beginning of 1971, implying these high values for the period 1965-70. After an unstable movement for the points 1971-74, the profit coefficient settles down and is rather stable for 1975-84, therefore again confirming the 1970 break. The evidence on the 1983 break is once more invisible.

Dynamics: although remaining volatile, the coefficient on the lagged dependent variable ('autoregressive' coefficient) seems to have reached a definitely lower level after 1975 than before. This may be interpreted as a quicker reaction of investment to changes in one or other of its determinants.

Among the two probable breaks in German investment behaviour shown by the statistical tests in the previous Annex, only the first one in 1970 seems effective. The scarcity of recent data does not perhaps make it possible to reveal the last break. But there is evidence of relative stability of the coefficients after 1970. Compared with the pre-1970 period, this stability is characterized by a lower demand elasticity, a weaker influence of relative prices, a more important role for profits and an increase in the speed with which investment reacts to a change in one of its determinants. The moving regressions carried out on the putty-clay model confirm the lower demand elasticity, but reveal volatility in the influence of profits which remains high throughout the period.

France

The movements in the French coefficients generally seem to be more regular then for Germany, except maybe for profits.

Demand: the moving regression coefficients are stable until the point 1976, therefore suggesting stable demand coefficients for 1968-76, around a value of 0,2. The unstable behaviour which starts in 1977 may either be attributed to the deleted 1971 observations or to the new 1977 observations or both. This unstable period lasts until 1982, when the 1977 observations are no longer included in the sample. The evidence for a break in 1977 therefore seems clear, maybe to be added to a 1971 break. The second stable period for the demand coefficients, seems to be 1978-1983/84, the latter depending on whether the sharp increase in the coefficient (from about 0,10 to 0,20) in 1984 proves to be significant. As for Germany, the moving regression outcomes are consistent with those of the statistical tests.

Relative prices: the movements in the relative prices, though fairly regular, are difficult to interpret, probably because of the rather short-lived nature of stable periods. The only conclusion which emerges clearly is that there is a break after 1976, thus confirming the assumptions of a break in 1977. The changes afterwards have no clear-cut interpretation, except for the 1984 break which seems again to be present.

Profits: the role of profits, after having been stable until the point 1975, was negatively affected between the two points 1976 and 1979. As for demand, the 1977-78 break in the coefficient is clear and stability is only reached in 1982. This again suggests two stable periods, 1968-75 and 1978-84 where the profit influence on investment is nearly the same (coefficient value around 0,8). The 1971 break might possibly be the cause of the 1976 changes in the moving regression coefficient.

Dynamics: contrary to Germany, the mean lag in France has increased over the recent past. It has been stable, say around the value of half a quarter, until 1977 and after a transitional period in 1977-78, it has attained levels around one quarter and a half throughout the period 1978-84 (disregarding two outliers).

The analysis of the individual coefficients has to be confronted with the global results of the previous Annex on the possible occurrence of breaks. There we found evidence on possible breaks in 1971, 1976-78 and in 1984. The moving regressions approach leads to similar conclusions but also permits the examination of which determinants may be responsible for the breaks. The first break in 1971 seems to have been due solely to profit, the role of which seems to have strengthened. The much more marked break in 1976-78 affected all the determinants and led to a simultaneous weaking of their influence. Investment behaviour seems to have become more 'inert' (increase in the weight of the lagged dependent variable) and therefore less sensitive to variations in demand, relative prices and profit. This assessment is confirmed by the analyses on the putty-clay model. Finally, the last break at the end of 1984, which was rapid but concentrated on the last quarter of 1984, was probably due to a strengthening of demand at the expense of relative prices.

United Kingdom

The results for the United Kingdom give rather volatile coefficients, which move in broader bands than the German or French coefficients.

Figure II.2.a. **Moving regressions: long-term demand coefficients for France**

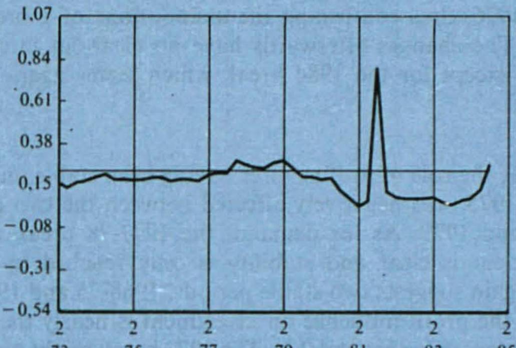


Figure II.2.d. **Moving regressions: coefficients of lagged dependent variable for France**

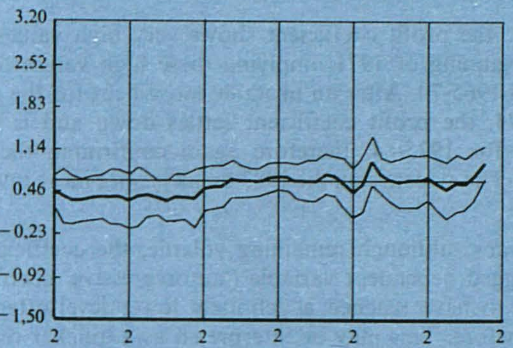


Figure II.2.b. **Moving regressions: long-term relative price coefficients for France**

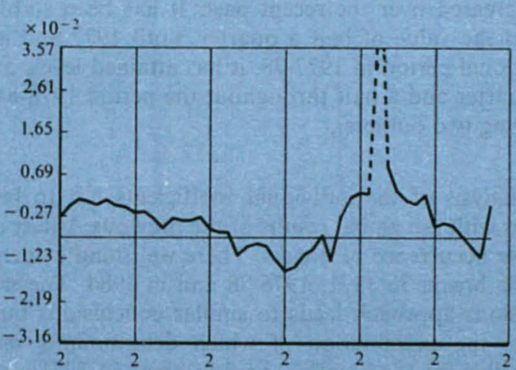


Figure II.2.e. **Moving regressions: autoregressive mean lags for France**

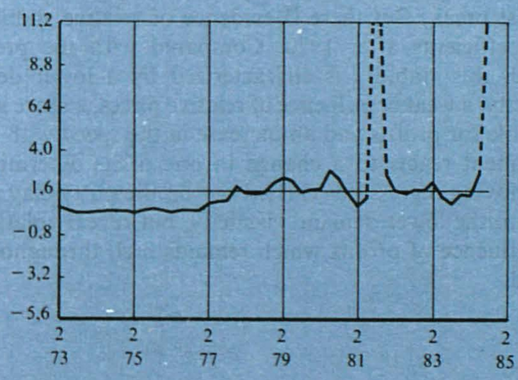
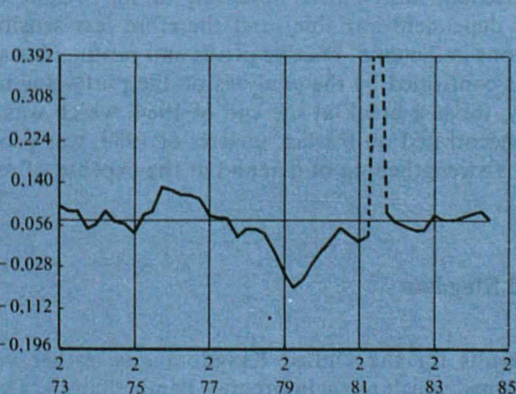


Figure II.2.c. **Moving regressions: long-term profit coefficients for France**



Demand: until the point 1982, there is no real break in the demand elasticity, although there are two temporary perturbations in 1977-78 and 1980-81. In both cases it is possible that these breaks in the moving regression coefficients also correspond to breaks five year earlier, in 1972 and 1975. Starting at the end of 1982, the role of demand became more important, although it levelled off again in 1984.

Relative prices: examination of the role of relative prices is particularly difficult: the estimated coefficient is very often positive (whereas it should in theory be negative). The only interesting results to be noted are the 1977 break (possibly corresponding to a break five years earlier) and the 1981-82 break with a reinforcement of the price elasticity.

Figure II.3.a. **Moving regressions: long-term demand coefficients for United Kingdom**

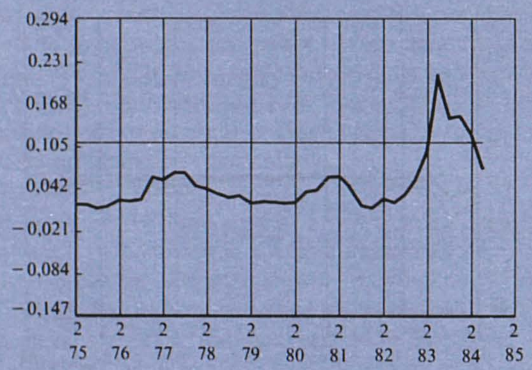


Figure II.3.b. **Moving regressions: long-term relative prices coefficients for United Kingdom**

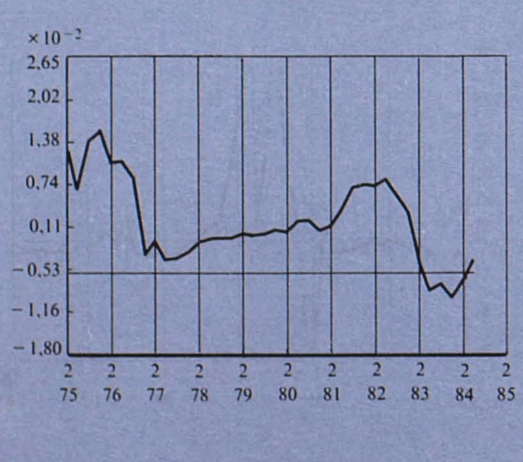


Figure II.3.c. **Moving regressions: long-term profit coefficients for United Kingdom**

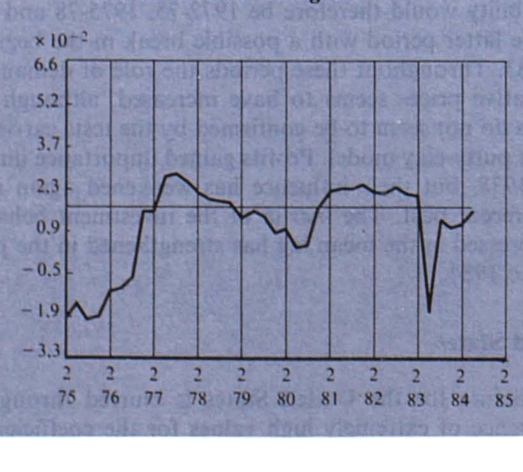


Figure II.3.d. **Moving regressions: coefficients of lagged dependent variable for United Kingdom**

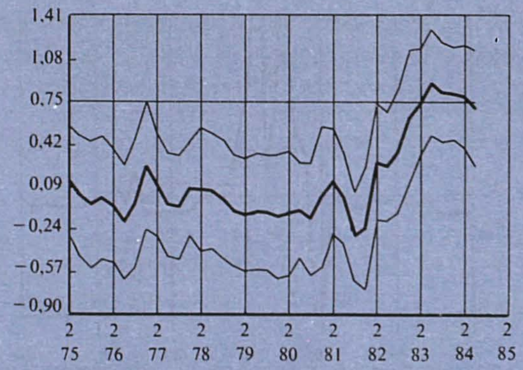
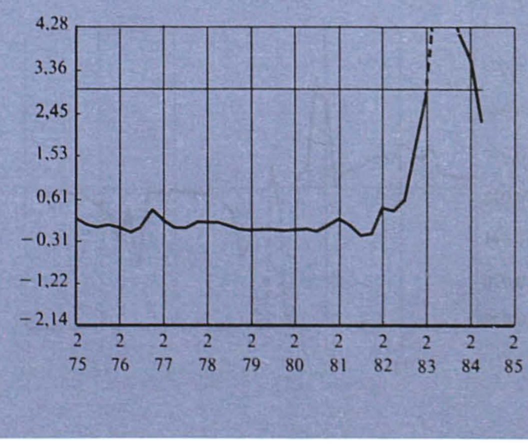


Figure II.3.e. **Moving regressions: autoregressive mean lags for United Kingdom**



Profits: the profit coefficient is moving within extremely narrow margins, between −0,02 and 0,03, but is nevertheless extremely volatile. Two breaks show up (points at 1977 and at 1980) corresponding to changes in the years 1972 and 1975. The period 1981-84 is next characterized by a recovery with a possible slight decline in 1983-84, corresponding to a period of stability between 1978 and 1984.

Dynamics: the autocorrelative coefficient stays at about the same level until 1982, interrupted by a sharp increase in 1982-83. After 1982 it establishes itself at a much higher level than before, implying an increase in the lags with which investment determinants work through actual investments. Whether the new trends which set in for 1983-84 will be maintained in the future remains as yet an open question.

The conclusions which emerge from the moving regressions are for the United Kingdom broadly in line with those

Figure II.4.a. **Moving regressions: long-term demand coefficients for United States**

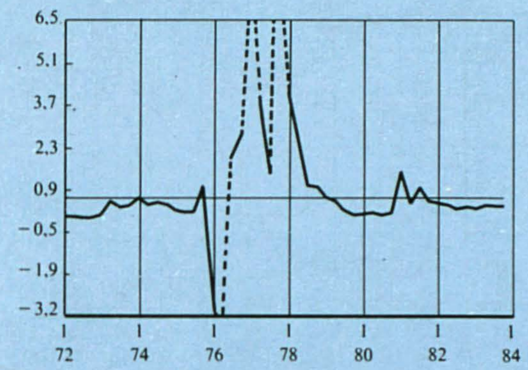


Figure II.4.b. **Moving regressions: long-term relative prices coefficients for United States**

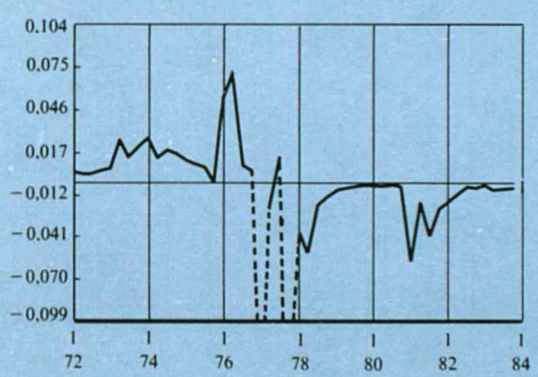


Figure II.4.c. **Moving regressions: long-term profit coefficients for United States**

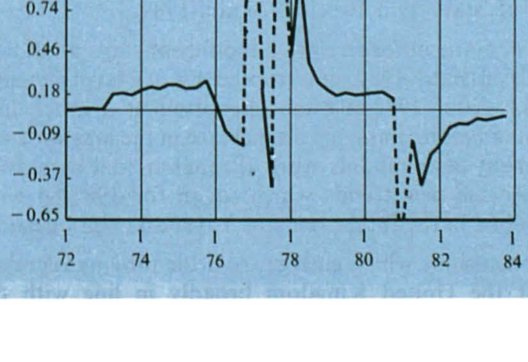


Figure II.4.d. **Moving regressions: coefficients of lagged dependent variable for United States**

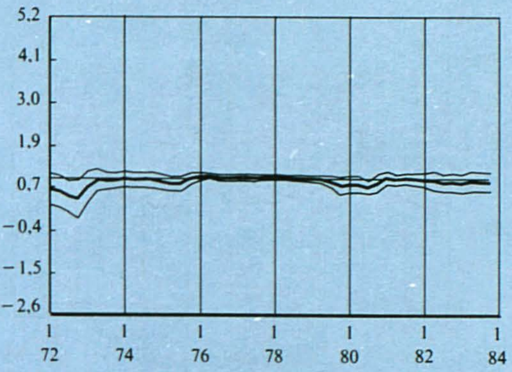
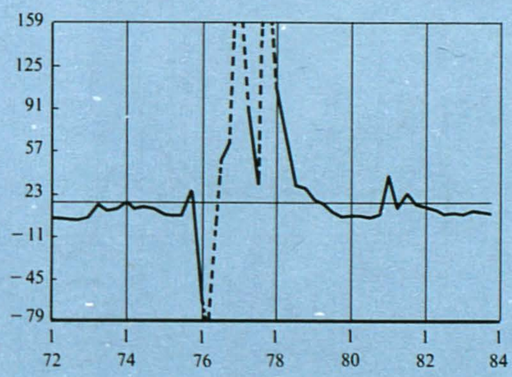


Figure II.4.e. **Moving regressions: autoregressive mean lags for United States**



derived from the stability tests (Annex III). Tentative periods of stability would therefore be 1972-75, 1975-78 and 1978-84, the latter period with a possible break in the beginning of 1983. Throughout these periods the role of demand and of relative prices seems to have increased, although these results do not seem to be confirmed by the tests carried out on the putty-clay model. Profits gained importance until the year 1978, but their influence has weakened again in the most recent past. The inertia of the investment behaviour as expressed in the mean lag has strengthened in the period 1975 to 1984.

United States

The picture for the United States is blurred through the occurrence of extremely high values for the coefficients of the lagged dependent variable, even surpassing the value of one in the first two quarters of 1976. These high values cause the long-run values of the coefficients to become very high, when the autocorrelation coefficient is close to one, or even shows an inversed sign, when the coefficient is higher than one. The high values are concentrated around those estimations for which the sample period ends between 1975/IV and 1978/IV, and also, but to a lesser extent, in 1981. The results for the individual coefficients have to be analysed abstracting from these high values.

Demand: there is some sign of an increasing demand elasticity until 1975, which is a vague indication of a break in 1971. A break in 1976 then shows up, which is again visible in 1981, if the 1976 observations are dropped. The graph suggests a stable period between 1978 and 1983 for the demand coefficients.

Relative prices: as for the demand coefficient, there are weak signs of the 1970 break, whereas the break in 1976 appears more clearly. Again a stable period seems to be 1978-83. On average during this period, the role of relative prices seems to have been enhanced.

Profits: the picture for profits is the same as for the two previous coefficients: a rising trend until 1975, suggesting a 1970 break, clear signs of the 1976 break in 1976 itself and in 1981, and a relatively stable period over 1978-83. Over this last period, profits are less important than they were before.

Dynamics: the period 1976-78 is associated with extremely high autocorrelation coefficients; before and after that period, the level is approximately the same.

To summarize, the US evidence from the moving regressions is partly in line with the global evidence from the previous Annex, except for the occurrence of the 1980 break which came out more clearly there in the earlier test.

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Estimation and simulation of international trade linkages in the QUEST model[1]

by Alexander Italianer[2]

[1] This chapter is part of the QUEST multinational modelling project and describes how the country models are linked through international trade flows. The QUEST project of the Directorate-General for Economic and Financial Affairs aims at the construction of linked quarterly econometric models for EC member countries and their main trading partners for economic forecasting and macroeconomic policy analysis.

[2] This document has been prepared under the direction of André Dramais, Head of Division, by Alexander Italianer, Administrator of the Directorate-General for Economic and Financial Affairs.

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1. Introduction

The QUEST (quarterly European simulation tool) modelling project of the Directorate-General for Economic and Financial Affairs aims at the construction of linked quarterly econometric models for the individual Community countries, the United States, Japan and their main trade partners. Because of its country disaggregation, the project may be seen as an extension of the Compact model,[1] in which the Community is treated as one single country. Furthermore the project also builds further on previous experiences at the Commission with the Comet and Eurolink models.[2] The QUEST project is conceived as a system of quarterly models for 25 countries and zones that divide the world exhaustively (cf. Box 1 for a list of countries and zones). In general, two types of individual country/zone models will be distinguished in the QUEST system: (i) medium-term macroeconomic models with a structure comparable to that of the Compact country models (50-60 equations) and (ii) trade-feedback models which are much smaller and only designed to ensure an endogenous transmission of international trade and prices.[3] It is planned to have macroeconomic models for all Community countries, the United States and Japan, while there will be trade-feedback models for the other countries and zones. The latter consist of the remaining OECD countries, the OPEC zone, a zone for the Eastern European centrally planned economies (CPEs), a zone for the newly industrializing countries (NICs) according to the OECD definition[4] and a rest of world zone.

Although these 25 countries and zones in reality are not only linked through merchandise trade and prices but also through interest rates, exchange rates, invisible trade, capital flows, migration etc., international trade linkage constitute an important element for the description of international dependencies in the QUEST model. Estimation and simulation of these trade linkages is the subject of this paper. In a certain sense the trade linkage system is the constant factor in the QUEST model: starting with simple trade-feedback models for most of the 25 countries and zones, they are consecutively replaced by the more detailed macroeconomic country models as soon as they become available. In such a way there is always an operational system which is gradually extended but guarantees throughout an exhaustive description of the international environment.

The trade linkages in the model are represented through the international transmission of volume and price movements. The transmission of volumes starts off in the country/zone models with an equation to determine the volume of total imports of goods. In a separate bilateral trade flow model this total import volume is allocated between the different exporters using bilateral import equations. Aggregating these equations for each exporter results in export volumes. Changes in import volumes thus have a direct effect on changes in export volumes. Price transmissions start off with an export price equation in the country/zone models. To determine import prices, these export prices are weighted, per importing country, using weights from the bilateral trade flow model. Changes in export prices therefore feed through in import prices. There is thus an explicit transmission of import volumes and export prices into export volumes and import prices.

The theoretical model which underlies this approach to trade linkages is described in Chapter 2, together with the specifications of the estimating equations. This model first determines total imports as a function of final demand, relative prices and domestic rates of capacity utilization. These import functions are presented and tested for their stability and robustness in Chapter 3. Results are presented for the four countries for which macroeconomic country models are constructed first: Germany, France, the United Kingdom and the United States. The second step of the approach consists, with export prices assumed to be given, of the allocation of total imports between its trade partners. This is the actual bilateral trade flow model, for which estimates and simulation results are presented in Chapter 4 of the paper. Notably, a closer look is taken at the trade flows between the four countries mentioned above, but aggregate export price elasticities are also derived for all the 25 countries and zones by simulation, and the performance of the model is compared with the evidence of the recent past. In Chapter 5, finally, some conclusions are drawn.

Box 1: Countries and zones in the QUEST model

Complete country models

1.	B/L	Belgium-Luxembourg Economic Union (BLEU)
2.	DK	Denmark
3.	D	Federal Republic of Germany
4.	GR	Greece
5.	E	Spain
6.	F	France
7.	IRL	Ireland
8.	I	Italy
9.	NL	Netherlands
10.	P	Portugal
11.	UK	United Kingdom
12.	US	United States
13.	JA	Japan

Country trade-feedback models

14.	CA	Canada
15.	AU	Australia
16.	AT	Austria
17.	FI	Finland
18.	NO	Norway
19.	SE	Sweden
20.	SW	Switzerland

Zone trade-feedback models

21.	RO	Rest of OECD countries:	Iceland, New Zealand, Turkey
22.	OP	OPEC:	Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, Venezuela
23.	CP	Centrally planned economies:	Albania, Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Romania, Union of Soviet Socialist Republics
24.	NI	Newly industrialized countries:	Argentina, Brazil, Hong Kong, Israel, Republic of Korea, Philippines, Singapore, South Africa, Taiwan, Thailand, Yugoslavia
25.	RW	Rest of the world:	all countries not included elsewhere, incl. trade not specified in terms of destination

Note: Belgium and Luxembourg are treated as B/L only in the trade linkage.

2. Specification of the equations

With export prices given, the two main types of behavioural equations that are of importance for the trade linkages are the total import equations and the bilateral import equations. Export volumes and import prices then follow from identities. The total import equations are part of the country/zone models, while the bilateral import equations form the essential body of the bilateral trade flow model. This chapter describes how one may derive both types of equations in a single, consistent, framework. Section 2.1 gives the justification for the choice of this framework, while the underlying theoretical model is explained in section 2.2. Sections 2.3 and 2.4 then present the actual specifications for the two types of equations.

2.1. The choice of a two-stage approach

In this section a justification is provided for the two-stage approach to trade linkages that is adopted. Point of departure is the requirement that, not counting statistical problems, the sum of all bilateral imports flowing into one country should equal total imports of this country. There are in principle two ways to ensure this accounting identity in an empirical model:[1] the first is to determine the bilateral imports from individual equations and then calculate total imports by identity; the second is to start from a separate behavioural equation for total imports (of goods), and next use bilateral import equations and impose an adding-up restriction. The latter may be done through a suitable choice for the specification of the bilateral import equations (e.g. import share equations adding up to one) or by attributing the residual from the accounting discrepancy to one or more bilateral equations in one way or the other (e.g. proportionally, or to a residual category). The basic form of these equations usually relates the bilateral trade flow to a volume and a relative price variable. The difference between the two approaches lies in the definitions of the volume variable and the associated deflator used in the relative price variable: in the first approach, the volume variable is usually final demand, while in the second approach it is total import volume. Similarly, the deflators used in the relative price variable are usually the final demand deflator and the deflator of total imports, respectively.

Theoretically, these two solutions for the adding-up problem between bilateral and total imports may both be cast in a comparable cost-minimizing or utility-maximizing framework. The second solution then follows from certain separability restrictions on the production function or utility function, and stems from the well-known two-stage budgeting procedure as developed in consumer theory by Gorman (1959) and Strotz (1957, 1959).

The transformation of this theory from consumer budgeting decisions to import flow determination was coined separately by Armington (1969) and Barten (1971). In some of the most well-known international modelling projects it is the prevailing approach (e.g. Link, EPA World Economic Model, Interlink, Comet, Compact), even though the separability assumptions underlying it have so far been rejected in general (cf. Winters (1984), Italianer (1986)). This rejection occurs, generally speaking, if the allocation of total imports over trade partners is not independent of the allocation of final demand between imports and domestic production. A typical example in this respect is the United Kingdom: the increased production of North Sea oil following two oil shocks has certainly induced substitution of imports by domestic production. This would not violate the separability assumptions if the geographical distribution of imports would have been left unaffected by this substitution. But as is obvious, the increase in production has mainly induced a decrease in the import share of the OPEC countries, thus violating the separability assumptions. Despite the fact that the assumptions which warrant the two-step approach are thus not always satisfied, the approach has nevertheless, for the time being, been retained for the QUEST linkage model. The main reasons behind this choice are the practical advantages which it offers: e.g. in this way the need for final demand variables for all 25 countries and zones of the model is avoided. It also allows the bilateral trade flow model to be simulated separately if import volumes and export prices are known. The disadvantages of the approach should however not be neglected: as the example of the United Kingdom has shown, there could be domestic production sectors which are in competition with only a limited group of countries, such that a substitution between domestic production and imports for the products of those sectors affects the geographical distribution of imports. In order to take account of these effects, which cannot be explained by the two-step model, and of other autonomous shifts in the geographical composition of imports (e.g. a change of preference from Middle-Eastern oil to North Sea oil), autonomous variables are introduced in the bilateral trade flow equations, such as dummies and trends. In this way it is hoped to eliminate—at least partially—the bias in the behavioural parameters of the import allocation system which otherwise might be present. Notably in order to deal with the energy problem, the effects on the estimation results for the total import equations are analysed of the exclusion of energy/oil. In this case a two-step approach would be maintained, but the total import variable in the bilateral trade flow equations could be changed according to whether the exporting country is a substantial energy/oil exporter or not.

2.2. The theoretical model

We derive the total import equation and bilateral import equations in one single framework, which is the subject of this section. Despite previous remarks about the separate treatment of different product categories such as oil, this framework is based on a one-good economy in order to simplify the presentation.[2] Moreover, the framework is consistent with the derivation of the demand for labour, capital and the determination of production capacity in the national QUEST models. This may be seen as follows. In the one-good economy, it is assumed that there is a representative producer in country j who has to satisfy a certain final demand F, using domestic inputs[3] $Y_1,...Y_p$ and bilateral imports of goods $X_{1j},...,X_{nj}$ ($X_{jj} = 0$ if j is a country, but not if j is a zone). The domestic inputs may be thought of as capital and labour, while for the sake of the argument it is assumed throughout that bilateral imports from i to j may be identified with bilateral exports from i to j. It is taken that it is possible to describe the relationship between final demand on the one hand, and the domestic inputs and bilateral imports on the other hand, by a regular production function H:

$$F = H(Y_1, ..., Y_p, X_{1j}, ..., X_{nj}, G), \tag{1}$$

where G represents other factors than domestic inputs and bilateral imports, e.g. time or autonomous preference shifts. It is assumed that final demand is given for the national producer who minimizes his production costs subject to (1):[4]

$$\min_{Y_h, X_{ij}} \quad \Sigma_h PY_h \,.\, Y_h + \Sigma_i PX_{ij} \,.\, X_{ij}, \tag{2}$$

where PY_h and PX_{ij} are the prices associated with Y_h and X_{ij} for $h=1, ..., p$ and $i=1, ..., n$, respectively. The prices PY_h could represent nominal wages and the user cost of capital, for instance, while PX_{ij} are the bilateral import prices. Under the assumption that H(.) is weakly separable[5] in the partitioning $(Y_1, ..., Y_p)$, $(X_{1j}, ..., X_{nj})$, (G), the production functioning may be written as[6]

$$F = H(y, m, G) \tag{3}$$

where y is a function of $Y_1, ..., Y_p$ only and similarly m is a function of all bilateral imports $X_{1j}, ..., X_{nj}$ only. If the domestic inputs Y_h are capital and labour, y could be regarded as a value-added production function, while m is usually called an import aggregator function. It should be noted, however, that y and m in general are not equal to value added Y and total imports of goods M in constant prices, even though the latter are usually taken in practice as proxies for the former.

The fact that the production function is weakly separable and may thus be written as in (3) is already a necessary and sufficient condition for the existence of a two-stage process[7] in which we first derive total imports and next allocate total imports over bilateral imports using only total import volume and the bilateral import prices, i.e. excluding final demand or the prices of the domestic production factors. While the allocation of total imports is not influenced by the prices of the domestic inputs, the opposite is the case for the allocation of the 'value-added' aggregate y: the demand for production factors is not influenced by bilateral import prices. In other words, the weak separability assumption guarantees the consistency between the usual two-factor production function approach and the separate allocation of total imports.

Under a somewhat stronger condition than mere weak separability, it is even true that the outcome of the two-stage process is the same as if (2) is only minimized subject to (1). For instance, a sufficient condition is that the function (1), and therefore the function (3), is homogeneous (of any positive degree). In such a case, the outcome of the cost-minimization problem (2) is equivalent to the result of the following two-stage process.[8]

The first stage is the one in which the producer decides on the amounts to spend on the domestic inputs aggregate y and the import aggregate m. This follows from the following cost-minimization problem subject to (2):

$$\min_{y, m} \quad py \,.\, y + pm \,.\, m \tag{4}$$

with py only a function of $PY_1, ..., PY_p$ and pm only a function of $PX_{1j}, ..., PX_{nj}$. The second stage is the one in which the individual domestic inputs $Y_1, ..., Y_p$ and bilateral imports $X_{1j}, ..., X_{nj}$ are determined (either through cost minimization, given y and m, or through 'utility maximization' of y and m given their corresponding money values $YV = py.y$ and $MV = pm.m$).

A specific functional form for (1) leads to specific functional forms for the demand equations for domestic inputs and bilateral imports. If (1) is of the form (3), there will be specific functional forms for the demand equations for the aggregates y and m, and next for the individual domestic inputs and bilateral imports.

In actual practice, it is the demand equation of total imports M which is usually estimated, with the domestic aggregate (if approximated by value added Y) usually defined through the well-known identity:

$$Y = F - M, \tag{5}$$

which is to be interpreted as an adding-up condition on final demand.

For the derivation of the equations in this paper, we will use specific functional forms for (3) and the total import aggregate m appearing in that equation, but not for the 'value-added' aggregate y, since the determination of the demand for domestic production factors is outside the scope of this paper. Nevertheless it is clear that an independent approach for the domestic inputs, starting from a specific functional form for y, is justified in the context of the framework sketched above.

2.3. Total import equation

2.3.1. Basic equation

The previous section showed that a sufficient condition for the two-stage approach to be consistent with a one-stage approach was the homogeneity of the weakly separable production function (3). For the derivation of the total import equation in this section, the widely used CES function, assumed to be homogeneous of degree q, is therefore adopted as a functional form for (3). The equation resulting from this function is then extended to include disequilibrium effects and dynamics.

The CES function, homogeneous of degree q, takes the following form:

$$F = A.(h.y^{-r} + (1-h).(G(t).m)^{-r})^{-q/r} \qquad (6)$$

with A the scaling parameter, h the distribution parameter, $c = 1/(1+r)$ the elasticity of substitution and with G written as a function of time, multiplicatively associated with the import aggregate m. It should be remembered that in (6), y and m are still functions of the domestic inputs and bilateral imports. The y function is left unspecified, and a functional form for the aggregator function m will be introduced below to derive the bilateral import equations.

Cost minimization of (4) subject to (6) leads, after some algebra, to the following loglinear import function:

$$\ln m = a + b.\ln(F.Z(t)) - c.\ln(pm/p) \qquad (7)$$

with Z(t) a transformation of the function G(t) ($Z(t) = G(t)^{-q}$), the coefficient b equal to the inverse of the degree of homogeneity q ($b = 1/q$) and c again the elasticity of substitution between the domestic aggregate y and imports m. Specification (7) allows the incorporation, through the function Z(t), of secular effects on imports through the formation of customs unions, abolition of trade barriers, international specialization, improved means of communication and trade integration in general. The relative price term in (7) requires some remarks. Given that m is an aggregator import quantity index of bilateral imports (e.g. a CES function), pm is the dual of this function, and therefore not the observed cif import index.[9] It is the index such that the product pm.m equals the total value of imports $\Sigma_i PX_{ij}.X_{ij}(.)$, with $X_{ij}(.)$ the derived demand functions for bilateral imports. Similarly, p is the dual of the CES function in (6), and therefore a function of pm, py and the function Z(t). Although m, pm and p are therefore not observable (being functions of parameters to be estimated), we proxy them in practice by, respectively, total imports of goods in constant prices M, the corresponding import unit value index PM and the final demand deflator PF. Experience shows that these proxies are acceptable: from here they will therefore be used in the equations to replace m, pm and p.

2.3.2. Cyclical influences

One of the characteristics of the import function (7) is that it is derived for a representative national producer in a cost-minimization framework or, for that matter, in a disequilibrium framework with effective demand. We can call upon the aggregation of micro-economic import functions in a more general disequilibrium framework to introduce the degree of capacity utilization DCU_j as an additional explanatory variable,[10]

$$\ln M = a + b.\ln(F.Z(t)) - c.\ln(PM/P) + d.DCU \qquad (8)$$

Next to the empirical phenomenon that increasing tensions on the goods market lead to an augmentation of imports, the introduction of the rate of capacity utilization is therefore also justified theoretically in a disequilibrium framework.

2.3.3. Dynamics

Even though equation (8) makes a distinction between secular and cyclical effects, it is still essentially static in nature. Before estimation, some further transformations have to be made in order to introduce dynamic elements. If dynamics are not introduced, the equations will suffer from autocorrelation, and moreover will have undesirable simulation properties.

A general way to introduce dynamics is to assume that equation (8) determines an optimal amount of imports M* instead of actual imports M. By assuming that actual imports adjust to optimal imports, e.g. through an error correction mechanism (ECM) or a partial adjustment model (PA), a dynamic link is then created between the explanatory variables of equation (8) and actual imports of goods M. The disadvantage of the ECM/PA approach, however, is that it assumes an equal distributed lag structure for each of the explanatory variables. Close inspection of equation (8) reveals why this is an unrealistic assumption. In 'allocation' systems like the present one, the volume effect stemming from the final demand variable is likely to exert an effect on imports fairly quickly: this follows from the input-output relationship between final demand and primary inputs, which is a direct, almost accounting, relationship. Changes in relative prices, on the other hand, may take some time to modify the structural split between domestic production and imports. This may be due to recognition lags, decision lags, delivery lags, replacement lags and production lags.[11] A shortage on the domestic goods market may also have a delayed effect on imports, but this effect is direct almost by definition and the delays are in principle reduced to delivery times, and may be considered to be instantaneous or lagged with one period at most, given the periodicity of our (quarterly) data. This implies therefore almost immediate effects of the variables for final demand and capacity utilization. For relative prices, on the other hand, we have to take account of lags. This would lead to the following dynamic functional form for the import function:

$$\ln M = a + b.\ln(F.Z(t)) - c(L).\ln(PM/PF) + d.DCU, \quad (9)$$

where c(L) is a distributed lag function.

In practice only one form for c(L) has been used:[12] the Koyck lag distribution, which is an infinite and geometrically declining distribution defined as $C(L) = c.(1-k).\Sigma_{i=0}^{\infty} k^i L$, with L the lag operator ($Lx_t = x_{t-1}$). The use of the Koyck lag requires a transformation of (9) to eliminate the infiniteness. This leads to an equation of the type:

$$\begin{aligned} \ln M = a &+ b.(\ln(F.Z(t)) - k.\ln(F_{-1}.Z(t-1))) \\ &+ k.\ln M_{-1} \qquad (10) \\ &- c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1}) \end{aligned}$$

In this equation, b, c and d still represent long-term values of the corresponding elasticities.

2.4. Bilateral import equations

By choosing a functional form for the import aggregator function in (3) and by minimization of total import costs with m_j given,[13] a specification for the bilateral import functions is obtained. These equations are extended to include also dynamics and disequilibrium effects.

2.4.1. Derivation

The most widely used functional form for the aggregator function in empirical work is the CES function, drawing on the approach by Hickman and Lau (1973). Research has shown, however, that in a model with a considerable number of trade partners (say more than 10), the CES function is too simple,[14] and a more general type of aggregator function is therefore needed. The aggregator function proposed is the CRESH (constant ratios of elasticities of substitution homothetic/homogeneous) function of Hanoch (1971). This function is a generalization of the CES function and defines the import quantity index m_j implicitly as follows:

$$\Sigma_i d_{ij}.(X_{ij}/m_j)^{-r_{ij}} - 1 \equiv 0, \quad (11)$$

where it is required for regularity that $r_{ij} > -1$. It may be seen that if all r_{ij} are equal, this function is a linear homogeneous CES function. If total import costs MZV_j are minimized:

$$\min_{X_{ij}} \quad MZV_j = \Sigma_i PX_{ij}.X_{ij} \quad (12)$$

subject to (11), the bilateral import equation resulting from the minimization problem has the following logarithmic form[15]

$$\ln X_{ij} = a_{ij} + \ln m_j - b_{ij}.\ln(PX_{ij}/pm_j) \quad (13)$$

with $b_{ij} = 1/(1+r_{ij})$. This formulation has a unitary elasticity of bilateral imports with respect to the import quantity index m_j, which is implied by the linear homogeneity of the CRESH function (11). The elasticity b_{ij}, which can be called 'relative price elasticity', is not the (Allen-Uzawa, partial) elasticity of substitution. The latter is defined, for the substitution between trade partners i and k, as:[16]

$$AES_{ik} = b_{ij}.b_{kj}/(\Sigma_h w_{hj} b_{hj}), \; i \neq k \quad (14)$$

with w_{hj} the import value share of country h in the optimum.

In the special case $b_{ij} = b_{kj}$ for all i and k, equation (13) corresponds to a CES aggregator function. It is therefore clear where the so-called 'simplicity' of the CES model arises from: this model amounts to equal relative price elasticities (and therefore Allen elasticities of substitution) for all bilateral trade flows going into one country.

As for the total import equation, some problems arise for equation (13) from the import quantity index m_j and the import price index pm_j: they are both defined implicitly and are moreover a function of the parameters of the model.

This implies that they are not observable and cannot be used for estimation. There are several ways to deal with these problems,[17] but the most practical solution in the present situation seems to proxy the import quantity index m_j by the sum of bilateral exports MZ_j ($=\Sigma_i X_{ij}$), and the import price index pm_j by a weighted average PMZ_j ($= MZV_j/MZ_j = (\Sigma_i X_{ij}.PX_{ij})/(\Sigma_i X_{ij})$) of the bilateral export prices PX_{ij}. The variable MZ_j is called quasi-fob import volume, and the price PMZ_j is called the quasi-fob import price. These proxies do not essentially invalidate the approach, since they capture the same phenomena contained in the aggregates m_j and pm_j, namely bilateral import volumes and prices: X_{ij} and PX_{ij}. Furthermore, the bilateral prices PX_{ij} have been proxied, in the absence of bilateral price data, by the total export price PX_i. This is justified under the assumption that country/zone i produces a homogeneous good for which there is no price discrimination according to the country of destination.

A further problem caused by the implicitly defined indices m_j and pm_j is the adding-up condition. Given that proxies are used, the adding-up condition which is still valid for (13), if m_j and pm_j are defined appropriately, no longer holds. As seen in Box 4, this is solved through a proportional adjustment on all bilateral value flows $XV_{ij}(=PX_i.X_{ij})$ during simulation such that $\Sigma_i XV_{ij} = MZV_j$. It should be noted that the adding-up condition in constant prices, which should hold because the proxy MZ_j is used, is respected automatically through the definition of the corresponding quasi-fob import price index PMZ_j:

$$\Sigma_i X_{ij} = (\Sigma_i X_{ij}.PX_i).(\Sigma_i X_{ij})/(\Sigma_i X_{ij}.PX_i) = MZV_j/PMZ_j = MZ_j \quad (15)$$

Given the proxies for m_j, pm_j and PX_{ij}, the basic, static, estimating equation for the bilateral import equations becomes:[18]

$$\ln X_{ij} = a_{ij} + \ln MZ_j - b_{ij}.\ln(PX_i/PMZ_j) \quad (16)$$

As for the total import equation, this static equation is the point of departure towards a complete estimating equation.

2.4.2. Dynamics

A first step to further develop equation (16) is through the introduction of dynamics. Using similar arguments as above on the specification of dynamics in allocation models, a Koyck lag of the form $b_{ij}.(1-c_{ij})\,(1-c_{ij}.L)^{-1}$ on the relative price term in (16) leads to the following specification:

$$\ln X_{ij} = a_{ij} + \ln MZ_j + c_{ij}.\ln(X_{ij}/MZ_j)_{-1} - b_{ij}.(1-c_{ij}).\ln(PX_i/PMZ_j) \quad (17)$$

Next to the dynamic version a correction for autocorrelation may also need to be applied, either to the form (16), or to the form (17). Furthermore it might also be needed to introduce additional lags on the relative price term, depending on the empirical results.

2.4.3. Disequilibrium effects

As noted above for the total import equation, the aggregation of micro markets in disequilibrium leads to aggregate import and export functions containing rates of capacity utilization for the importing and exporting country, respectively.[19] Since the bilateral trade flow system proposed is an import allocation model based on separability assumptions regarding the national production function, the domestic rate of capacity utilization will not appear in the bilateral import functions.[20] The foreign rates could however appear in the bilateral import equations, in the same form as the relative prices.[21] This approach is only feasible if rates of capacity utilization are available for all 25 countries/zones in the model; moreover, these rates should all be defined such that they have the same values when there is a 'normal' utilization of capacity. In the present situation, neither of the two conditions is fulfilled for the QUEST model: presently rates of capacity utilization are only available for four countries, and it is not sure that they have equivalent scales. It is therefore proposed to revert to the Barten and d'Alcantara (1977) approach in which, for a bilateral trade flow equation for exports from country i to country j, the rate of capacity utilization of country i appears in levels instead of relative to the levels of its competitors. This approach is justified in the sense that if the capacity utilization of country i is low relative to that of its competitors but high relative to its normal domestic level, the country will still not have an incentive to exert an extra push on exports. Thus including the level of the rate of capacity utilization DCU_i of country i in the bilateral export flow equation (16), after the introduction of a Koyck lag on the relative price, the following extension of (17) is obtained:

$$\ln X_{ij} = a_{ij} + \ln MZ_j + c_{ij}.\ln(X_{ij}/MZ_j)_{-1} - b_{ij}.(1-c_{ij}).\ln(PX_i/PMZ_j) + d_{ij}(DCU_i - c_{ij}.DCU_{i,-1}) \quad (18)$$

with a negative sign for d_{ij} to represent the positive effect of domestic slack in country i on export promotion in general and on exports to country j in particular.

Box 2: Data for total import equations

The data for the total import functions[1] are quarterly, seasonally adjusted, and in national accounts definitions originating—directly or indirectly—from national sources (Germany: DIW, France: Insee, the United Kingdom: CSO, the United States: OECD). The variable for the degree of capacity utilization (DCU) comes from national business surveys (Germany: IFO, France: Insee, United Kingdom: CBI, United States: Federal Reserve Bank). Imports of non-energy/oil were obtained through subtraction of energy/oil imports from total imports, except for the United Kingdom. The energy/oil concepts are the Standard International Trade Classification (SITC) category 33 (=crude petroleum and petroleum products) for the United Kingdom and the United States, SITC 3 (total energy) for France, and 'mining-products' for Germany. Sources are the Sysifo model (Statistisches Bundesamt definitions) for Germany, Insee national accounts for France, CSO for the United Kingdom and DRI for the United States.

3. Estimation, stability and robustness of the total import equations

In this chapter estimation results are presented for Germany, France, the United Kingdom and the United States for the total import equations derived in the previous chapter. As for the theoretical derivation, a basic equation is the point of departure, which is then extended to include disequilibrium effects and dynamics. These results are presented in section 3.2, after a discussion, in section 3.1, of the specification of the trend variable which represents trade integration effects in the total import equation. Next, section 3.3 examines the stability and robustness of the estimations, followed by an analysis of the problems posed by the inclusion of energy in the equations, in section 3.4. A description of the data sources is given in Box 2.

3.1. Trade integration

In the previous chapter, the following estimating equation for the total import equation was derived:

$$\begin{aligned}\ln M = a &+ b.(\ln(F.Z(t)) - k.\ln(F_{-1}.Z(t-1))) \\ &+ k.\ln M_{-1} \qquad (19) \\ &- c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})\end{aligned}$$

with M total imports of goods in constant prices, PM the corresponding deflator, F final demand in constant prices, PF its deflator and DCU the degree of capacity utilization. The secular function Z(t) is unspecified so far. Therefore, before passing on to estimation, its specification is first discussed, in conjunction with the long-run growth rates of the other variables appearing in equation (19).

3.1.1. Empirical evidence

For the specification of the trend variable Z(t), it is of importance to get an idea of the orders of magnitude that are involved in the estimation of equation (19). Therefore the medium-term and long-term average annual growth rates of the main variables appearing in that equation are presented in Table 1. As the degree of capacity utilization is typically a cyclical variable, it is not included in the table. Moreover, for the import variables, the results are presented including and excluding energy/oil. Next to the results for the four countries, the OECD average is also presented for comparison. Of particular interest are the third and sixth column in which appear growth rates for the share M/F of total import volume in final demand volume, and the inverted relative price PF/PM of equation (19). The latter variable has been inverted because in that form it is supposed to be positively correlated with the import volume share M/F. In addition Graphs 1 to 5 present the development over time of these two variables. Graph 1 compares the import volume shares in final demand. The graph shows that the economies of Germany, France and the United Kingdom are increasingly convergent in terms of import shares in final demand, going from 8-11% in 1963 to 17-18% in 1984. The same figure also shows the well-known limited openness of the United States economy, with the effects of the high dollar clearly appearing at the end of the period. The high growth rates for the import volume share in Table 1 for the United States are clearly due to the low starting level for this variable in the beginning of the 1960s.

The developments of the total import share in final demand M/F and the inverted relative price PF/PM are plotted in Graphs 2-5. In principle there should be a positive correlation between the two variables. Similar variances may be noted between the two variables for France and the United States, while the correlation seems at first sight weaker for the two other countries. There is a clear break between the two series in the course of 1974 due to the oil price shock. This problem will have to be treated when the stability of the equations is analysed in section 3.3 below.

For the specification of the trend variable Z(t) it is interesting to look at the medium-term and long-term relationships between imports, final demand and relative prices. The following medium/long-term relationship, between the import elasticity b with respect to final demand and the average annual growth rates of the variables mentioned above (indicated with a dot), may be calculated from equation (19)

$$b \approx \dot{M}/\dot{F} - c(\dot{PF}/\dot{PM})/\dot{F} \qquad (20)$$

This relationship shows that if there is no change in relative prices, the volume elasticity equals approximately the ratio of the average annual growth rates of import volume and final demand volume. Assuming an elasticity of substitution equal to 0,5, the calculation according to equation (20) is presented in the last column of Table 1. Even though these implicit volume elasticities are only a rough approximation, they reveal that for almost all countries and sub-periods imports grow consistently faster than final demand, also when corrected for changes in relative prices. Indeed, through the formation of customs unions, abolition of trade barriers, international specialization and improved means of communication, this phenomenon must be ascribed to a steady trade integration between most national economies irrespective of the general economic situation. This trade integration is a secular movement and should be distinguished from the reaction of imports to small shocks in final demand, such as those generated for policy simulations. In other words, there should be a difference between the properties of the import equation for forecasting, where the

Table 1

Medium-run and long-run growth rates of the main variables appearing in the total import equation (incl. and excl. energy/oil), 1965-84

		Import volume	Final demand volume	Import volume share	Final demand deflator	Import deflator	Relative price	Implicit volume elasticity
		M	F	M/F	PF	PM	PF/PM	b
FR of Germany								
1965-73	T	8,0	4,8	3,1	4,3	1,4	2,8	1,4
	N	8,3		3,3		1,2	3,1	1,4
1974-79	T	6,5	3,4	3,0	4,1	3,1	1,0	1,8
	N	7,0		3,4		3,1	1,0	1,9
1980-84	T	1,0	0,9	0,1	3,7	4,9	−1,1	1,7
	N	1,9		1,0		4,8	−1,1	2,7
1965-84	T	5,6	3,2	2,3	4,5	4,4	0,1	1,7
	N	6,1		2,8		3,5	1,0	1,7
France								
1965-73	T	12,9	6,3	6,3	5,0	2,6	2,3	1,9
	N	13,6		6,9		2,5	2,4	2,0
1974-79	T	6,5	3,6	2,7	9,6	5,6	3,8	1,3
	N	6,9		3,1		5,5	3,9	1,4
1980-84	T	2,2	1,4	0,8	10,3	9,8	0,5	1,4
	N	2,7		1,3		10,1	0,1	1,9
1965-84	T	8,2	4,2	3,9	8,3	7,5	0,7	1,9
	N	8,8		4,4		6,4	1,8	1,9
United Kingdom								
1965-73	T	7,2	3,7	3,3	6,2	6,1	0,1	1,9
1970-73	N	10,4	5,1	5,0	8,5	9,3	−0,6	2,1
1974-79	T	2,6	2,1	0,5	15,2	12,3	2,6	0,6
	N	5,2		3,1		11,5	3,4	1,7
1980-84	T	5,0	1,9	3,1	7,3	7,3	−0,0	2,6
	N	6,4		4,4		6,7	0,6	3,2
1965-84	T	4,5	2,3	2,1	10,1	10,1	−0,0	2,0
1970-84	N	5,8	2,1	3,6	12,0	10,4	1,4	2,4
United States								
1965-73	T	10,2	4,1	5,9	4,6	5,1	−0,5	2,5
1967-73	N	9,6	3,9	5,5	5,1	6,2	−1,1	2,6
1974-79	T	6,1	3,7	2,4	7,4	8,5	−1,1	1,8
	N	6,1		2,4		7,6	−0,3	1,7
1980-84	T	10,6	3,3	7,1	5,1	−3,0	8,3	2,0
	N	11,9		8,4		0,8	4,3	3,0
1965-84	T	7,8	3,3	4,3	6,0	7,0	−0,9	2,5
1967-84	N	7,7	3,1	4,4	6,4	6,7	−0,3	2,5

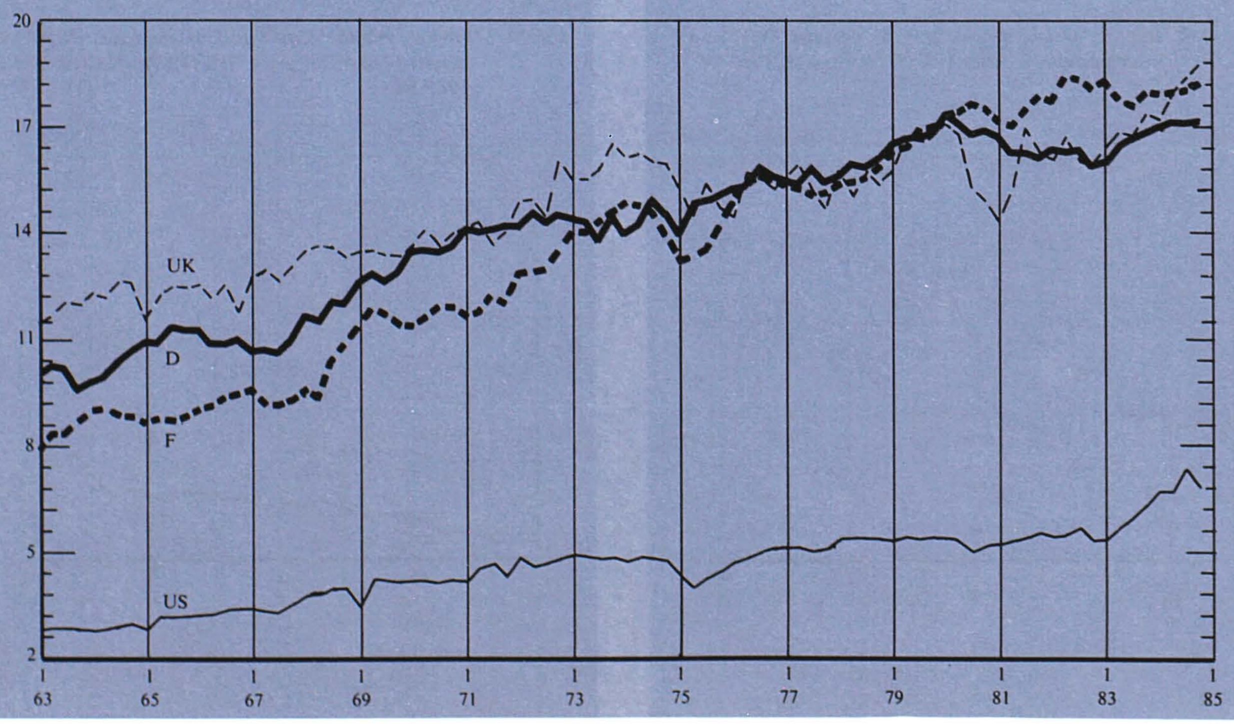
Table 1 *(continued)*

Medium-run and long-run growth rates of the main variables appearing in the total import equation (incl. and excl. energy/oil), 1965-84

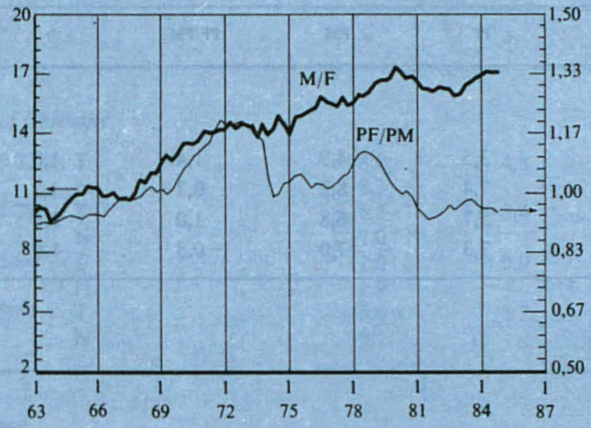
	Import volume	Final demand volume	Import volume share	Final demand deflator	Import deflator	Relative price	Implicit volume elasticity
	M	F	M/F	PF	PM	PF/PM	b
OECD							
1965-73	9,2	5,4	3,6	3,5	4,9	1,4	1,6
1974-79	4,2	3,3	0,9	7,4	8,2	0,7	1,2
1980-84	3,9	2,4	1,5	5,7	6,8	1,0	1,4
1965-84	5,9	3,7	2,1	7,3	7,0	−0,3	1,6

Seasonally adjusted average annual rates.
Source for OECD: National Accounts, Vol. 1, OECD, Paris, 1985.
T = total imports.
N = excl. energy/oil.

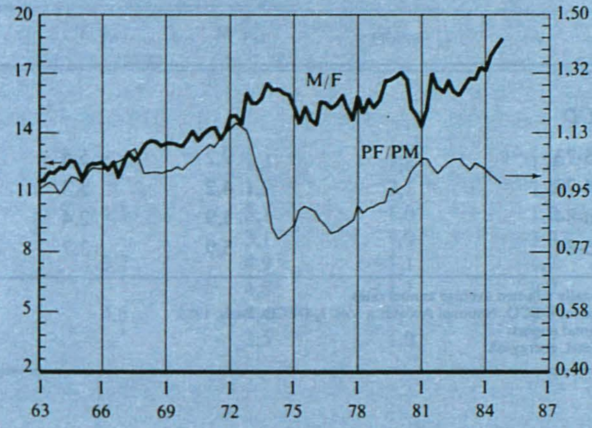
Graph 1: **Import volume shares in final demand, 1963-84**



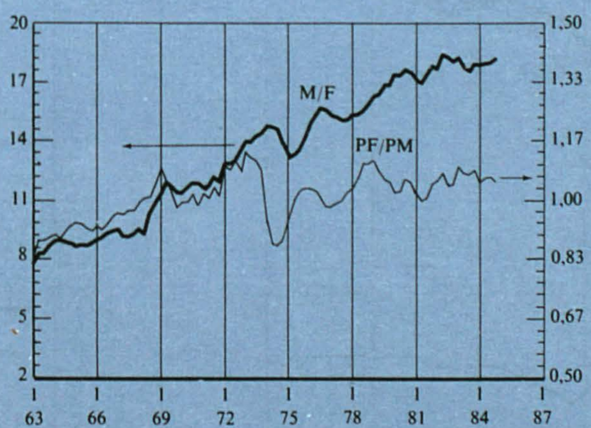
Graph 2: **Import volume shares in final demand (M/F) and inverted relative price (PF/PM), Germany, 1963-84**



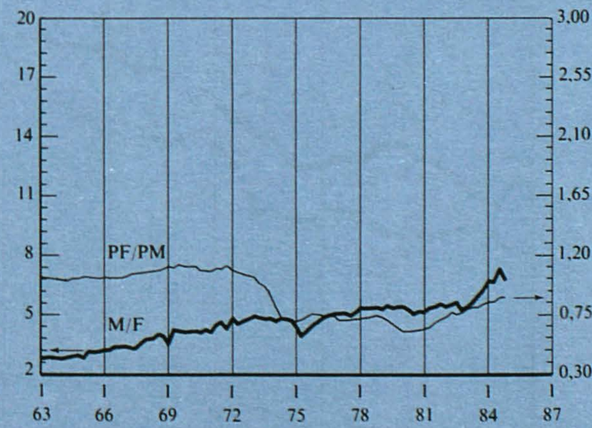
Graph 4: **Import volume shares in final demand (M/F) and inverted relative price (PF/PM), United Kingdom, 1963-84**



Graph 3: **Import volume shares in final demand (M/F) and inverted relative price (PF/PM), France, 1963-84**



Graph 5: **Import volume shares in final demand (M/F) and inverted relative price (PF/PM), United States, 1963-84**



secular trade integration effect plays a role, and for the analysis of economic behaviour through e.g. multiplier analysis. This difference is introduced in equation (19) through the variable Z(t), whose specification is next discussed.

3.1.2. Specification of the trade integration effect

Specifying Z(t) as a function of time alone implies that it plays a role for forecasting, but has no effect in the kind of analysis where simulations of (policy) shocks are compared to baseline simulations.

Reverting to Table 1, it is evident from the third column that the long-run growth rate of the average OECD total import volume share sets a lower limit to that of the other four countries. A trend has therefore been fitted to the development of this share over the period 1960-84, and the fitted value of this trend has been introduced as the variable Z(t). Graph 6 shows the development of the OECD share (which was interpolated from annual data) over time, together with the fitted trend value Z(t). The latter was obtained through fitting the OECD share, say W, to a logistic curve of the following type:

$$W = 1/(1 + \exp(a + b.t)) \qquad (21)$$

This logistic curve was chosen in order to avoid the usual assumption that a variable grows continuously at an exponential rate. Such a specification is to be avoided since the share of imports in final demand has a maximum equal to 1, and the fitted curve should represent this property, as does equation (21).

After making the transformation ln (1/W − 1), specification (21) leads to a linear estimating equation. Due to the change in the level and curvature of the W-curve before and after 1975, the coefficients for these two periods have been separated (spline regression), and a dummy introduced for 1975/I-1975/IV to account for the slump in that year. This leads to the following estimation result:

$$\ln(1/W - 1) = \underset{(0,0055)}{2,1233} + \underset{(0,0123)}{0,1028}\,D75 - \underset{(0,0290)}{0,3252}\,D7684 - \underset{(0,0002)}{0,0089}\,t + \underset{(0,0004)}{0,0061}\,t7684 \qquad (22)$$

$\bar{R}^2 = 98,6$ SER = 2,2% DW = 0,237

Sample period: 1960/I-1984/IV

D75:	= 1 for 1975/I-1975/IV, = 0 otherwise,
D7684:	= 1 for 1976/I-1984/IV, = 0 otherwise,
t:	= 1960/I = 0, 1960/II = 1, etc.
t7684:	= t for 1976/I-1984/IV, = 0 otherwise,

For the period 1960-74, this equation gives annual growth rates of 3,0-3,2% for the average OECD import volume share, while this figure is reduced to 1,1% for the 1976-84 period. These two growth rates are comparable to the OECD figures for the corresponding periods in the third column of Table 1. If the fitted value of equation (22) is called V_t, the trend variable introduced in the estimating equation (19) is now obtained as:

$$Z(t) = 1/(1 + \exp(V_t)) \qquad (23)$$

In the following subsection it is seen that the introduction of Z(t) in (19) strongly reduces the volume elasticities, while at the same time guaranteeing the secular growth of imports compared to final demand.

3.2. Estimation

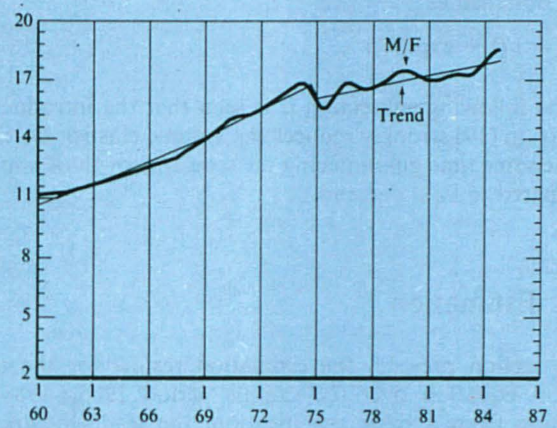
This section presents the estimation results for the total import equation over the sample period 1965/I-1984/IV. Starting from a basic specification, the trade integration variable, degree of capacity utilization and dynamics are introduced consecutively.

3.2.1. The effect of trade integration

Before starting the actual estimations the effects of the introduction of the trade integration variable Z(t) are analysed. For this purpose the static total import equation is estimated without and with introduction of Z(t). The corresponding estimation results are presented in Tables 2 and 3. In Table 2 Z(t) = 1, while in Table 3 the fitted value of equation (23) is used.

This operation brings the volume elasticities b down from the range 1,7-2,3 (which could be expected on the basis of Table 1) to the range 1,0-1,5. Although the volume elasticities in Table 3 are significantly different from 1 (except for the United Kingdom), they are now at more acceptable levels to cope with economic behaviour (e.g. as a reaction to policy shocks) as compared to secular trends. It may be seen that the countries for which the elasticities are closest to 1 are those for which the average 1965-84 growth of the import ratios in Table 1 is closest to the OECD average, which is in all four cases lower or equal. It may seem that the introduction of Z(t) leads to a deterioration of the explanatory power of the equation. As will be seen below, however, this is mainly due to the fact that the equation is not yet estimated in its complete form. In the complete form the loss of fit is negligible. The price to pay in order to obtain the distinction between secular trends and realistic

Graph 6: **Import volume share in final demand (M/F) and fitted logistic spline trend, OECD average, 1960-84**



economic behaviour in the total import equation is therefore low and acceptable. The elasticity of substitution is the highest for the United States in the two tables, the elasticity for the United Kingdom even being positive if we include the trade integration effect. Moreover, in Table 3, the elasticities of substitution are not significant for France and Germany. Finally, the Durbin-Watson statistics in the two tables give a clear indication of positive autocorrelation in all cases.

The specification of Table 2 is directly comparable to that of the Compact model of which QUEST is to be considered as an extension. It is therefore interesting to compare the estimation results with the import equation from Dramais (1986, p. 149),

$$\ln M = -4{,}273 + 1{,}331 \ln F - 0{,}264 \ln (PM/PD) \quad (24)$$
$$(0{,}584) \quad (0{,}083) \qquad (0{,}106)$$

$\bar{R}^2 = 0{,}996$ DW = 1,910 Sample period: 1958-82

PD = domestic demand deflator

If one disregards the differences that hamper formal comparison of the Compact equation with those for the QUEST model,[2] the most striking difference between Compact and Table 2 is the volume elasticity: while ranging from 1.7 to 1.9 for the three European countries in Table 2, it equals a mere 1.3 for Compact.

Theoretically, the differences between these elasticities could be ascribed to two causes. The first is that the Compact equation is an EUR 10 aggregate, and therefore the elasticities of the countries other than those of Table 2 might be lower. However, the simultaneous increase in trade integration which took place over the period under consideration makes this a purely hypothetical possibility. The second, and probably more realistic explanation is that the dependent variable in Compact concerns extra-EC imports only. Since the strong development of imports is to a large extent due to intra-EC trade integration, this would explain the seemingly low Compact elasticity. Moreover, this would justify a comparison of the Compact equation with Table 3 rather than with Table 2, and from that comparison the results are quite acceptable. As an illustration of this point Table 4 shows the intra-EUR 10 share in the imports of the three European countries under consideration, together with the EUR 10 average. For example, this table shows that for the EUR 10 there was on average a growth differential of 0,6 percentage points between the volumes of intra-EUR 10 imports and total imports over the 1965-84 period.[3] Under *ceteris paribus* assumptions, this growth differential suggests differences in volume elasticities between intra-EUR 10 and total imports of the order of 0,6, which corresponds roughly to the differences between Table 2 and the Compact equation.

As it is evident that the trade integration variable Z(t) reduces the final demand elasticities to values in an *a priori* acceptable range, it will be used in all subsequent estimations.

3.2.2. Cyclical influences

With respect to the general formulation (19), cyclical influences and lags on the relative prices have hitherto been omitted. In this subsection cyclical influences in the form of the rate of capacity utilization DCU are introduced:

$$\ln M = a + b.\ln(F.Z(t)) - c.\ln(PM/PF) + d.DCU \quad (25)$$

The coefficient d of the rate of capacity utilization DCU is a quasi-elasticity: a one-percentage point increase in the rate of capacity utilization will increase imports by about d%. Furthermore it is usually assumed that the effects of the degree of capacity utilization are stronger, the higher its value becomes (non-linear effects). In a first instance, however, only a linear effect is retained.[4]

Table 2

Static import equation with volume and price effect, excluding integration effect

ln M = a + b.ln F + c.ln (PM/PF)

	a	b	c	SER	$\bar{R}^2$	DW
FR of Germany	−6,304 (0,080)	1,731 (0,013)	−0,144 (0,035)	2,3	99,5	1,01
France	−7,169 (0,081)	1,924 (0,015)	−0,094 (0,061)	2,8	99,7	0,42
United Kingdom	−10,516 (0,365)	1,778 (0,033)	−0,035 (0,048)	3,7	97,6	1,07
United States	−10,679 (0,266)	2,315 (0,047)	−0,258 (0,041)	4,9	98,3	0,94

Sample period: 1965/I to 1984/IV.
Standard errors below coefficients.
SER = estimated standard error of the equation.
$\bar{R}^2$ = coefficient of determination, corrected for degrees of freedom.
DW = Durbin-Watson statistic.

Table 3

Static import equation with volume and price effect, including integration effect

ln M = a + b.ln (F.Z(t)) + c.ln (PM/PF)

	a	b	c	SER	$\bar{R}^2$	DW
FR of Germany	−5,869 (0,115)	1,134 (0,013)	−0,083 (0,053)	3,5	99,0	0,43
France	−7,759 (0,103)	1,360 (0,012)	−0,107 (0,073)	3,4	99,5	0,37
United Kingdom	−4,567 (0,280)	0,993 (0,020)	0,013 (0,052)	4,1	97,1	0,95
United States	−9,925 (0,222)	1,483 (0,026)	−0,286 (0,037)	4,3	98,7	1,24

For notes, see Table 2.

Table 4

Intra-EUR 10 import shares in the value of total imports of goods, 1965-84

(%)

	1965	1974	1980	1984
FR of Germany	49,6	50,6	49,8	48,7
France	49,1	51,3	51,7	56,9
United Kingdom	24,1	31,7	40,8	44,1
EUR 10	45,6	48,6	50,2	51,4

The import volume share in final demand (corrected for trend) and the degree of capacity utilization have been plotted in Graphs 7 to 10. For all four countries the movements in the latter are smoother than for the former. Nevertheless the variations between the two variables move approximately together, except perhaps for the earlier periods in France and the United States.

Table 5 presents the estimation results of equation (25). The effect of the degree of capacity utilization is positive and highly significant in three cases, and ranges from 0,25% in France to 0,48% for the United Kingdom. Compared to Table 3, the volume elasticities b hardly change. The same holds for the elasticities of substitution except for Germany, which has not the expected sign, although the coefficient is not significantly different from zero in both cases, as for France and the United Kingdom. In terms of estimated standard errors there is an improvement in the goodness of fit of between 5 and 15%. The Durbin-Watson statistics also improve slightly, except for France.

3.2.3. Dynamics

A final step is to introduce dynamics in the equations. As was argued above, it is proposed to do this via a distributed lag on the relative price variable, which leads to the general type of equation (9). This could be expected to improve the significance of the substitution elasticities and to remove — at least partially — the autocorrelation which is still present in equation (5). More specifically, a Koyck distributed lag is introduced for the distributed lag function c(L) in (9). This leads to the specification (10). Results for the estimation of this equation are given in Table 6. It is evident that the introduction of the Koyck lag hardly changes the final demand elasticities b and the quasi-elasticities d for the degree of capacity utilization, in the latter case with the exception of France, where the coefficient d was already unstable. The picture for the elasticities of substitution, although they now all have the theoretically expected sign, is hardly changed: only the elasticity for France increases markedly, but is significant at 11% only. Except for the United States, therefore, the elasticities of substitution still pose a problem. Compared to Table 5, the introduction of dynamics improves the goodness of fit considerably in terms

Table 5

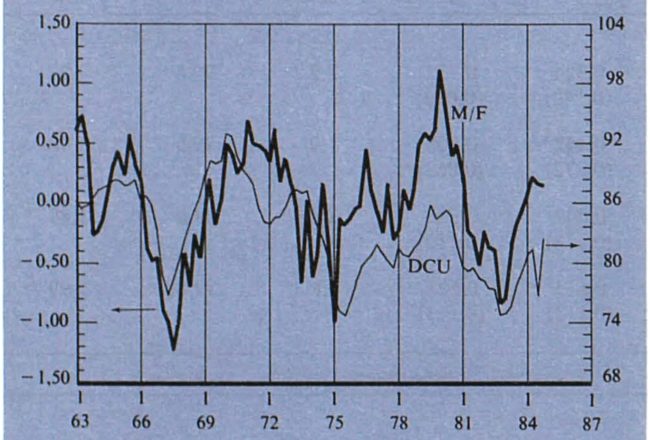
Static import equation extended with degree of capacity utilization

ln M = a + b.ln (F.Z(t)) + c.ln (PM/PF) + d.DCU

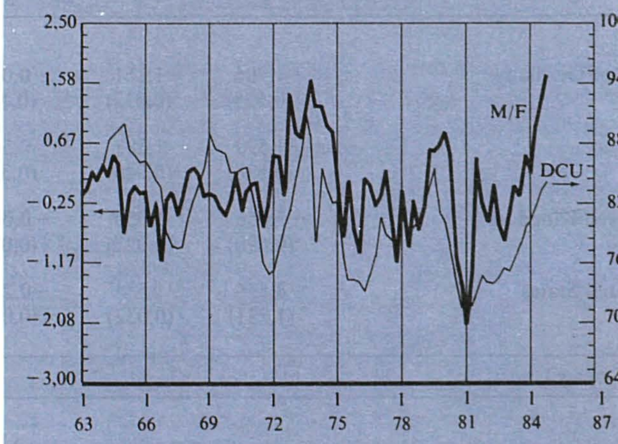
	a	b	c	d	SER	$\bar{R}^2$	DW
FR of Germany	−6,516 (0,177)	1,167 (0,014)	0,009 (0,051)	0,435 (0,097)	3,1	99,2	0,55
France	−8,014 (0,210)	1,366 (0,013)	−0,082 (0,075)	0,245 (0,177)	3,3	99,5	0,37
United Kingdom	−5,663 (0,320)	1,044 (0,020)	−0,024 (0,045)	0,483 (0,092)	3,5	97,9	1,28
United States	−10,710 (0,261)	1,533 (0,026)	−0,281 (0,033)	0,432 (0,093)	3,8	98,9	1,55

For notes, see Table 2.

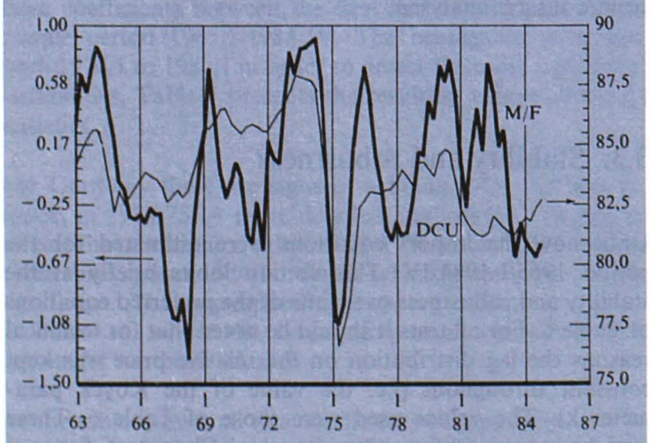
Graph 7: **Detrended import volume share in final demand (M/F) and degree of capacity utilization, Germany, 1963-84**



Graph 9: **Detrended import volume share in final demand (M/F) and degree of capacity utilization, United Kingdom, 1963-84**



Graph 8: **Detrended import volume share in final demand (M/F) and degree of capacity utilization, France, 1963-84**



Graph 10: **Detrended import volume share in final demand (M/F) and degree of capacity utilization, United States, 1963-84**

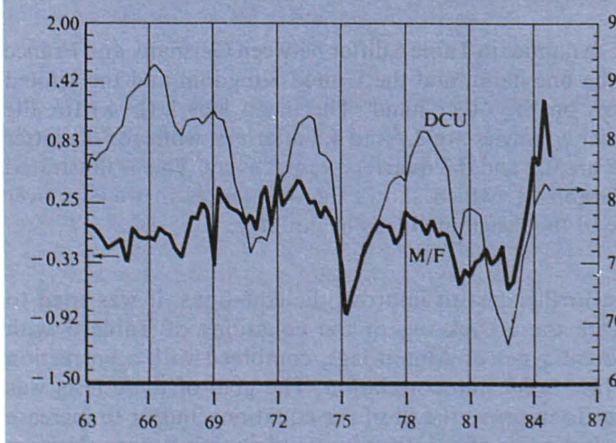


Table 6

Dynamic import equation with Koyck lag on the relative price

$\ln M = a + k.\ln M_{-1} + b.(\ln(F.Z(t)) - k.\ln(F_{-1}.Z(t-1))) + c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})$

	a	b	c	d	k	SER	$\bar{R}^2$	DW
FR of Germany	−1,706 (0,525)	1,161 (0,032)	−0,032 (0,126)	0,324 (0,140)	0,732 (0,080)	2,2	99,6	2,27
France	−1,599 (0,538)	1,383 (0,040)	−0,506 (0,313)	0,442 (0,272)	0,808 (0,063)	1,9	99,9	1,78
United Kingdom	−3,856 (0,690)	1,050 (0,027)	−0,040 (0,064)	0,449 (0,118)	0,325 (0,112)	3,3	98,0	1,89
United States	−8,526 (1,231)	1,534 (0,032)	−0,283 (0,041)	0,413 (0,113)	0,203 (0,113)	3,8	99,0	1,99

For notes, see Table 2.

of the estimated standard errors of the equation, notably for Germany and France whose standard errors are reduced by 35 and 45%, respectively. Furthermore the positive autocorrelation seems to have been generally removed, as far as can be judged from the Durbin-Watson statistics.

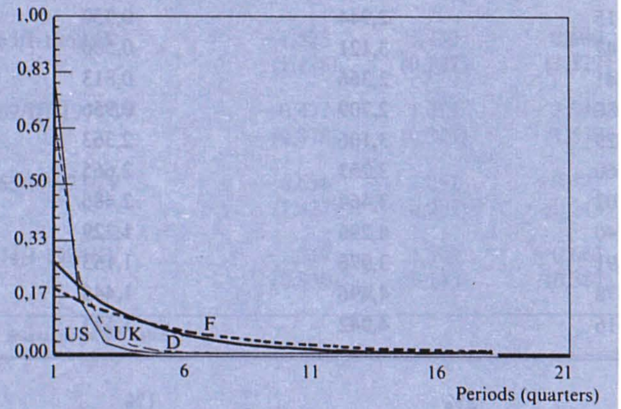
The dynamics in Table 6 differ between Germany and France on the one hand, and the United Kingdom and the United States on the other hand. The mean lags $k/(1-k)$ for the former countries are 2,7 and 4,2 quarters, while for the latter they are 0,5 and 0,3 quarters, respectively. This is illustrated in Graph 11, which shows the differences in weights over time of the distributed lags by country.

As a further test to improve the equations, it was tried to replace the Koyck lag in the equations of Table 6 with different types of Almon lags, combined with a correction for first-order autocorrelation. The goal of these tests was either to improve the fit of the equations and/or to increase the elasticities of substitution or their significance. Neither of these criteria could be enhanced in this way, however. In the absence of further tests, the estimation results of Table 6 therefore seem to have to be preferred, as long as the restrictions are respected that the equation should be estimated over the complete 1965-84 period, and that the dependent variable and its deflator concern imports of goods including energy/oil. Below the consequences of relaxing these two conditions are analysed.

3.3. Stability and robustness

Until now the import equations were estimated for the period 1965/I-1984/IV. This section looks briefly at the stability and robustness over time of the preferred equations of Table 6. For all tests it should be noted that for technical reasons the lag distribution on the relative price was kept constant throughout (i.e. the value of the Koyck parameter k). The values used were those of Table 6. Three tests have been performed: a 'moving' Chow test, forward recursive regressions and backward recursive regressions. They are discussed consecutively.

Graph 11: **Weights of distributed Koyck lags for estimations of Table 9**



3.3.1. 'Moving' Chow test

The Chow test is used to test the stability of all four coefficients that are not fixed (i.e. a, b, c, and d from Table 6). Each time it is tested whether there is a significant break for these coefficients between the first and second part of the sample period 1965/I-1984/IV. The breakpoint is moved from 1970/I to 1980/I in order to detect the most significant instabilities. Table 7 presents the resulting values of the F-statistics.

For Germany there are signs of a break after the first oil shock, in 1974-75. A more detailed analysis for this period reveals that the highest value of the F-Statistic, 5,239, occurs at the breakpoint 1974/I-1974/II, which is therefore highly significant. The corresponding two regressions are given in Table 11, where the assumption of a constant Koyck parameter has been relaxed.

As the table shows, all five coefficients change considerably between the two sub-periods. The change in the volume elasticity b may be ascribed to the fact that the trend growth of the trade integration variable Z(t) is much stronger before than after the oil shock (cf. equation (22)). The substitution elasticities become significant for both periods since the jump in the relative price for all imports due to the first oil shock (cf. Graph 2) is incorporated through the division in two sub-periods.[5] For instance, if the observation 1974/II would be included in the first estimation of Table 8, the coefficient changes from $-0{,}678$ to $-0{,}420$. The quasi elasticity on capacity utilization, on the other hand, becomes insignificant for the most recent period.

For France there are at first sight no breaks around the first oil shock period. Rather the breaks seem to be located in the beginning of the 1970s. A more detailed look at the test results reveals a break in 1969/II-III with a corresponding value for the F-Statistic of 5,779, which is highly significant. As a next step, Chow tests were performed allowing for the possibility of two breaks, the first of which was in 1969/II-III. This does indeed show a second highly significant break located in 1973/IV-1974/I. Table 9 gives the estimation results for the three sub-periods corresponding to the two breakpoints, whereas the estimation over the period 1965/I-1973/IV has also been included for comparison. The equations for the two sub-periods before the first oil shock show rather unstable behaviour, therefore it is perhaps better to compare the equation for this complete period with the one for 1974/I-1984/IV. Doing so, a slight, insignificant, increase in the volume elasticity, from 1,1 to 1,3 may be noticed. The substitution elasticity increases between the two periods and is significant at 10% only for the second equation. As for Germany, there seems to be a relationship between jumps in the relative price (cf. Graph 3) and the occurrence of a break. The quasi-elasticity on the degree of capacity utilization decreases from 3,2 to 0,6 between the two periods, although this is not necessarily expected on the basis of Graph 8. Finally the value of the Koyck parameter also increases considerably, implying that imports react more slowly to changes in the economic environment.

The 'moving' Chow tests for the United Kingdom give indication of breaks over the complete 1970-80 decade. Closer scrutiny reveals a maximum value for the F-Statistic at the 1979/I-1979/II breakpoint. Not surprisingly, this breakpoint occurs at a time when the British North Sea oil production made significant import substitution possible. This took place independently of relative price movements (at least at that time). Estimations in Table 10, for the two sub-periods corresponding to this breakpoint, nevertheless do not improve the defaults which were to be noted for the estimations over the complete sample period. Notably the elasticity of substitution is not improved and becomes highly positive, although still not significantly different from zero. Therefore, whereas for the previous two countries a decomposition into 'stable' sub-periods was sufficient to obtain satisfactory estimation results this is certainly not

Table 7

F-statistics from moving Chow tests (with fixed lag distribution)

Break starting in	FR of Germany F(4,72)	France F(4,72)	United Kingdom F(4,72)	United States F(4,72)
1970/I	1,113	2,515	2,944	0,350
1971/I	1,711	1,947	3,121	0,506
1972/I	1,938	0,141	2,366	0,813
1973/I	1,916	0,080	2,709	0,956
1974/I	2,446	0,329	3,106	2,363
1975/I	3,635	0,560	3,253	2,665
1976/I	0,940	0,702	3,464	2,486
1977/I	0,983	0,740	4,296	1,229
1978/I	1,136	0,391	3,976	1,153
1979/I	1,093	0,378	4,496	1,445
1980/I	0,881	0,316	4,042	1,524

Critical levels:	10%	5%	1%
F(4,72)	2,03	2,50	3,60

Table 8

Import equations for Germany before and after 1974/I-1974/II

$$\ln M = a + k.\ln M_{-1} + b.(\ln(F.Z(t)) - k.\ln(F_{-1}.Z(t-1))) + c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})$$

Germany	a	b	c	d	k	SER	$\bar{R}^2$	DW
1965/I-1974/I	−2,740 (0,794)	0,823 (0,066)	−0,678 (0,155)	0,937 (0,137)	0,328 (0,148)	2,0	99,4	1,97
1974/II-1984/IV	−2,308 (0,732)	1,201 (0,082)	−0,463 (0,187)	0,155 (0,172)	0,650 (0,096)	1,7	98,3	2,26

For general notes, see Table 2.

Table 9

Import equations for France with breakpoints at 1969/II-1969/III and 1973/IV-1974/I

$\ln M = a + k.\ln M_{-1} + b.(\ln(F.Z(t)) - k.\ln(F_{-1}.Z(t-1))) + c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})$

France	a	b	c	d	k	SER	$\bar{R}^2$	DW
1965/I-1969/II	−1,525 (1,178)	1,730 (0,127)	−0,600 (1,529)	1,619 (0,961)	0,873 (0,096)	1,7	98,9	1,59
1969/III-1973/IV	−0,477 (0,878)	1,073 (0,325)	−2,348 (1,539)	−3,735 (1,761)	0,790 (0,095)	1,6	99,1	2,58
1965/I-1973/IV	−6,636 (1,427)	1,051 (0,057)	−0,373 (0,149)	3,202 (0,699)	0,171 (0,161)	2,2	99,5	2,00
1974/I-1984/IV	−1,757 (0,930)	1,303 (0,143)	−0,663 (0,387)	0,617 (0,261)	0,774 (0,094)	1,5	99,3	1,78

For general notes, see Table 2.

Table 10

Import equations for the United Kingdom before and after 1979/I-1979/II

$\ln M = a + k.\ln M_{-1} + b.(\ln(F.Z(t)) - k.\ln(F_{-1}.Z(t-1)) + c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})$

United Kingdom	a	b	c	d	k	SER	$\bar{R}^2$	DW
1965/I-1979/I	−4,145 (0,744)	0,996 (0,029)	−0,021 (0,056)	0,219 (0,110)	0,133 (0,138)	3,0	97,8	1,90
1979/II-1984/IV	−11,204 (3,798)	1,615 (0,290)	0,783 (0,413)	0,124 (0,475)	0,164 (0,208)	3,0	90,2	1,70

For general notes, see Table 2.

Table 11

Import equations for the United States before and after 1974/I-1974/II

$\ln M = a + k.\ln M_{-1} + b.(\ln (F.Z(t)) - k.\ln(F_{-1}.Z(t))) + c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})$

United States	a	b	c	d	k	SER	$\bar{R}^2$	DW
1965/I-1974/I	−11,747 (1,781)	1,439 (0,040)	−0,353 (0,108)	0,110 (0,172)	−0,216 (0,175)	4,0	97,6	2,03
1974/II-1984/IV	−6,492 (1,477)	1,498 (0,061)	−0,417 (0,090)	0,637 (0,139)	0,382 (0,135)	2,9	98,2	2,10

For general notes, see Table 2.

the case for the United Kingdom. From the preliminary evidence it is clear that an allowance has to be made for United Kingdom oil production other than the mere division of the sample period into sub-periods. This point will be treated in the next section.

The last country for which the results of the Chow tests are analysed is the United States. This was the only country for which all coefficients were in the expected intervals and significant in Table 6. The maximum value of the F-Statistic (3,078) which is found after detailed inspection of the Chow test results is for a break at 1974/I-1974/II and is only significant at 5%. As may be seen from Table 11 where the two corresponding estimations are presented, this is probably due to the fact that the estimates for the volume elasticity and the substitution elasticity remain relatively stable between the two periods, while the quasi-elasticity on the degree of capacity utilization strongly increases and becomes significant. A similar phenomenon appears for the Koyck parameter k which becomes significantly positive after having been (insignificantly) negative for the pre-1974 era. From Graph 10 it was already clear that there was little correlation between the detrended import volume share and the degree of capacity utilization before 1974, so the estimation for the second sub-period presents a welcome improvement in this respect.

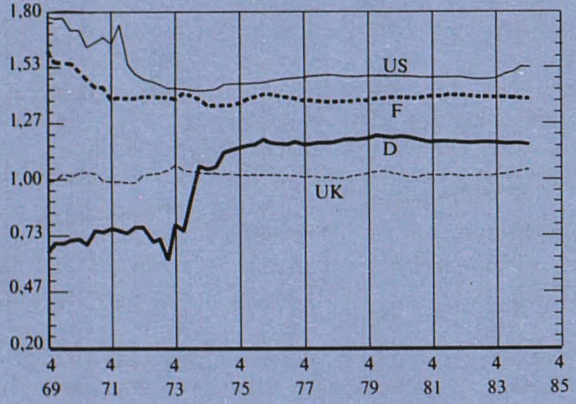
3.3.2. Forward and backward recursive regressions

As a second and third test for the stability over time of the estimated coefficients forward and backward recursive regressions have been performed. The method consists of starting with an estimation for the first (last) 20 observations and then adding each time one observation until the end (beginning) of the sample period is reached. In this way it may be detected whether additional observations change the coefficients abruptly. If so, this might be an indication of a break, at least if the change is persistent (otherwise it could be a sign of lack of robustness). Given the difficulties in interpretation due to the fact that the degrees of freedom corresponding to the different individual regressions are not equal, and due to the fact that it is difficult to distinguish breaks from signs of lack of robustness, the recursive regressions have mainly been used to verify the conclusions drawn on the basis of the moving Chow tests. The resulting values for the final demand elasticity, substitution elasticity and quasi-elasticity on the degree of capacity utilization are presented in Graphs 12 to 14 for the forward regressions and Graphs 15 to 17 for the backward regressions.[6]

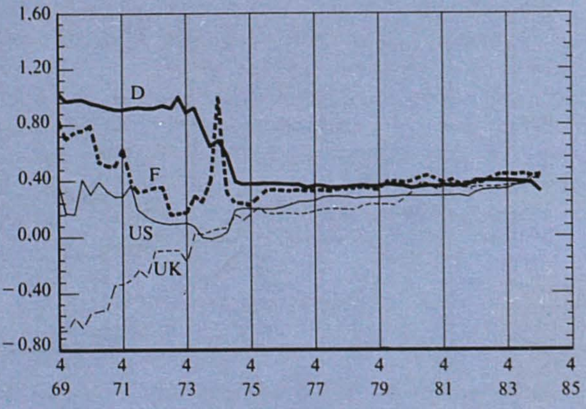
For Germany the forward recursive regressions show a clear jump in the first quarters of 1974 for all three elasticities. The backward regressions show that the split made in 1974/I-II in Table 11 is justified: the coefficient values for the second equation there are found to be robust from the backward regressions (note that the estimates themselves appear in Graphs 15 to 17 at observation 1974/II). The evidence to draw from the forward and backward recursive regressions is therefore in accordance with the two-period split of Table 11 before and after the first oil shock.

For France, the two breakpoints 1969/II-III and 1973/IV-1974/I appear clearly from the backward recursive regressions for the final demand elasticity, while the second breakpoint is also visible in the forward regressions. The same observations may be made for the elasticity of substi-

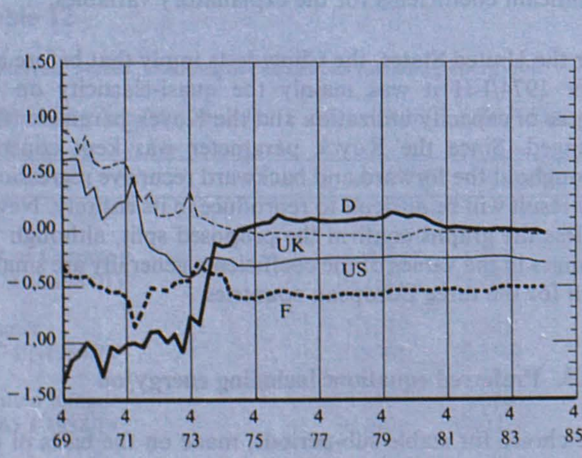
Graph 12: **Import elasticities with respect to final demand from forward recursive regressions, 1969/IV-1984/IV**



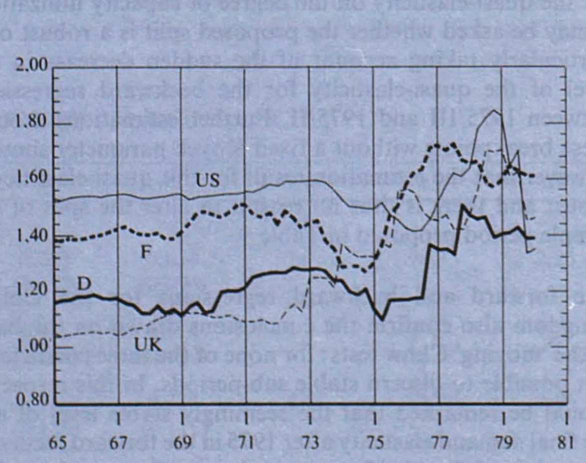
Graph 14: **Quasi-elasticities with respect to degree of capacity utilization from forward recursive regressions, 1969/IV-1984/IV**



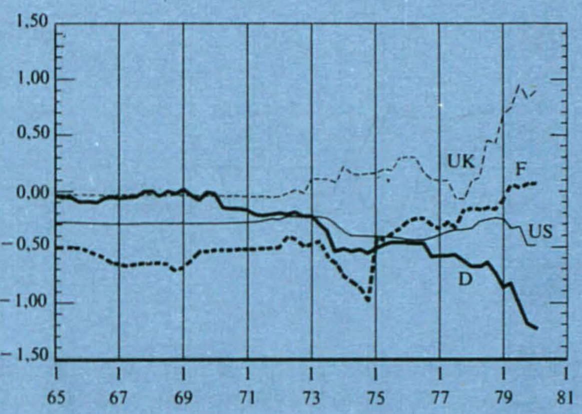
Graph 13: **Elasticities of substitution from forward recursive regressions, 1969/IV-1984/IV**



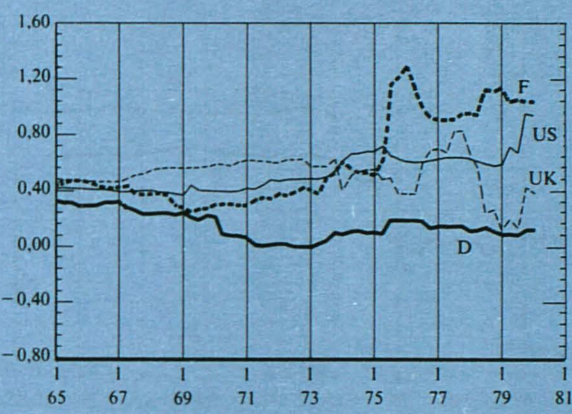
Graph 15: **Import elasticities with respect to final demand from backward recursive regressions, 1965/I-1980/I**



Graph 16: **Elasticities of substitution from backward recursive regressions, 1965/I-1980/I**



Graph 17: **Quasi-elasticities with respect to degree of capacity utilization from backward recursive regressions, 1965/I-1980/I**



tution, although the estimates corresponding to the sub-periods 1965/I-1973/IV and 1974/I-1984/IV seem less robust. A possible cause for this lack of robustness could be the large trough in the relative prices as shown in Graph 3. Also for the quasi-elasticity on the degree of capacity utilization, it may be asked whether the proposed split is a robust one, particularly taking account of the sudden decrease in the level of the quasi-elasticity for the backward regressions between 1975/III and 1975/II. Further estimations around these breakpoints without a fixed Koyck parameter showed however that the estimation result for this quasi-elastiticy is robust and there is thus no reason to alter the split of the sample period proposed in Table 9.

The forward and backward regressions for the United Kingdom also confirm the conclusions drawn on the basis of the 'moving' Chow tests: for none of the three coefficients is it possible to discern stable sub-periods. In this respect it should be remarked that the seemingly stable level of e.g. the final demand elasticity after 1975 in the forward recursive regression of Graph 12 conceals that, as the sample period extends, the influence of individual observations on the estimated coefficients decreases, such that their effects are in a sense 'damped' and will only appear as small ripples in the graph. These regression results therefore confirm our previous conclusion that, as long as energy is included in the import aggregate, it is virtually impossible to obtain a stable, robust total import equation with acceptable and significant coefficients for the explanatory variables.

For the United States, the Chow tests imply that before and after 1974/I-II it was mainly the quasi-elasticity on the degree of capacity utilization and the Koyck parameter that changed. Since the Koyck parameter was kept constant throughout the forward and backward recursive regressions, this result will be difficult to reproduce in its entirety. Nevertheless the graphs confirm the proposed split, although the changes in the values of the coefficients generally are smaller than for the three European countries.

3.3.3. Preferred equations including energy/oil

The choice for stable sub-periods, made on the basis of the 'moving' Chow tests, was confirmed by the forward and backward recursive regressions. For the purposes of the Quest model, such as forecasting and policy analysis, estimations are needed that are stable over the most recent period. These results have been gathered from Tables 6, 8, 9 and 11 in Table 12. Graphs of the corresponding actual and fitted values are provided in Graphs 18 to 21. Note that for the United Kingdom the complete sample period has been maintained, although it was clear from the stability tests that this period can hardly be called 'stable'. From the point of view of fit the equations are acceptable, except again for the United Kingdom.

There is also the question of the differences in fit between Tables 2 and 3 after the inclusion of the integration variable Z(t). Therefore it was tested whether exclusion of Z(t) in the estimations of Table 12 improved the estimated standard errors considerably. The largest improvement occurred for France, where the estimated standard errors improved from 1,5% to 1,3%, provided the equation excluding Z(t) was estimated in first differences (in levels the Koyck parameter tended to 1). It may therefore be concluded that the inclusion of Z(t) has no serious effects on the fit of the equations.

Concerning autocorrelation, it is well-know that the Durbin-Watson statistic is biased in the direction of rejecting the hypothesis of autocorrelation if the lagged dependent variable is included,[7] so the seemingly acceptable DWs do not allow for a final judgement. The significance of the coefficients is generally acceptable, except for the quasi-elasticity on the degree of capacity utilization for Germany and the substitution elasticity for the United Kingdom (the one for France is significant at 10%). In the next section it is shown how these characteristics change if energy/oil is excluded from the total import aggregate.

3.4. Excluding energy/oil from the equations

From the results above it is clear that the assumption of separability between bilateral imports and domestic inputs in the final demand production function is not always justified, notably for the United Kingdom. In this section this problem is solved by separating total imports into energy/oil imports and other imports. Before presenting the estimation results, it is first discussed whether this solution is in accordance with the assumptions concerning separability.

3.4.1. Separating energy/oil: consequences for separability assumptions

Two solutions seem possible to deal with the violation of the separability assumptions due to the inclusion of energy/oil in the total import equations. One would be to drop the assumption of separability completely, and to derive the demand for bilateral imports simultaneously with the demand for domestic production factors such as labour and capital. Total imports would then simply result as the sum

Table 12

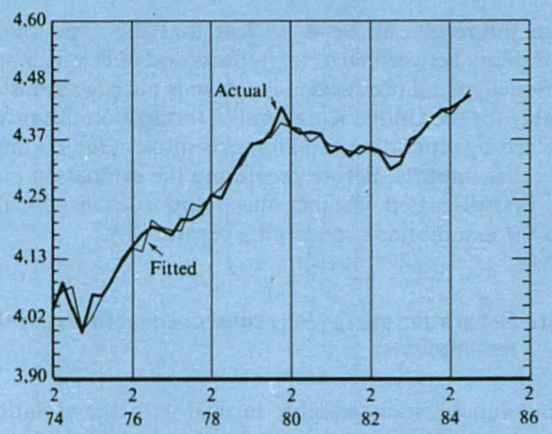
Preferred 'stable' total import equations including energy/oil

$\ln M = a + k.\ln M_{-1} + b.(\ln (F.Z(t)) - k.\ln(F_{-1}.Z(t-1))) + c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})$

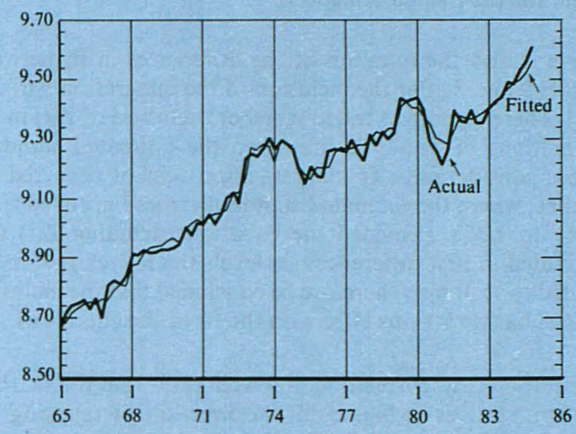
	a	b	c	d	k	SER	$\bar{R}^2$	DW
FR of Germany 1974/II-1984/IV	−2,308 (0,732)	1,201 (0,082)	−0,463 (0,187)	0,155 (0,172)	0,650 (0,096)	1,7	98,3	2,26
France 1974/I-1984/IV	−1,757 (0,930)	1,303 (0,143)	−0,663 (0,387)	0,617 (0,261)	0,774 (0,094)	1,5	99,3	1,78
United Kingdom 1965/I-1984/IV	−3,856 (0,690)	1,050 (0,027)	−0,040 (0,064)	0,449 (0,118)	0,325 (0,112)	3,3	98,0	1,89
United States 1974/II-1984/IV	−6,492 (1,477)	1,498 (0,061)	−0,417 (0,090)	0,637 (0,139)	0,382 (0,135)	2,9	98,2	2,10

For general notes, see Table 2.

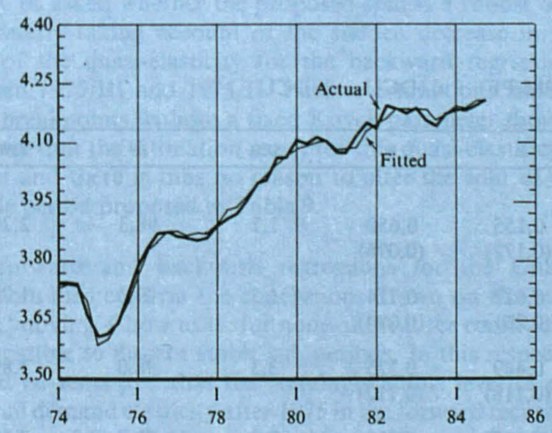
Graph 18: **Actual and fitted values for preferred import equation incl. energy/oil, Germany, 1974/II-1984/IV**



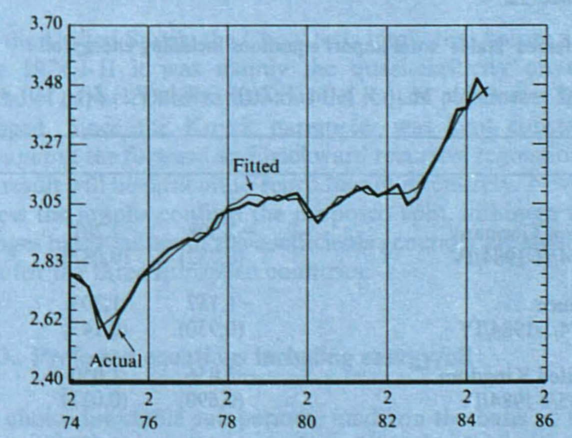
Graph 20: **Actual and fitted values for preferred import equation incl. energy/oil, United Kingdom, 1965/I-1984/IV**



Graph 19: **Actual and fitted values for preferred import equation incl. energy/oil, France, 1974/I-1984/IV**



Graph 21: **Actual and fitted values for preferred import equation incl. energy/oil, United States, 1974/II-1984/IV**



of bilateral imports. This approach would however still be based on variables in which the energy sector would be mixed with the rest of the economy. Therefore, apart from the econometric complications caused by this approach because of the simultaneous determination of the demand for domestic production factors and bilateral imports, it might be more fruitful anyway to separate the energy sector out. One could, for instance, change the separability assumptions: instead of separability between the determination of domestic inputs and imports, one could subdivide total imports into energy/oil imports and a residual category. Without necessarily having to assume separability between domestic inputs and energy/oil imports, separability could be assumed between non-energy/oil imports and the other inputs in the production function. Even though the availability of bilateral trade flows relating to total merchandise trade only would make it impossible to pursue this line of thought consistently throughout the bilateral trade flow model, it would be a first step towards the disentangling of a problem that otherwise would continue to produce unrealistic model results. For the bilateral trade flows, it would be possible for instance, to replace the import volume by the volumes of only energy/oil imports or only non-energy/oil imports when it is clear that the supplying country produces for the most part only goods belonging to one of these categories. A bilateral trade flow equation concerning a flow originating in the OPEC zone, for instance, would have energy/oil imports as volume variable, whereas this would be non-energy/oil imports for a flow originating e.g. in Japan. For countries which export both in non-negligible amounts, one could think of a variable weighting of the two import concepts, or of simply taking total imports. Although these consequences for the bilateral trade flow model have not been implemented for the estimation and simulation of the model in the next chapter, it nevertheless seems useful, as a first step, to make already the distinction between energy/oil and non-energy/oil for total imports. In doing so, attention has been focused on the effects for the total import equations if energy/oil is excluded, leaving aside the determination of energy/oil imports for the moment.[8]

3.4.2. Estimation results

Before presenting estimation results excluding energy/oil imports, it should be mentioned that the data used for energy/oil imports differ in definition between countries (cf. Box 2). For the United Kingdom and the United States the Standard International Trade Classification (SITC) category 33 (crude petroleum and petroleum products) has been used, for France the SITC-3 classification (total energy), and for Germany the category 'mining products', which is more extensive than energy alone. In Table 13, in which value and volume shares of these energy/oil concepts in total imports for 1970-84 are presented, the numbers are therefore only comparable for the United Kingdom and the United States, and for value shares only due to differences in base years. As could be expected, the strongest reduction in foreign energy dependency (in volume terms) has been achieved by the United Kingdom, but the other countries have also, for various reasons, been able to cut drastically their oil import volume.

Table 13

Value and volume shares of oil/energy in total imports of goods, 1970-84

(%)

		1970/I	1974/I	1980/I	1984/IV
FR of Germany	Value	9,7	17,5	18,6	15,8
	Volume	16,0	13,5	11,5	7,5
France	Value	12,3	19,6	25,7	24,0
	Volume	12,8	9,5	8,0	5,5
United Kingdom	Value	7,9	17,5	12,4	12,3
	Volume	26,9	25,1	13,1	9,3
United States	Value	7,8	21,3	33,6	17,9
	Volume	7,6	9,2	9,7	4,6

Note: Definitions differ by country. Germany: mining products. France: SITC 3. United Kingdom: SITC 33. United States: SITC 33. The ratios between values and volumes vary between countries because constant price calculations are made using different base years.

Table 14 presents the estimation results if energy/oil is excluded. The specification has been kept the same as for the total import equation, whose estimation results are also presented for comparison. For each country, except the United Kingdom, results are given for two samples: the largest possible sample given the data availability, and the sample of the preferred equations from Table 12. Starting from that table, four problems remained to be solved: the insignificant quasi-elasticity on the degree of capacity utilization for Germany, the significance of the elasticity of substitution and the goodness of fit for the United Kingdom, and possibly the significance of the elasticity of substitution for France. Table 14 shows that the exclusion of energy/oil indeed increases and renders significant the substitution elasticities of Table 12 for France and the United Kingdom. The quasi-elasticity on the degree of capacity for Germany and the estimated standard errors for the United Kingdom are not improved however. Moreover, for the post-1973 period in Germany, the elasticity of substitution now also becomes insignificant. Apparently, for Germany, the best

Table 14

Estimation results for the total import equation including and excluding energy/oil

$\ln M = a + k.\ln M_{-1} + b.(\ln(F.Z(t)) - k.\ln(F_{-1}.Z(t-1))) + c.(1-k).\ln(PM/PF) + d.(DCU - k.DCU_{-1})$

		a	b	c	d	k	SER	$\bar{R}^2$	DW
FR of Germany	T	−1,706	1,161	−0,032	0,324	0,732	2,2	99,6	2,27
1965/I-1984/IV		(0,525)	(0,032)	(0,126)	(0,140)	(0,080)			
	N	−1,955	1,272	−0,014	0,274	0,737	2,6	99,5	2,26
		(0,614)	(0,068)	(0,239)	(0,162)	(0,077)			
1974/II-1984/IV	T[1]	−2,308	1,201	−0,463	0,155	0,650	1,7	98,3	2,27
		(0,732)	(0,082)	(0,187)	(0,172)	(0,096)			
	N	−2,848	1,246	−0,506	0,162	0,601	2,0	98,1	2,23
		(0,983)	(0,077)	(0,325)	(0,187)	(0,116)			
France	T	−1,599	1,383	−0,506	0,442	0,808	1,9	99,9	1,78
1965/I-1984/IV		(0,538)	(0,040)	(0,313)	(0,272)	(0,063)			
	N	−2,554	1,268	−0,662	0,721	0,672	2,0	99,9	1,87
		(0,487)	(0,053)	(0,154)	(0,235)	(0,057)			
1974/I-1984/IV	T[1]	−1,757	1,303	−0,663	0,617	0,774	1,5	99,3	1,78
		(0,930)	(0,143)	(0,387)	(0,261)	(0,094)			
	N	−2,740	1,133	−0,807	1,100	0,607	1,5	99,4	1,98
		(0,880)	(0,131)	(0,193)	(0,260)	(0,085)			
United Kingdom	T	−4,889	1,107	−0,039	0,596	0,262	3,3	94,7	1,92
1970/II-1984/IV		(1,003)	(0,047)	(0,059)	(0,123)	(0,134)			
	N	−13,348	1,579	−0,269	0,390	0,337	3,4	97,6	1,94
		(2,558)	(0,061)	(0,075)	(0,147)	(0,126)			
United States	T[1]	−8,088	1,549	−0,294	0,383	0,252	3,9	98,4	2,06
1967/II-1984/IV		(1,316)	(0,041)	(0,047)	(0,127)	(0,120)			
	N	−8,580	1,589	−0,803	0,425	0,240	4,1	98,3	2,15
		(1,408)	(0,038)	(0,086)	(0,131)	(0,123)			
1974/II-1984/IV	T[1]	−6,492	1,498	−0,417	0,637	0,382	2,9	98,2	2,10
		(1,477)	(0,061)	(0,090)	(0,139)	(0,135)			
	N	−7,066	1,630	−0,795	0,553	0,399	3,1	98,3	2,26
		(1,670)	(0,079)	(0,184)	(0,163)	(0,138)			

T = total imports of goods, incl. energy/oil.
N = total imports of goods, excl. energy/oil.
[1] Preferred equation from Table 12.
For general notes, see Tables 2 and 13.

remedy against the instability of the total import equation is the reduction of the sample period, and not the exclusion of energy/oil, although the fact that for Germany this variable is defined as 'mining products' may bias the results. This conclusion is confirmed if the sample period is reduced somewhat more to 1975/IV-1984/IV. The elasticity of substitution and the quasi-elasticity on the degree of capacity utilization then become both significant at 10% for the total import equations, while for the non-energy/oil equation the elasticity of substitution becomes insignificant.[9]

For the other countries, the exclusion of energy/oil generally has beneficiary effects on the size and the significance of the coefficients, notably the elasticity of substitution. For France, the latter now becomes highly significant for both sample periods and increases in both cases by 15% in absolute value to 0,66 and 0,81, respectively. For the United Kingdom the exclusion of energy/oil not only increases the elasticity of substitution to a significant value of 0,27, but also the volume elasticity b, as might be expected on the basis of Table 1. The exclusion of energy/oil also has a strong effect on the elasticity of substitution for the United States, whose value for both periods now becomes equal to 0,8.

One can therefore conclude that, with the exception of Germany, the exclusion of energy/oil from the total import concept has had a positive effect on the estimation results, and in particular on the value and significance of the elasticities of substitution. Further research will have to reveal whether the fact that energy/oil was defined for Germany as 'mining products' is to blame for the as yet non-satisfactory effects of the exclusion of energy/oil on the estimation results. On the basis of the work carried out so far, the estimation results for the total import equation over the period 1975/IV-1984/IV seem to be preferable for this country.[10]

Box 3: Data for the bilateral trade flow model

Coverage

International merchandise trade flows may in general be distinguished by three characteristics: by type of goods (e.g. agricultural goods, oil, raw materials, manufactures), by the origin of the flow (the exporting country or zone) and by the destination of the flow (the importing country or zone). When expressed in monetary units, the flows may furthermore be valued as cif (i.e. including cost, insurance and freight), fob (free on board) or fas (free alongside ship). The last type of valuation is not very common. With the exception of some countries (e.g. the United States) imports are usually valued cif, and exports are usually valued fob. In theory one would therefore expect that the value of a trade flow as declared by an importing country would exceed the value of the same flow as declared by the exporter with the amount of money needed to cover cost, insurance and freight. In practice this is not the case, however, and it matters therefore whether bilateral export or import data are used.[1]

In constructing a linkage model, several choices have to be made, out of the possibilities described above, as regards the coverage of world trade. A first, natural, choice concerns the periodicity of the data. With the country models being based on quarterly data it is a logical and almost unavoidable step that the trade linkage data should also be quarterly. Secondly there is the number and type of countries and zones that will be distinguished separately as trade partners. The QUEST model covers almost completely the individual OECD countries, with additional zones for the OPEC, European CPEs, NICs and the rest of the world. This choice is consistent with the coverage and definitions used for other, related, purposes at the Directorate-General for Economic and Financial Affairs. Thirdly there is the choice of the type of goods. In a final stage, it is planned to cover more than one category of goods (e.g. SITC Categories 0-1, 2+4, 3 and 5-9), but initially the trade flow model will treat all goods as one, homogeneous group. From several points of view this is not a very satisfactory approach, but it was imposed by data availability and limited resources. As is clear from Chapter 3, notably the inclusion of energy in the trade aggregate may be a source of problems. Finally one has to choose between (fob) bilateral export data or (cif) bilateral import data. The choice made here was governed by the nature of the linkage model: in its proposed set-up, the trade flow system is a separate model with import volumes and export prices as exogenous inputs, and export volumes and import prices as main endogenous outputs (see section 4.2). With import prices defined as weighted averages of export prices (with shares in total imports as weights), one can therefore say that the trade flow model predicts export volumes and import shares. Since the level of exports has to be explained, it was chosen to use bilateral export (fob) data for the bilateral trade flows, making the implicit assumption that the fob import shares are close to import shares based on cif data. Whether this assumption is justified becomes clear if the cif import price is estimated as a function of the import price based on the fob import shares. On the other hand, there should be a conversion from cif to fob for the import volume, since it is the fob import volume which is allocated between bilateral (fob) exports.

Data sources

The data for the bilateral trade flow estimations have been derived from sources other than those for the estimations of the total import functions.[2] When the macroeconomic country models are linked to the trade flow system, some additional bridge equations (quasi-identities) are therefore required. The main reason for deriving the trade flow data from other sources was to have a consistent and complete data set right from the start of the QUEST project, which could not be guaranteed otherwise. This data base consists of the following quarterly, seasonally adjusted, variables for each of the 25 countries/zones from Box 1:

cif imports in current US dollars (MV_j);
cif import unit value indices, average 1980 = 100 (PM_j);
fob exports in current US dollars (XV_i);
export unit value indices, average 1980 = 100 (PX_i);

in addition there are:

605 bilateral trade flows (fob exports) in current US dollars between the 25 countries and zones (25 × 25 minus the intra-trade of the 20 individual countries, which is zero) ($XV_{ij} = XX_{ij}$)

From these basic data it is possible to construct imports and exports in constant prices (M_j, X_i), quasi-fob imports ($MZV_j = \Sigma_i XV_{ij}$), quasi-fob import prices (PMZ_j) and the competitors' price indices (PXC_i).

The basic data set was mainly constructed using data from the International Monetary Fund (IMF) and the United Nations (UN). As far as data were not interpolated from annual data they were seasonally adjusted using the Dainties method of the Statistical Office of the European Communities. For total imports and exports in value and their unit values, the main source is the International Financial Statistics (IFS) tape of the IMF. The data for the CPE zone are mostly interpolated annual data (except for the CPE countries which are IMF members) from the *Yearbook of International Trade Statistics* or the *Monthly Bulletin of Statistics* of the UN. For the current values, the data for the rest of the world zone were obtained as a residual with respect to the world total from the same UN sources. The corresponding unit value indices are an aggregate from IFS zone indices.

The main source for the bilateral export data is the Direction of Trade (DOT) tape of the IMF. The trade flows within and between the OPEC and CPE zones are interpolations from annual data obtained from the abovementioned UN sources. Bilateral exports with as destination the rest of the world zone (column RW in Table 15) were calculated as a residual with respect to total exports. Each bilateral flow originating in the rest of the world zone (row RW in Table 15) has been calculated such that the share of this flow in the total of other bilateral exports with the same destination (the sum of the first 24 elements in each column of Table 15) was the same as the corresponding share based on (cif) bilateral import data. It is possible to calculate the latter share since for import data one may calculate the residual with respect to total cif imports in the same way as for exports. Another solution would have been to apply a fob/cif ratio to cif imports to obtain fob imports, and then to calculate flows originating in the rest of the world zone as a residual with respect to this total. Due to differences between bilateral fob and cif data which may be large, this leads in practice to some negative flows.[3] The present solution, though far from perfect, avoids this problem and concentrates the most important statistical discrepancies in the intra trade of the rest of the world zone, which consequently becomes negative. This is not unrealistic, however, since it is well known that the 'world trade balance' in practice is far from zero.[4] The result of this procedure is that the sum of all bilateral exports flowing into one country or zone are only 'quasi-fob', and not necessarily equal to cif imports multiplied by a fob/cif ratio.

As an illustration of the orders of magnitude, Table 15 gives the 1984 world trade matrix, based on fob export data and expressed in millions of US dollars. Table 16 presents the same bilateral trade flows, but now expressed as a percentage of the value of 1984 world exports. Table 17, finally, gives the changes in these shares for 1984 compared to 1965, and therefore shows the changes in the structure of world trade over a period of 20 years.

The following Tables 15, 16 and 17 belong to Box 3.

Table 15

Bilateral export flows (fob) between 25 countries/zones, millions of US dollars, 1984

Importers

Exporters	B/L	DK	D	GR	E	F	IRL	I	NL	P	UK	US	CA
B/L	0,0	472,6	10 235,5	256,9	451,2	9 551,1	194,2	2 662,5	7 218,8	176,7	5 133,7	3 138,9	293,5
DK	271,1	0,0	2 564,5	106,0	142,3	708,6	88,3	623,5	531,5	38,0	2 053,0	1 558,8	148,4
D	11 999,9	3 529,3	0,0	1 743,4	3 099,9	21 579,0	744,1	13 262,9	14 814,7	774,1	14 261,3	16 421,1	1 519,0
GR	84,7	33,4	945,5	0,0	29,0	405,8	11,4	660,5	162,8	14,6	298,3	404,0	28,2
E	598,2	153,1	2 260,1	139,9	0,0	3 537,6	92,7	1 406,0	1 240,3	560,4	2 136,8	2 252,2	228,9
F	8 014,8	717,7	13 726,5	807,3	3 054,4	0,0	435,3	10 170,8	4 442,5	654,3	7 389,0	7 535,6	990,0
IRL	415,1	73,1	977,5	41,4	116,8	807,4	0,0	301,3	676,3	24,2	3 322,7	937,9	162,6
I	2 125,4	555,4	11 824,0	1 260,4	1 154,1	10 291,2	194,6	0,0	2 107,5	361,0	4 943,7	7 946,9	804,0
NL	9 094,8	967,4	19 567,3	595,3	638,2	6 857,2	315,1	3 660,6	0,0	299,5	6 238,2	3 314,7	339,1
P	171,5	83,4	709,4	16,0	229,3	647,6	25,9	221,2	306,9	0,0	796,6	452,8	44,4
UK	4 072,2	1 590,7	9 874,0	469,3	1 756,2	9 394,8	4 525,5	3 815,2	8 182,7	515,1	0,0	13 702,4	1 573,0
US	5 301,1	605,2	9 083,9	456,0	2 561,3	6 036,7	1 354,7	4 374,8	7 554,4	960,6	12 209,6	0,0	46 524,2
CA	543,1	76,2	977,0	38,4	74,8	575,9	76,7	450,3	826,5	49,2	1 941,2	66 300,1	0,0
JA	1 346,8	933,2	6 608,2	790,5	642,5	1 933,1	247,5	1 030,7	1 811,8	153,9	4 664,8	60 429,1	4 286,4
AU	163,2	32,2	718,6	28,6	104,1	519,8	2,8	438,1	404,2	23,3	889,2	2 645,8	262,4
AT	286,3	165,8	4 676,2	91,5	236,8	609,3	31,8	1 480,5	389,5	37,7	688,4	647,4	126,4
FI	199,2	550,2	1 296,0	75,3	98,8	533,2	75,7	285,8	478,1	28,5	1 613,2	1 091,6	113,4
NO	170,3	669,1	3 126,0	38,7	64,8	638,0	29,4	292,7	1 377,0	77,3	6 892,9	968,8	108,1
SE	1 087,3	2 438,0	3 403,9	110,9	335,2	1 475,0	184,7	1 051,4	1 313,6	91,3	3 004,3	3 341,5	383,7
SW	626,9	311,3	5 054,7	160,9	506,5	2 140,0	73,2	1 900,8	686,0	158,6	2 070,7	2 542,1	235,8
RO	266,3	49,3	1 477,5	133,9	81,3	347,5	11,1	617,3	249,6	57,2	908,1	1 326,0	109,3
OP	2 134,1	479,8	8 763,1	1 624,3	6 311,4	10 814,9	26,6	12 129,1	5 645,6	1 326,9	2 973,4	24 642,9	1 641,8
CP	2 039,4	741,6	10 105,0	720,2	813,2	3 472,9	130,2	5 535,8	2 644,9	89,4	2 145,2	2 146,8	207,4
NI	1 888,1	627,5	7 440,1	697,1	1 168,4	3 218,8	236,5	3 948,8	5 185,8	357,4	5 915,8	48 550,5	3 273,4
RW	2 962,0	659,0	7 723,9	358,3	3 801,3	8 557,4	285,3	5 511,8	4 220,1	682,6	6 381,6	44 519,8	4 682,0
World	55 862,0	16 514,5	143 138,1	10 760,4	27 471,9	104 652,4	9 393,4	75 832,4	72 471,4	7 511,9	98 871,4	316 817,1	68 085,3

Exporters	JA	AU	AT	FI	NO	SE	SW	RO	OP	CP	NI	RW	World
B/L	429,8	159,9	435,7	217,2	354,0	711,6	1 396,5	256,6	1 911,3	938,1	1 673,0	3 621,7	51 891,0
DK	453,6	110,3	130,0	312,2	1 019,1	1 811,2	297,2	136,5	755,8	295,5	507,9	1 303,1	15 966,4
D	2 432,0	1 291,9	8 565,5	1 669,6	1 922,4	4 561,3	9 112,0	1 519,9	9 843,7	9 349,2	9 913,9	12 254,1	176 189,9
GR	56,1	27,8	47,8	16,9	4,1	30,8	40,0	55,4	571,0	286,7	101,0	495,4	4 811,2
E	369,1	95,6	106,3	83,7	99,7	210,9	413,3	332,6	2 150,1	583,1	677,1	3 833,3	23 560,7
F	1 028,9	434,8	694,8	376,2	721,0	1 227,6	3 632,1	341,6	9 078,2	2 983,0	3 448,4	15 661,3	97 565,9
IRL	164,8	116,4	52,6	49,5	87,0	147,2	108,2	23,0	357,7	48,6	149,1	481,1	9 641,5
I	840,8	636,1	1 656,4	345,9	355,6	767,5	2 980,8	758,5	8 616,6	2 487,2	3 556,7	6 743,8	73 314,0
NL	381,8	287,0	574,2	371,8	538,1	1 165,4	1 037,5	389,9	2 566,9	844,6	1 664,2	3 968,2	65 677,0
P	47,8	20,7	52,8	72,3	86,3	184,1	125,3	45,6	131,4	83,1	101,3	523,5	5 179,1
UK	1 239,2	1 578,0	427,2	904,8	1 295,2	3 857,3	2 085,0	1 009,3	6 722,2	1 740,9	5 417,7	8 024,3	93 772,0
US	23 574,9	4 792,5	374,9	349,8	859,4	1 542,1	2 562,5	2 007,9	14 385,4	4 187,7	29 033,1	37 197,6	217 889,9
CA	4 393,9	504,1	36,7	90,8	253,0	133,0	190,8	285,1	1 530,8	1 855,5	2 310,6	6 777,6	90 290,9
JA	0,0	5 173,2	421,8	503,6	496,1	1 008,2	1 087,5	1 492,2	15 838,9	3 000,8	30 905,9	24 893,6	169 699,9
AU	6 150,0	0,0	10,7	15,5	9,2	37,8	42,4	1 448,8	1 602,1	840,0	3 766,7	3 618,1	23 773,5
AT	164,2	63,4	0,0	130,3	139,6	297,8	1 087,4	130,9	1 004,6	1 910,2	695,1	648,2	15 739,3
FI	172,7	139,9	99,0	0,0	612,7	1 653,3	167,6	55,6	421,2	2 801,4	366,4	542,6	13 471,5
NO	267,3	44,5	81,6	273,7	0,0	1 868,3	130,7	74,9	136,9	163,2	596,3	824,6	18 915,1
SE	422,8	337,9	338,6	1 687,3	2 703,8	0,0	482,0	201,0	1 494,0	750,1	1 149,9	1 590,9	29 379,1
SW	850,1	229,9	1 006,5	203,3	210,2	514,9	0,0	230,2	1 827,8	762,0	1 920,1	1 625,9	25 849,0
RO	881,8	839,1	133,3	22,8	15,8	53,8	397,5	6,7	2 932,4	422,6	495,5	1 560,3	13 396,1
OP	37 831,0	1 477,4	842,1	195,2	94,7	324,3	847,7	3 618,7	5 538,0	3 068,0	22 314,0	24 355,4	179 020,1
CP	1 636,6	87,4	2 159,6	2 972,8	452,7	1 372,5	869,9	910,7	6 693,0	91 647,0	4 523,4	31 347,7	175 465,1
NI	14 414,2	2 676,6	687,6	251,3	705,0	911,3	2 245,6	717,1	10 036,6	8 235,4	18 166,9	51 731,8	193 287,1
RW	20 079,2	1 221,3	499,4	329,8	342,6	739,9	987,5	681,1	11 872,3	19 045,8	38 622,7	−57 565,6	127 201,0
World	118 282,3	22 345,6	19 435,1	11 446,2	13 377,4	25 132,0	32 327,1	16 729,7	118 018,6	158 329,4	182 076,6	186 058,1	1 910 937,0

Table 16

Shares of bilateral export flows (fob) in the value of 1984 world exports (× 10 000)

Importers

Exporters	B/L	DK	D	GR	E	F	IRL	I	NL	P	UK	US	CA
B/L	0,0	2,5	53,6	1,3	2,4	50,0	1,0	13,9	37,8	0,9	26,9	16,4	1,5
DK	1,4	0,0	13,4	0,6	0,7	3,7	0,5	3,3	2,8	0,2	10,7	8,2	0,8
D	62,8	18,5	0,0	9,1	16,2	112,9	3,9	69,4	77,5	4,1	74,6	85,9	7,9
GR	0,4	0,2	4,9	0,0	0,2	2,1	0,1	3,5	0,9	0,1	1,6	2,1	0,1
E	3,1	0,8	11,8	0,7	0,0	18,5	0,5	7,4	6,5	2,9	11,2	11,8	1,2
F	41,9	3,8	71,8	4,2	16,0	0,0	2,3	53,2	23,2	3,4	38,7	39,4	5,2
IRL	2,2	0,4	5,1	0,2	0,6	4,2	0,0	1,6	3,5	0,1	17,4	4,9	0,9
I	11,1	2,9	61,9	6,6	6,0	53,9	1,0	0,0	11,0	1,9	25,9	41,6	4,2
NL	47,6	5,1	102,4	3,1	3,3	35,9	1,6	19,2	0,0	1,6	32,6	17,3	1,8
P	0,9	0,4	3,7	0,1	1,2	3,4	0,1	1,2	1,6	0,0	4,2	2,4	0,2
UK	21,3	8,3	51,7	2,5	9,2	49,2	23,7	20,0	42,8	2,7	0,0	71,7	8,2
US	27,7	3,2	47,5	2,4	13,4	31,6	7,1	22,9	39,5	5,0	63,9	0,0	243,5
CA	2,8	0,4	5,1	0,2	0,4	3,0	0,4	2,4	4,3	0,3	10,2	347,0	0,0
JA	7,0	4,9	34,6	4,1	3,4	10,1	1,3	5,4	9,5	0,8	24,4	316,2	22,4
AU	0,9	0,2	3,8	0,1	0,5	2,7	0,0	2,3	2,1	0,1	4,7	13,8	1,4
AT	1,5	0,9	24,5	0,5	1,2	3,2	0,2	7,7	2,0	0,2	3,6	3,4	0,7
FI	1,0	2,9	6,8	0,4	0,5	2,8	0,4	1,5	2,5	0,1	8,4	5,7	0,6
NO	0,9	3,5	16,4	0,2	0,3	3,3	0,2	1,5	7,2	0,4	36,1	5,1	0,6
SE	5,7	12,8	17,8	0,6	1,8	7,7	1,0	5,5	6,9	0,5	15,7	17,5	2,0
SW	3,3	1,6	26,5	0,8	2,7	11,2	0,4	9,9	3,6	0,8	10,8	13,3	1,2
RO	1,4	0,3	7,7	0,7	0,4	1,8	0,1	3,2	1,3	0,3	4,8	6,9	0,6
OP	11,2	2,5	45,9	8,5	33,0	56,6	0,1	63,5	29,5	6,9	15,6	129,0	8,6
CP	10,7	3,9	52,9	3,8	4,3	18,2	0,7	29,0	13,8	0,5	11,2	11,2	1,1
NI	9,9	3,3	38,9	3,6	6,1	16,8	1,2	20,7	27,1	1,9	31,0	254,1	17,1
RW	15,5	3,4	40,4	1,9	19,9	44,8	1,5	28,8	22,1	3,6	33,4	233,0	24,5
World	292,3	86,4	749,0	56,3	143,8	547,6	49,2	396,8	379,2	39,3	517,4	1 657,9	356,3

Exporters	JA	AU	AT	FI	NO	SE	SW	RO	OP	CP	NI	RW	World
B/L	2,2	0,8	2,3	1,1	1,9	3,7	7,3	1,3	10,0	4,9	8,8	19,0	271,5
DK	2,4	0,6	0,7	1,6	5,3	9,5	1,6	0,7	4,0	1,5	2,7	6,8	83,6
D	12,7	6,8	44,8	8,7	10,1	23,9	47,7	8,0	51,5	48,9	51,9	64,1	922,0
GR	0,3	0,1	0,3	0,1	0,0	0,2	0,2	0,3	3,0	1,5	0,5	2,6	25,2
E	1,9	0,5	0,6	0,4	0,5	1,1	2,2	1,7	11,3	3,1	3,5	20,1	123,3
F	5,4	2,3	3,6	2,0	3,8	6,4	19,0	1,8	47,5	15,6	18,0	82,0	510,6
IRL	0,9	0,6	0,3	0,3	0,5	0,8	0,6	0,1	1,9	0,3	0,8	2,5	50,5
I	4,4	3,3	8,7	1,8	1,9	4,0	15,6	4,0	45,1	13,0	18,6	35,3	383,7
NL	2,0	1,5	3,0	1,9	2,8	6,1	5,4	2,0	13,4	4,4	8,7	20,8	343,7
P	0,3	0,1	0,3	0,4	0,5	1,0	0,7	0,2	0,7	0,4	0,5	2,7	27,1
UK	6,5	8,3	2,2	4,7	6,8	20,2	10,9	5,3	35,2	9,1	28,4	42,0	490,7
US	123,4	25,1	2,0	1,8	4,5	8,1	13,4	10,5	75,3	21,9	151,9	194,7	1 140,2
CA	23,0	2,6	0,2	0,5	1,3	0,7	1,0	1,5	8,0	9,7	12,1	35,5	472,5
JA	0,0	27,1	2,2	2,6	2,6	5,3	5,7	7,8	82,9	15,7	161,7	130,3	888,0
AU	32,2	0,0	0,1	0,1	0,0	0,2	0,2	7,6	8,4	4,4	19,7	18,9	124,4
AT	0,9	0,3	0,0	0,7	0,7	1,6	5,7	0,7	5,3	10,0	3,6	3,4	82,4
FI	0,9	0,7	0,5	0,0	3,2	8,7	0,9	0,3	2,2	14,7	1,9	2,8	70,5
NO	1,4	0,2	0,4	1,4	0,0	9,8	0,7	0,4	0,7	0,9	3,1	4,3	99,0
SE	2,2	1,8	1,8	8,8	14,1	0,0	2,5	1,1	7,8	3,9	6,0	8,3	153,7
SW	4,4	1,2	5,3	1,1	1,1	2,7	0,0	1,2	9,6	4,0	10,0	8,5	135,3
RO	4,6	4,4	0,7	0,1	0,1	0,3	2,1	0,0	15,3	2,2	2,6	8,2	70,1
OP	198,0	7,7	4,4	1,0	0,5	1,7	4,4	18,9	29,0	16,1	116,8	127,5	936,8
CP	8,6	0,5	11,3	15,6	2,4	7,2	4,6	4,8	35,0	479,6	23,7	164,0	918,2
NI	75,4	14,0	3,6	1,3	3,7	4,8	11,8	3,8	52,5	43,1	95,1	270,7	1 011,5
RW	105,1	6,4	2,6	1,7	1,8	3,9	5,2	3,6	62,1	99,7	202,1	− 301,2	665,6
World	619,0	116,9	101,7	59,9	70,0	131,5	169,2	87,5	617,6	828,5	952,8	973,6	10 000,0

Table 17

Absolute changes in the shares of bilateral export flows (fob) in the value of world exports, 1965-84 (× 10 000)

Importers

Exporters	B/L	DK	D	GR	E	F	IRL	I	NL	P	UK	US	CA
B/L	0,0	-2,2	-20,8	-1,3	-1,5	0,1	-0,2	2,3	-37,5	-0,8	10,4	-12,0	-2,0
DK	-0,1	0,0	-6,6	0,1	-0,8	0,4	0,0	-1,2	-0,1	-0,2	-17,4	-1,8	-0,3
D	-11,4	-12,6	0,0	-0,6	-6,2	8,9	0,5	9,3	-20,8	-4,2	37,1	9,3	-2,3
GR	0,3	0,1	1,0	0,0	0,0	1,2	0,0	2,6	0,3	-0,0	0,2	0,4	0,1
E	1,7	0,2	4,7	0,6	0,0	13,1	0,3	5,5	4,0	1,9	4,3	5,7	0,7
F	-10,1	-1,4	-31,7	-0,9	-1,9	0,0	0,9	14,1	-1,6	-0,6	13,9	7,7	0,2
IRL	1,9	0,3	3,3	0,2	0,3	3,4	0,0	1,3	2,5	0,1	-6,1	3,6	0,5
I	-4,1	-1,3	-19,4	-0,5	-3,5	14,3	0,4	0,0	-7,1	-0,7	7,9	8,6	0,4
NL	-3,1	-1,5	7,7	1,4	-1,9	7,1	0,3	3,4	0,0	0,2	3,0	4,4	-1,2
P	0,2	-0,2	1,2	-0,1	0,4	2,0	0,1	0,3	0,8	0,0	-1,3	-0,9	-0,3
UK	-4,9	-10,6	9,0	-2,2	-5,3	20,3	-4,0	1,6	12,5	-3,4	0,0	-6,1	-22,8
US	-7,0	-8,0	-40,5	-6,8	-12,8	-20,3	3,4	-24,8	-18,6	0,9	-23,7	0,0	-58,4
CA	-3,5	-0,1	-4,4	-0,2	-1,3	-1,4	-0,4	-2,3	-2,1	-0,0	-48,3	97,8	0,0
JA	4,4	2,5	23,1	1,6	1,8	7,5	0,8	2,6	3,2	0,6	13,5	181,7	11,0
AU	-2,2	-0,0	-1,6	-0,6	-0,0	-4,1	-0,1	-3,3	0,0	-0,0	-23,3	-3,6	-0,8
AT	0,4	-0,5	0,1	-0,5	0,5	1,3	0,1	-1,4	-1,2	-0,2	0,3	-0,2	0,0
FI	-1,5	-0,0	-1,8	-0,3	-0,3	-0,6	-0,3	-0,8	-2,0	0,0	-6,9	1,1	0,4
NO	-0,6	-2,0	5,8	-0,5	-0,6	0,9	-0,0	-0,7	4,6	0,1	22,4	-1,8	0,1
SE	-1,7	-6,3	-12,8	-1,0	-1,9	-2,6	0,2	-1,0	-4,1	-0,7	-12,4	4,7	-0,5
SW	-1,6	-1,3	-1,0	-0,5	-1,8	-1,9	0,2	-2,8	-2,1	-0,9	-0,4	-2,3	-1,1
RO	-1,5	-0,7	1,2	0,3	-0,0	-1,8	-0,1	-0,0	-0,3	-0,4	-24,7	-5,1	-0,2
OP	0,1	-0,9	5,8	7,2	23,2	-3,7	-0,5	19,6	-4,9	5,1	-54,9	43,2	-8,5
CP	4,8	-1,6	5,5	-1,2	0,9	5,2	-0,1	7,1	6,4	-0,0	-18,8	3,9	-1,0
NI	-1,5	-0,9	5,2	0,8	-0,2	4,4	-1,4	-9,3	4,3	0,8	-24,5	165,0	10,3
RW	-13,4	-0,6	-35,1	-1,2	6,2	-27,7	-2,2	-7,7	-8,0	-6,3	-77,2	29,2	-16,4
World	-54,5	-49,7	-102,1	-6,2	-6,5	25,9	-2,1	14,3	-71,8	-8,8	-227,0	532,6	-92,3

Exporters	JA	AU	AT	FI	NO	SE	SW	RO	OP	CP	NI	RW	World
B/L	0,4	-0,3	0,1	-0,9	-1,1	-3,1	-0,3	0,2	4,1	-0,1	0,5	-4,0	-69,5
DK	1,7	0,2	-0,5	-0,9	-1,8	-5,7	-1,6	-0,5	2,2	-3,4	-0,3	-1,7	-40,2
D	2,7	-2,2	-5,9	-6,9	-8,5	-26,3	-14,4	0,2	20,8	1,6	4,6	-38,2	-65,3
GR	-0,1	0,1	-0,0	-0,0	-0,0	-0,0	0,0	0,3	2,6	-2,5	-0,4	1,7	7,7
E	1,2	0,2	0,3	0,1	-0,2	0,1	0,9	1,6	10,1	1,7	2,1	12,9	73,4
F	2,8	-0,4	-1,1	-1,6	-1,1	-3,2	-11,8	-0,0	8,6	-0,4	1,6	-14,3	-32,2
IRL	0,8	0,5	0,2	0,2	0,4	0,6	0,4	0,1	1,6	0,0	0,6	0,7	17,5
I	2,5	0,7	-0,2	-0,3	-0,2	-3,4	-5,2	0,9	26,9	-4,6	-4,7	-7,7	-0,4
NL	0,2	-0,7	-0,8	-0,9	-1,8	-5,0	-2,1	0,3	4,5	-1,2	-1,7	-7,9	2,7
P	0,0	-0,1	-0,1	0,2	0,2	-0,1	0,1	0,0	0,4	0,1	-0,1	-7,0	-4,0
UK	-1,4	-34,0	-3,2	-6,2	-6,4	-13,5	-3,3	-17,3	-0,7	-8,1	-49,3	-86,6	-245,9
US	12,2	-17,4	-1,1	-2,2	-2,4	-9,9	-6,3	-8,5	1,2	14,5	11,7	-103,2	-328,3
CA	7,3	-4,4	-0,3	0,2	-2,8	-0,8	-0,5	-1,0	2,9	-5,4	2,0	-9,2	21,8
JA	0,0	10,0	1,9	1,7	-1,6	2,0	2,4	3,7	53,8	4,4	80,0	24,7	437,3
AU	5,8	0,0	-0,1	0,0	-0,3	-0,3	-0,1	-3,1	6,0	-2,1	7,7	-9,6	-35,9
AT	0,6	-0,1	0,0	-0,0	-0,0	-1,2	-0,7	0,1	3,3	-3,0	-0,3	-0,2	-3,0
FI	0,8	-0,1	0,3	0,0	2,3	3,3	0,4	-0,0	1,6	-1,0	-0,2	-0,2	-5,6
NO	0,9	-0,3	-0,0	-0,0	0,0	-2,3	-0,2	-0,2	-0,6	-2,5	0,6	-1,0	22,0
SE	0,9	-1,1	-0,2	-1,8	-10,7	0,0	-1,8	-0,1	5,0	-4,3	-0,7	-3,1	-58,1
SW	1,4	-1,1	-1,4	-0,8	-0,8	-2,6	0,0	0,1	5,3	-0,5	-0,5	-3,1	-21,6
RO	1,6	1,9	0,4	-0,3	-0,1	-0,7	1,3	0,0	14,8	-2,5	0,2	1,5	-15,2
OP	145,9	-4,7	4,4	0,8	-2,5	-2,7	3,1	16,7	24,1	10,0	90,8	53,0	369,8
CP	-4,6	-1,0	0,0	1,0	-0,9	-1,5	0,4	0,9	16,4	-183,0	-1,2	13,6	-148,8
NI	39,4	10,4	1,3	-0,3	1,3	-1,8	7,4	1,2	42,0	3,6	50,9	102,2	410,6
RW	29,4	-6,9	-1,2	-1,3	-2,7	-9,5	-3,3	-2,9	26,6	-34,5	97,5	-219,6	-288,7
World	252,3	-51,0	-7,1	-20,1	-41,8	-87,6	-35,2	-7,3	283,4	-222,9	291,4	-306,0	0,0

4. The bilateral trade flow model

The total import equations which were discussed in the previous chapter represented the first step of the two-stage approach that was derived in Chapter 2. The discussion of the bilateral trade flow model starts, in section 4.1, with the estimation of the bilateral import equations, which constitute the second step of this two-stage approach. For the estimations, the results for each bilateral trade flow are not analysed individually due to limits in space and time. Instead greater attention is paid to the trade flows between the four countries for which total import equations were estimated in the previous chapter. For the other flows, the long-term bilateral relative price elasticities are presented only. After having discussed the structure of the trade linkage model in section 4.2, section 4.3 presents the results of simulations which give an idea of the explanatory power of the model within and post-sample, and of the aggregate export price elasticities that are implicit in the bilateral trade flows. The data used are discussed in Box 3.

4.1. Estimation

In Chapter 2 the following estimating equation was derived for the bilateral trade flow from i to j:

$$\begin{aligned} \ln X_{ij} = {} & a_{ij} + \ln MZ_j + c_{ij}.\ln(X_{ij}/MZ_j)_{-1} \\ & - b_{ij}.(1-c_{ij}).\ln(PX_i/PMZ_j) \\ & + d_{ij}.(DCU_i - c_{ij}.DCU_{i,-1}) \end{aligned} \qquad (26)$$

with X_{ij} bilateral (fob) exports from i to j in constant prices (value flow deflated by total export price PX_i), MZ_j quasi-fob imports in constant prices ($MZ_j = \Sigma_i X_{ij}$), PMZ_j the quasi-fob import price of j and DCU_i the degree of capacity utilization of i. This equation is essentially an import volume share equation, since the elasticity of bilateral exports with respect to quasi-fob import volume is equal to one.[5] Consequently one could move the latter term to the left-hand side of the equation to result in the logarithm of an import volume share X_{ij}/MZ_j. The coefficient b_{ij} is the relative price elasticity, c_{ij} is the Koyck parameter while d_{ij} is a quasi-elasticity with respect to the degree of capacity utilization whose sign is expected to be negative.

In the following subsections, some general comments are given first concerning the estimation strategy and the estimates for equation (26). Then the estimation results for the trade flows between Germany, France, the United Kingdom and the United States are presented in detail.

4.1.1. General comments

The estimation strategy for each bilateral trade flow equation was the following. Firstly, the initial sample period was determined at 1974/I-1984/IV, since stability tests on aggregate export functions derived from a specification for the bilateral trade flows comparable to equation (26) revealed a significant break in the allocation structure of world trade after the first oil shock for a large percentage of the 25 countries/zones.[6] These statistical results are illustrated by Table 18, which gives the development of the volume shares of the 25 countries/zones in world trade volume over the period 1965-84. The table shows clearly that the changes in the OPEC share of world exports are one of the major factors behind the structural change in the composition of world trade. But even if the OPEC trade is excluded from total world exports, structural changes have taken place, e.g. the more than proportional increase of the exports of Greece, Spain, Ireland, Portugal, Japan, rest of OECD zone (Turkey, Iceland, New Zealand) and the NICs. Moreover it is also clear that the 1974-84 period is itself not always stable and that structural changes within this period also have occurred.

Nevertheless, the starting point was to estimate equation (26), excluding the degree of capacity utilization variable, for all bilateral trade flows over the complete period 1974/I-1984/IV. Often these estimations produced results which were not satisfactory: relative price elasticities b_{ij} not with the expected sign, being not significantly different from zero or seeming too large in absolute value; Koyck parameters c_{ij} outside the (0,1) interval; high estimated standard errors; signs of negative or positive autocorrelation. There was a high correlation between the occurrence of such anomalies and the absolute value of the trade flow. This is quite normal since small flows usually are extremely erratic and subject to statistical errors and therefore actually hardly fit for econometric estimation. A second cause for the unsatisfactory results was the occurrence of structural shifts within the 1974-84 period.

In both cases it was tried to improve the equations through the introduction of dummies, trends or a correction for autocorrelation. In making these improvements, emphasis was placed on the most recent past, say the 1980-84 period. For instance, if the years 1974-75 were the cause of unsatisfactory results, the sample period was simply shortened to 1976/I-1984/IV such that the 1980s were at least described in a satisfactory way. Examples of these modifications are given below for the trade flows between the four countries. Structural shifts and trends were usually identified through a comparison of the plot for the import volume share X_{ij}/MZ_j with the inverted relative price PMZ_j/PX_i. The resulting long-run bilateral relative price elasticities are presented in Table 19. In section 4.3 the corresponding aggregate export price elasticities are calculated by simulation, i.e. the 'averages' corresponding to each row (exporter). As can already be seen from a comparison between Table 16 and Table 19,

Table 18

Volume shares in world exports, 1965-84

(%)

	1965	1970	1974	1980	1984
BLEU	2,821	2,986	3,203	3,218	3,314
Denmark	0,925	0,837	0,827	0,845	0,941
FR of Germany	8,469	9,458	10,107	9,888	10,903
Greece	0,111	0,139	0,189	0,256	0,285
Spain	0,343	0,552	0,712	1,031	1,338
France	4,233	4,557	5,205	5,774	5,849
Ireland	0,272	0,301	0,303	0,418	0,551
Italy	3,110	3,433	3,464	3,866	4,214
The Netherlands	2,925	3,320	3,772	3,680	3,728
Portugal	0,265	0,218	0,193	0,231	0,315
United Kingdom	6,852	5,808	5,592	5,482	5,499
EUR 12	30,325	31,609	33,566	34,689	36,936
United States	10,337	9,035	9,944	10,988	8,858
Canada	3,232	3,490	3,241	3,371	4,284
Japan	3,183	4,112	5,107	6,492	8,119
Australia	1,198	1,228	0,989	1,096	1,242
Austria	0,638	0,691	0,741	0,870	0,978
Finland	0,678	0,708	0,632	0,704	0,746
Norway	0,775	0,817	0,834	0,923	1,023
Sweden	1,817	1,808	1,802	1,538	1,801
Switzerland	1,580	1,554	1,487	1,475	1,524
Rest of OECD	0,573	0,499	0,412	0,460	0,767
OECD	54,336	55,550	58,754	62,606	66,278
OPEC	23,620	23,738	21,790	14,739	9,046
CPEs	6,453	6,496	7,008	7,789	8,379
NICs	4,121	4,255	5,096	7,813	9,798
Rest of world	11,471	9,962	7,353	7,053	6,499

there is a correlation between the absolute value of the relative price elasticities and the size of the flow. Although Table 19 indicates numerous elasticities larger than 1 in absolute value, the aggregate export price elasticities exceed the value of 1 significantly in only a few cases and vary mostly in the range −0,6 to −1,1.

4.1.2. Trade between the four countries (D, F, UK, US)

Graphs 22 to 33 give the bilateral trade flow share in the quasi-fob import volume (X_{ij}/MZ_j with i exporter and j importer) and the inverted relative price (PMZ_j/PX_i). According to the theory of Chapter 2, there should be a positive correlation between those two variables. Since the plots have been scaled to display the same variation for each of the two curves, the absolute value of the vertical difference between them is not of importance, since it goes into the constant. What matters, however, is the change in the vertical distance: this represents autonomous movements in the import volume share accounted for by changes in relative prices. Such jumps in the vertical distance may therefore be a sign of a structural break in the trade allocation system. Unless sufficient empirical explanations for these shifts are available, the only way to represent them adequately is through the use of dummy variables. Consequently, this is the approach that has been adopted for these estimations. This may be considered as a first empirical solution to the problems raised if energy/oil is included in the trade flow. Subsequently, refinements could be achieved through the separation of total imports in energy/oil imports and the residual as proposed in Chapter 3.

Table 20 gives the standard estimations for the 12 trade flows between the four countries Germany, France, the United Kingdom and the United States. Almost all of the anomalies mentioned above show up: positive relative price elasticities for the flows from France to Germany, the UK to Germany and the UK to France, a very high elasticity (in absolute value) for the flow from Germany to the UK, a Koyck parameter exceeding 1 for the UK to France and signs of autocorrelation for at least the trade flow from the UK to Germany and vice versa.

In addition Table 21 presents estimates of the same equations, but with the degree of capacity utilization included (as in equation (26)). Theoretically the sign of the degree of capacity utilization would be expected to be negative, since domestic slack in the exporting country would lead to enhanced export efforts. The sign is negative in only 6 out of 12 cases, and never significant. Also the positive coefficients are not significantly different from zero. From this evidence the introduction of disequilibrium effects, at least in its present form, makes no significant contribution to the explanation of bilateral trade flows.

Close inspection of Graphs 22 to 33 reveals that in none of the 12 cases do the estimated relationships of Table 20 seem to be stable over the period 1974/I-1984/IV. Drawing on these graphs dummies have been introduced in the equations and sometimes the sample period modified in order to obtain significant relative price coefficients b_{ij} and Koyck parameters c_{ij} in their *a priori* expected intervals. Table 22 shows the results after the inclusion of dummies and a possible change of sample period.[7] Comparison of the dummy periods and sample periods of Table 22 with Graphs 22 to 33 should explain the choices made, hence they are not discussed in detail.

As stated above, a change in the vertical distance between the curves for the import volume share and the relative price has been taken as indicating the need for an autonomous change in the relationship between import volume shares and relative prices. The introduction of dummies and modification of the sample periods improves the results of Table 20 considerably. The relative price coefficients and Koyck parameters are now all significant (usually at 1%) and have values in their expected intervals.

As far as can be judged from the Durbin-Watson statistics there is hardly any autocorrelation. The estimated standard errors, varying between 2,8% and 8,2%, may seem high at first sight. It should however be remembered that the equations mainly relate to variables which are extremely volatile, very often due to causes lying outside the theoretical model. Usually, the smaller the trade flow becomes, the higher is the unexplained component. This is an unavoidable reality working with bilateral trade flows. One consolation is that errors tend to cancel each other out in calculating the actual outputs of the linkage model, total exports and import prices. This is clear from the simulations presented in section 4.3.

In Table 23 the degree of capacity utilization according to equation (26) is added to the specifications of Table 22. As concluded from Table 21, the addition of this variable does not produce significant negative coefficients at 5%, so its exclusion from the bilateral trade flow model seems necessary. Unless it proves possible to introduce a concept such as an exporter's degree of capacity utilization relative to the average of its competitors, exclusion seems to be the only viable conclusion.

The long-run relative price elasticities in Table 22 vary between −0,3 and −1,7 while the mean lag of the Koyck distribution on the relative prices ($=c_{ij}/(1-c_{ij})$) varies between 0,3 and 1,4 quarters, indicating a fast adjustment of import volume shares to relative price changes. Although the Koyck parameters of Table 20 are perhaps not entirely

Table 19

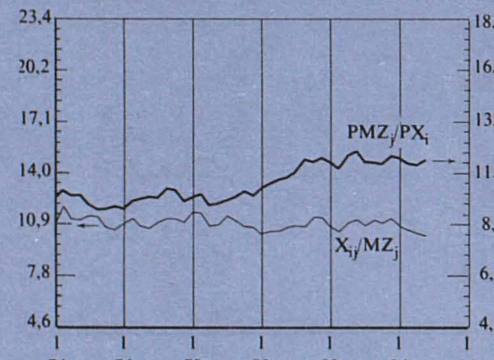
Long-run bilateral relative price elasticities

Importer j

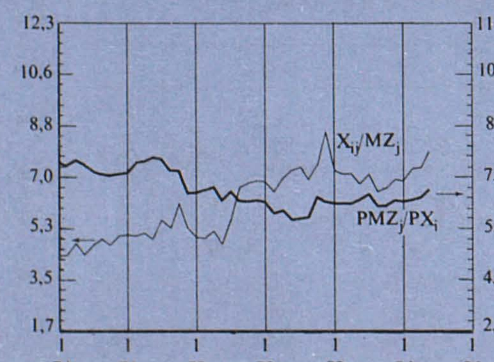
Exporter i	B/L	DK	D	GR	E	F	IRL	I	NL	P	UK	US	CA
B/L	0,00	−2,11	−0,52	−0,84	−0,93	−0,50	−1,34	−0,87	−0,35	−0,27	−0,46	−1,92	−1,51
DK	−1,26	0,00	−1,13	−1,34	−1,30	−0,95	−1,30	−1,08	−1,11	0,00	−0,58	−1,62	−1,17
D	−1,03	−1,15	0,00	−0,63	−1,15	−1,21	−1,26	−0,79	−0,76	−0,46	−0,71	−1,72	−0,66
GR	−1,10	−2,38	−0,55	0,00	−0,27	−0,70	−2,77	−0,28	−1,04	0,00	−0,29	−0,59	−1,13
E	−1,38	−1,02	−0,93	−0,48	0,00	−1,06	−2,54	−0,89	−1,43	−0,29	−1,01	0,00	−0,91
F	−0,73	−1,66	−0,31	−1,45	−1,13	0,00	−1,30	−1,02	−0,74	−0,87	−1,07	−0,87	−1,13
IRL	−0,71	−2,96	−0,78	−2,36	−1,43	−1,68	0,00	−2,37	−2,16	−2,57	−0,48	−1,58	−2,13
I	−1,51	−2,88	−0,52	−1,50	−0,23	−1,42	−1,71	0,00	−0,65	−0,94	−1,94	−1,23	−1,49
NL	−0,57	−1,00	−0,83	−1,59	−1,26	−0,61	−1,28	−1,12	0,00	−2,20	−1,24	−1,00	−1,65
P	−1,42	−0,33	−0,51	−1,23	−1,72	−2,24	−0,64	−1,07	−0,48	0,00	−1,22	−0,87	−0,27
UK	−0,75	−0,52	−0,98	−0,64	−0,72	−1,26	−0,04	−0,88	−0,66	−0,73	0,00	−1,63	−0,87
US	−0,85	−1,51	−0,98	−1,87	−1,16	−1,44	−1,81	−0,95	−1,17	−1,26	−1,24	0,00	−1,01
CA	−0,78	−2,14	−0,72	−1,85	−0,07	−0,92	−1,73	−2,20	−1,45	−2,95	−0,14	−0,51	0,00
JA	−1,97	−2,84	−2,68	−0,49	−1,24	−1,15	−2,34	−1,66	−0,43	−2,15	−1,43	−1,65	−1,07
AU	−0,13	0,00	0,00	0,00	−0,73	0,00	0,00	−0,66	−1,09	−1,65	−0,32	−0,92	0,00
AT	−1,32	−0,21	−0,82	−0,64	−1,74	−1,18	−1,49	−1,10	−0,83	−0,49	−0,37	−1,10	−0,83
FI	−1,98	−0,97	−1,66	−0,51	−0,36	−2,74	−1,19	−0,63	−1,95	0,00	−0,78	−1,16	−2,28
NO	−1,47	−1,04	−2,17	−2,73	0,00	−0,66	−1,07	−1,80	−1,15	−2,15	−0,57	−2,02	−0,90
SE	−1,55	−0,78	−1,21	−0,39	−0,57	−0,53	−0,95	−1,30	−1,17	−0,33	−0,73	−1,18	−0,41
SW	−0,06	−0,53	−0,90	−1,58	−0,23	−0,39	−1,26	−0,76	−0,32	−0,24	−1,01	−0,71	−0,60
RO	−1,74	−2,35	−0,95	−1,60	−1,15	−1,23	0,00	−1,79	−0,73	−1,94	−1,31	−1,18	−0,24
OP	−1,14	−0,54	−0,44	−2,20	−1,70	−0,47	−1,06	−1,18	−1,24	−0,09	−1,93	−2,65	−1,19
CP	−2,80	−0,93	−1,14	−0,80	−0,93	−1,38	0,00	−0,88	−2,21	−1,80	−1,61	−2,21	−0,52
NI	−2,18	−2,15	−1,29	−1,84	−0,39	−2,42	−0,06	−1,07	−1,54	0,00	−0,64	−2,03	−2,88
RW	−0,80	−1,02	−1,00	−1,99	−1,81	−0,88	−1,80	−1,66	−0,82	−2,32	−1,79	−0,95	−0,93

Exporter i	JA	AU	AT	FI	NO	SE	SW	RO	OP	CP	NI	RW
B/L	−1,04	−0,20	−0,41	−0,70	−0,40	−0,09	−1,12	−0,60	0,00	−0,04	−1,33	−2,08
DK	−1,70	−1,33	−1,38	−0,80	−1,05	−0,83	−1,42	−0,56	−1,35	−0,82	−1,62	−1,67
D	−1,56	−0,32	−0,81	−1,34	−1,07	−0,61	−1,41	−0,65	−1,24	−0,77	−0,29	−0,88
GR	−2,90	−1,25	−0,98	−0,69	0,00	−1,79	−1,69	−1,45	−1,22	−0,56	0,00	−1,08
E	−1,29	−0,43	−0,35	−0,05	−0,78	−1,26	−0,59	−1,36	−0,61	−0,59	0,00	−1,53
F	−1,16	−2,08	−0,04	−1,13	−0,01	−1,45	−0,50	−0,26	−0,70	−0,57	−0,64	−0,81
IRL	−0,71	−0,98	−2,88	−1,68	−0,93	−0,74	−2,31	−2,66	−1,55	−0,34	−1,38	−2,76
I	−1,28	−1,98	−0,89	−1,75	−0,41	−1,77	−2,04	−1,60	−0,72	−1,14	−0,59	−1,31
NL	−0,52	−0,45	−1,33	−1,08	−2,66	−0,20	−0,88	−0,20	−1,09	−2,21	−0,87	−0,06
P	−0,58	−0,55	−1,58	−2,43	−1,09	−0,25	−1,51	−1,45	−1,22	−1,49	0,00	−2,06
UK	−0,66	−1,22	−2,31	−1,06	−0,27	−1,70	−1,52	−1,74	−1,09	−0,93	−2,38	−1,72
US	−1,05	−1,33	−0,67	−1,54	−0,58	−0,64	−1,26	−1,66	−1,58	−3,22	−0,91	−1,13
CA	−0,56	−0,63	−1,26	−2,73	−0,44	−1,24	−0,73	−0,46	−1,22	−1,43	−1,34	−1,00
JA	0,00	−1,94	−3,02	−0,60	−0,41	−0,59	−1,20	−1,17	−1,20	−0,59	−0,53	−1,55
AU	−1,52	0,00	−0,46	−0,64	−0,55	−0,19	0,00	−1,02	−0,70	−1,06	−1,25	−1,45
AT	−1,82	−0,58	0,00	−0,38	−0,33	−0,67	−1,12	−0,17	−0,64	−0,62	−0,09	−1,05
FI	−2,01	−0,33	−0,30	0,00	−1,43	−0,49	−1,43	−0,31	−0,37	−0,23	−1,24	−1,62
NO	−2,38	−0,33	−1,63	−1,41	0,00	−1,14	−1,14	−0,35	−2,74	−0,62	−0,70	−2,29
SE	−0,95	−0,11	−0,35	−0,84	−0,49	0,00	0,00	−1,04	−1,01	−0,18	−0,59	−0,55
SW	−0,54	−0,55	−1,39	−1,49	−0,44	−1,41	0,00	−0,92	−0,48	−1,90	−0,38	−0,79
RO	−1,04	−1,35	−1,49	−0,86	0,00	−1,12	−2,43	−1,81	−2,84	−1,56	−0,83	−1,02
OP	−0,13	−0,05	−1,72	−3,18	−3,04	−1,71	−0,94	−0,56	−0,73	−1,12	−0,88	−0,26
CP	−2,49	−0,06	−0,57	−0,51	−0,76	0,00	−1,04	−0,54	−1,47	−0,95	−0,55	−0,80
NI	−0,98	−0,52	−1,36	−1,41	−0,73	0,00	−2,62	−0,75	−1,03	−0,62	−1,85	−2,36
RW	−1,27	−1,22	−1,12	−0,91	−1,78	−1,03	−0,89	−1,93	−1,24	−1,13	−1,71	0,00

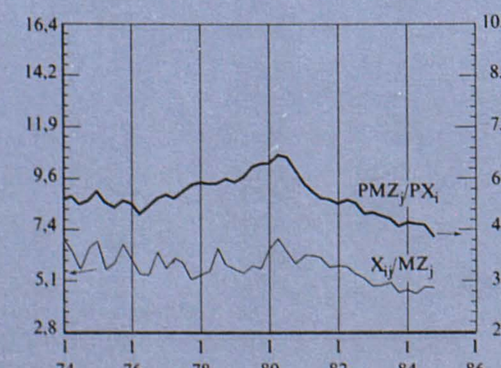
Graph 22: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from France to Germany, 1974/I-1984/IV**



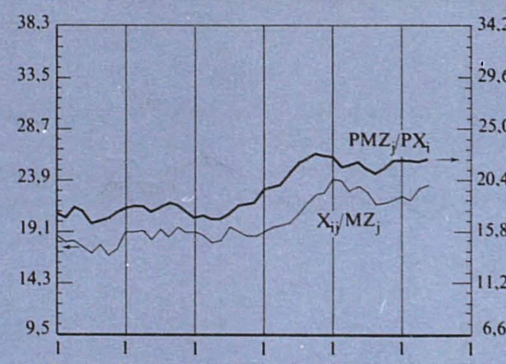
Graph 23: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from United Kingdom to Germany, 1974/I-1984/IV**



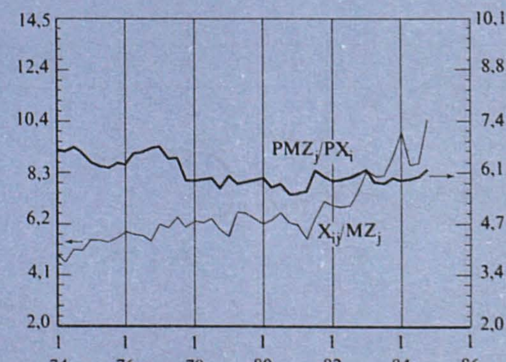
Graph 24: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from United States to Germany, 1974/I-1984/IV**



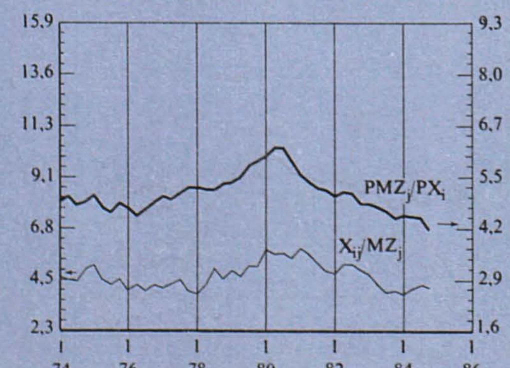
Graph 25: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from Germany to France, 1974/I-1984/IV**



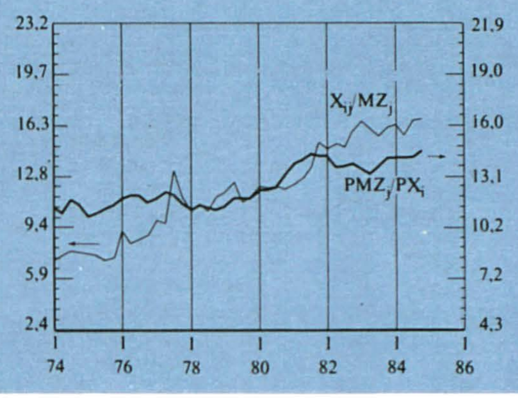
Graph 26: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from United Kingdom to France, 1974/I-1984/IV**



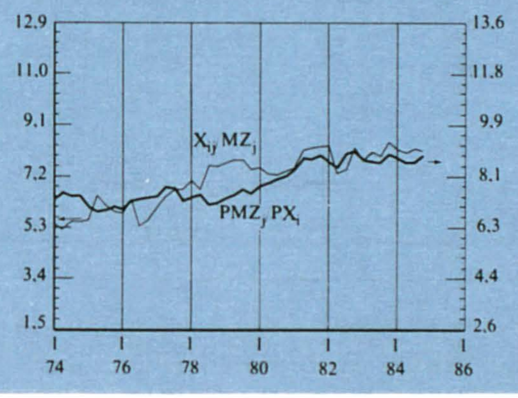
Graph 27: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from United States to France, 1974/I-1984/IV.**



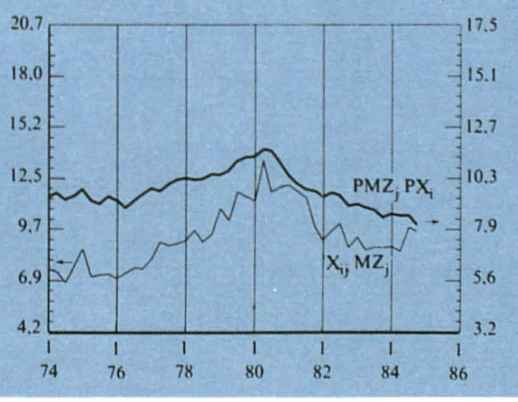
Graph 28: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from Germany to United Kingdom, 1974/I-1984/IV**



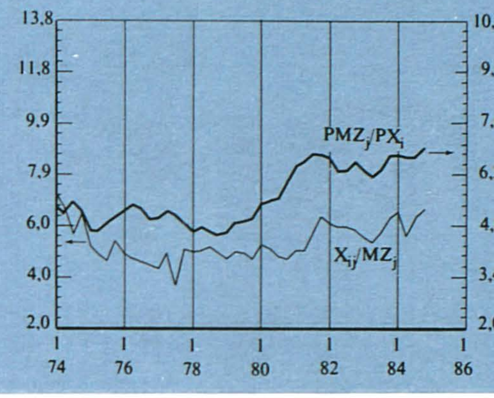
Graph 29: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from France to United Kingdom, 1974/I-1984/IV**



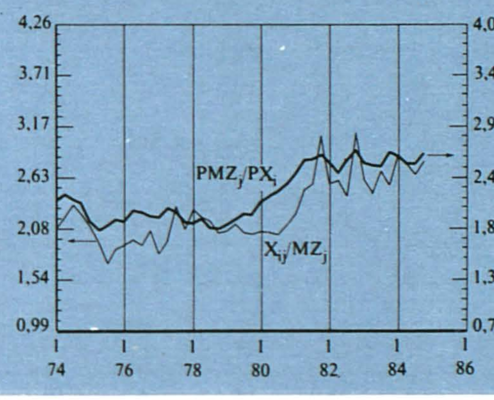
Graph 30: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from United States to United Kingdom, 1974/I-1984/IV**



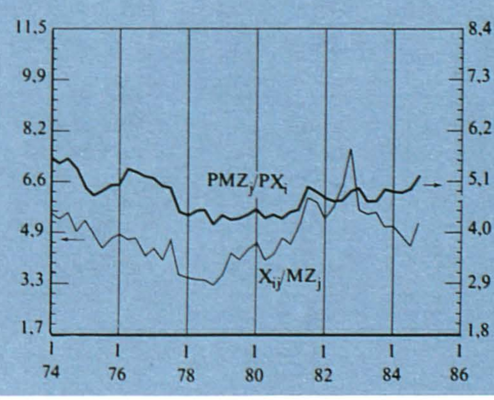
Graph 31: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from Germany to United States, 1974/I-1984/IV**



Graph 32: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from France to United States, 1974/I-1984/IV**



Graph 33: **Import volume share (X_{ij}/MZ_j) and inverted relative price (PMZ_j/PX_i) for bilateral trade flow from United Kingdom to United States, 1974/I-1984/IV**



valid, it is interesting to note that the simple average of Koyck parameters from Table 22 equals 0,40, compared to a value of 0,67 in Table 20 (mean lags: 2/3 quarter and 2 quarters). This decrease in the value of the Koyck parameter is a general phenomenon which occurred frequently if the bilateral trade flow equations were modified in order to remove the anomalies mentioned above. The concomitant increase in the speed with which bilateral volume flows adjust to relative price changes is contrary to what might be expected in bilateral trade flow models. Generally it is assumed that trade structures adjust only gradually to relative price movements. In the Compact model,[8] for instance, the Koyck parameter varies between 0,60 and 0,88. These parameters being annual, they would, in a quarterly model, correspond to values above 0,8, which is considerably higher than the present parameters.

Several explanations may be advanced for this discrepancy. It could be, for instance, that the introduction of dummies or trends in fact replaces delayed price effects. Another possible explanation is that the quarterly Koyck parameters,

Table 20

Standard estimations for the bilateral trade flows between Germany, France, the United Kingdom and the United States, excluding degree of capacity utilization

$\ln X_{ij} = a_{ij} + \ln MZ_j + c_{ij}.\ln(X_{ij}/MZ_j)_{-1} + b_{ij}.(1-c_{ij}).\ln(PX_i/PMZ_j)$

i	j	a_{ij}	b_{ij}	c_{ij}	1984 share	SER	$\bar{R}^2$	DW
F	D	−1,290 (0,322)	0,072 (0,102)	0,418 (0,146)	9,6	3,2	91,3	1,68
UK	D	−0,335 (0,278)	1,076 (1,413)	0,872 (0,105)	6,9	7,7	92,8	2,40
US	D	−1,329 (0,348)	−0,940 (0,286)	0,513 (0,126)	6,3	7,9	64,2	1,95
D	F	−0,709 (0,143)	−0,905 (0,090)	0,547 (0,090)	20,6	2,9	97,4	2,09
UK	F	0,043 (0,202)	21,811 (96,214)	1,016 (0,076)	9,0	7,2	91,8	2,33
US	F	−1,247 (0,316)	−1,068 (0,248)	0,564 (0,108)	5,8	6,4	85,9	2,16
D	UK	−0,393 (0,141)	−2,599 (0,604)	0,809 (0,065)	14,4	7,2	95,5	2,54
F	UK	−0,660 (0,208)	−1,058 (0,389)	0,746 (0,079)	7,5	5,8	92,6	2,32
US	UK	−0,488 (0,176)	−1,659 (0,593)	0,769 (0,079)	12,3	7,5	89,0	2,38
D	US	−1,313 (0,357)	−0,706 (0,247)	0,552 (0,121)	5,2	9,4	87,2	2,13
F	US	−2,293 (0,406)	−1,019 (0,138)	0,393 (0,107)	2,4	6,9	95,1	2,33
UK	US	−0,685 (0,323)	−0,853 (0,916)	0,781 (0,102)	4,3	10,4	83,5	2,11

Sample period: 1974/I to 1984/IV.
i = exporter, j = importer.
1984 share = 1984 share of exports of i in value of quasi-fob imports of j.
For general notes, see Table 5.

when correctly transformed in order to be comparable with the annual parameters, usually do not correspond to the annual Koyck parameters, even although they should be of comparable size, theoretically speaking.[9] Evidence on this last possibility is provided in Table 24, which is similar to the standard estimations of Table 20 but estimated on annualized data. Comparing the estimations for which b_{ij} is negative and c_{ij} between 0 and 1 between these two tables, it may be noticed that the relative price elasticities are in comparable ranges given their standard errors, but that the annual Koyck parameters of Table 24, although generally somewhat lower than the quarterly parameters, are consistently higher than the values obtained when the quarterly parameters c are transformed with the formula $(c/4).(1-c^4)/(1-c)$.

The rather low values for the Koyck parameters and the corresponding high speeds of adjustment to relative price changes imply that during simulation the long-run effects will be attained within a relatively short time period, say one to two years. This is a feature to be taken into account when analysing the simulations.

Table 21

Standard estimations for the bilateral trade flows between Germany, France, the United Kingdom and the United States, including degree of capacity utilization

$$\ln X_{ij} = a_{ij} + \ln MZ_j + c_{ij}.\ln(X_{ij}/MZ_j)_{-1} + b_{ij}.(1-c_{ij}).\ln(PX_i/PMZ_j) + d_{ij}\,(DCU_i - c_{ij}.DCU_{i,-1})$$

i	j	a_{ij}	b_{ij}	c_{ij}	d_{ij}	1984 share	SER	$\bar{R}^2$	DW
F	D	−1,400 (1,104)	0,071 (0,104)	0,424 (0,307)	0,259 (0,780)	9,6	3,2	91,5	1,69
UK	D	−0,446 (0,432)	1,212 (1,154)	0,854 (0,122)	0,570 (0,616)	6,9	7,6	92,9	2,44
US	D	−1,205 (0,536)	−0,985 (0,304)	0,508 (0,153)	−0,347 (0,523)	6,3	7,9	63,5	1,95
D	F	−0,717 (0,200)	−0,907 (0,092)	0,549 (0,094)	0,032 (0,250)	20,6	2,9	97,4	2,10
UK	F	0,064 (0,084)	14,499 (41,702)	1,025 (0,034)	−0,134 (0,428)	9,0	7,3	91,6	2,33
US	F	−1,231 (0,399)	−1,071 (0,226)	0,512 (0,121)	−0,424 (0,353)	5,8	6,3	86,0	2,13
D	UK	−0,387 (0,326)	−2,602 (0,621)	0,810 (0,095)	−0,026 (0,943)	14,4	7,3	95,4	2,54
F	UK	−0,518 (2,286)	−1,062 (0,523)	0,755 (0,522)	−0,578 (5,768)	7,5	5,8	92,5	2,34
US	UK	−0,521 (0,308)	−1,656 (0,637)	0,767 (0,095)	0,163 (0,626)	12,3	7,5	88,8	2,39
D	US	−1,462 (0,770)	−0,725 (0,245)	0,548 (0,151)	0,378 (0,972)	5,2	9,5	87,0	2,16
F	US	−2,487 (0,834)	−1,026 (0,142)	0,404 (0,119)	0,481 (0,863)	2,4	6,9	95,0	2,40
UK	US	−0,686 (0,352)	−0,856 (0,936)	0,779 (0,105)	−0,022 (0,636)	4,3	10,5	83,1	2,11

For notes, see Table 20.

Table 22

Estimation for bilateral trade flows between Germany, France, the United Kingdom and the United States, including dummies and excluding the degree of capacity utilization

$$\ln X_{ij} = \ln MZ_j + a_{ij} + b_{ij}.\ln(PX_i/PMZ_j) + c_{ij}.\ln(X_{ij}/MZ_j)_{-1}$$

i	j	a_{ij}	b_{ij}	c_{ij}	Dummy	$b_{ij}/(1-c_{ij})$	SER	$\bar{R}^2$	DW	Dummies	Sample
F	D	−1,465*	−0,209**	0,326**	−0,051*	−0,310	2,9	31,4	1,71	79/II-84/IV	74/I-84/IV
UK	D	−2,214*	−0,711*	0,275***	0,277*	−0,981	5,8	84,9	1,87	79/II-84/IV	77/I-84/IV
US	D	−1,951*	−0,730*	0,255***	−0,101*	−0,980	7,0	64,5	1,81	77/I-84/IV	74/I-84/IV
D	F	−0,692*	−0,552*	0,543*	−0,035*	−1,208	2,8	92,5	2,13	79/II-84/IV	74/I-84/IV
UK	F	−1,228**	−0,557***	0,558*	0,156**	−1,260	6,6	82,9	1,90	83/I-84/IV	77/I-84/IV
US	F	−1,888*	−0,944*	0,343***	0,094**	−1,437	6,1	77,3	1,93	81/I-84/IV	77/I-84/IV
D	UK	−1,528*	−0,512*	0,280**	0,151*	−0,711	4,0	93,9	1,70	81/IV-84/IV	77/IV-84/IV
F	UK	−1,611*	−0,661*	0,384*	0,083*	−1,073	3,5	82,2	1,93	78/III-80/I	77/I-84/IV
US	UK	−1,487*	−0,801*	0,356*	0,142*	−1,244	6,4	86,2	1,90	79/I-84/IV	74/I-84/IV
D	US	−1,141*	−0,713*	0,585*	−0,139*	−1,718	5,0	78,9	2,14	80/II-84/IV	78/I-84/IV
F	US	−2,159*	−0,494*	0,430*	0,183*	−0,867	5,9	83,4	2,00	81/IV-82/IV	74/I-84/IV
UK	US	−1,945*	−0,948*	0,418*	0,264*	−1,629	8,2	79,8	1,82	82/IV	74/I-84/IV
					0,148*					79/II-84/IV	

Significance of coefficients: * = 1%, ** = 5%, *** = 10%.
For general notes, see Table 20.

Table 23

Estimations for bilateral trade flows between Germany, France, the United Kingdom and the United States, including dummies and the degree of capacity utilization

$$\ln X_{ij} = \ln MZ_j + a_{ij} + b_{ij}.\ln(PX_i/PMZ_j) + c_{ij}.\ln(X_{ij}/MZ_j)_{-1} + d_{ij}\,(DCU_i - c_{ij}.DCU_{i,-1})$$

i	j	a_{ij}	b_{ij}	c_{ij}	d_{ij}	Dummy	$b_{ij}/(1-c_{ij})$	SER	$\bar{R}^2$	DW	Dummies	Sample
F	D	−1,579**	−0,211**	0,331***	0,229	−0,051*	−0,315	2,9	92,4	1,74	79/II-84/IV	74/I-84/IV
UK	D	−2,175*	−0,854*	0,184	−0,503	0,307*	−1,047	5,8	90,3	1,81	79/II-84/IV	77/I-84/IV
US	D	−1,874*	−0,754*	0,249***	−0,155	−0,100*	−1,004	7,0	68,6	1,81	77/I-84/IV	74/I-84/IV
D	F	−0,745*	−0,567*	0,552*	0,199	−0,040**	−1,266	2,8	97,6	2,22	79/II-84/IV	74/I-84/IV
UK	F	−1,252***	−0,538	0,566*	0,142	0,152**	−1,240	6,7	86,4	1,90	83/II-84/IV	77/I-84/IV
US	F	−2,022*	−0,972*	0,359**	0,349	0,122**	−1,516	6,1	84,8	1,95	81/I-84/IV	77/I-84/IV
D	UK	−1,487**	−0,509*	0,282	−0,059	0,149*	−0,709	4,1	96,1	1,68	81/IV-84/IV	77/IV-84/IV
F	UK	−1,093	−0,599*	0,386*	−1,007	0,085*	−0,976	3,6	93,7	2,00	78/III-80/I	77/I-84/IV
US	UK	−1,810*	−0,767*	0,332*	0,482	0,154*	−1,148	6,3	92,1	2,02	79/I-84/IV	74/I-84/IV
D	US	−1,149**	−0,713*	0,585*	0,026	−0,139**	−1,718	5,1	94,4	2,15	80/II-84/IV	78/I-84/IV
F	US	−2,475*	−0,478*	0,449*	0,854	0,189*	−0,868	5,8	96,5	2,15	81/IV-82/IV	74/I-84/IV
UK	US	−1,825*	−1,106*	0,329*	−0,788***	0,271*	−1,648	8,0	90,7	1,87	82/IV	74/I-84/IV
						0,162*					79/II-84/IV	

For general notes, see Table 22.

Table 24

Standard estimations for the bilateral trade flows between Germany, France, the United Kingdom and the United States, excluding degree of capacity utilization, based on annual data

$$\ln X_{ij} = a_{ij} + \ln MZ_j + c_{ij}.\ln(X_{ij}/MZ_j)_{-1} + b_{ij}.(1-c_{ij}).\ln(PX_i/PMZ_j)$$

i	j	a_{ij}	b_{ij}	c_{ij}	SER	$\bar{R}^2$	DW
F	D	−3,572 (0,957)	0,119 (0,053)	−0,613 (0,433)	2,2	95,8	1,88
UK	D	−1,478 (0,657)	2,149 (0,660)	0,425 (0,248)	9,1	90,5	3,00
US	D	−1,041 (0,751)	−1,641 (1,098)	0,606 (0,268)	6,6	72,4	1,30
D	F	−1,129 (0,236)	−0,926 (0,122)	0,278 (0,147)	2,9	97,5	2,56
UK	F	0,600 (0,405)	3,903 (2,060)	1,207 (0,151)	5,7	95,0	1,76
US	F	−1,368 (0,402)	−1,646 (0,477)	0,503 (0,133)	4,2	93,6	1,53
D	UK	−0,552 (0,279)	−2,515 (0,796)	0,714 (0,125)	7,0	95,9	2,05
F	UK	−0,853 (0,422)	−0,687 (0,726)	0,664 (0,157)	5,7	92,8	2,51
US	UK	−0,735 (0,297)	−2,271 (0,894)	0,631 (0,127)	7,1	90,3	1,55
D	US	−1,438 (0,601)	−0,949 (0,481)	0,509 (0,205)	7,8	91,0	2,04
F	US	−3,122 (0,697)	−0,999 (0,182)	0,172 (0,182)	5,6	96,9	2,13
UK	US	−1,182 (1,142)	−0,201 (2,025)	0,616 (0,358)	14,2	68,0	1,30

Sample period: 1974-84, annual data.
For general notes, see Table 20.

Box 4: Mathematical representation of the main relationships in the trade linkage model

Schematically one may represent the structure of the trade linkage model by the following set of equations.

A. Inputs from national models

(1a) $M_j = f(F_j, PM_j/PF_j, EX_j, DCU_j)$
(1b) $M_j = f(X_j, PM_j/PX_j)$
(2) $PX_i = f(PXC_i, EX_i, ...)$

B.1 Cif/fob conversion

(3) $MV_j = PM_j.M_j$
(4) $MZV_j = f(MV_j)$
(5) $MZ_j = MZV_j/PMZ_j$

C.1 Import allocation

(6) $XX_{ij} = PX_i.MZ_j.f(PX_i/PMZ_j, \text{time, dummies})$
(7) $XV_{ij} = XX_{ij}.MZV_j/(\Sigma_h XX_{hj})$
(8) $X_{ij} = XV_{ij}/PX_i$

C.2 Output from linkage model

(9) $X_i = \Sigma_j X_{ij}$
(10) $PXC_i = \Sigma_j v_{ij}.PW_{ij}$
with $v_{ij} = XV_{ij}/\Sigma_k XV_{ik}$ (export value share)
$PW_{ij} = (\Sigma_{h \neq i} XV_{hj})/(\Sigma_{h \neq i} X_{hj})$
(weighted prices of competitors of exporter i on market j)
(11) $PMZ_j = (\Sigma_i XV_{ij})/(\Sigma_i X_{ij})$

B.2 Fob/cif conversion

(12) $PM_j = f(PMZ_j)$

DCU_j : degree of capacity utilization
EX_i : exchange rate, national currency per US dollar
F_j : final demand in constant prices
M_j : cif imports in constant prices
MV_j : cif imports in current prices
MZ_j : quasi-fob imports in constant prices
MZV_j : quasi-fob imports in current prices ($= \Sigma_i XV_{ij}$)
PF_j : final demand deflator
PM_j : cif import unit value index
PMZ_j : quasi-fob import unit value index ($=(\Sigma_i XV_{ij})/(\Sigma_i X_{ij})$)
PX_i : export unit value index
PXC_i : competitors' price index
X_i : fob exports in constant prices
X_{ij} : bilateral fob exports from i to j, after adding-up, in constant prices (deflated by total export price)
XV_{ij} : bilateral fob exports from i to j, after adding-up, in current prices
XX_{ij} : bilateral fob exports from i to j, before adding-up, in current prices
h, i, j, k : 25 countries/zones from Box 1 (in the summations h, i are exporters, j, k are importers). All variables except F_j and PF_j are expressed in US dollars; for the sake of brevity equations (1) and (2) are assumed to be expressed in US dollars. Furthermore, $XV_{ij} = XX_{ij}$ in the data.

Part A gives the behavioural equations for the variables which are an input into the linkage model, i.e. import volumes M_j and export prices PX_i. Equation (1a) represents the import volume equation for the macroeconomic country models, while (1b) stands for the same equation in a trade-feedback model. In (1a), the volume effect comes from final demand F_j, while in (1b) this effect is, due to limited data availability, restricted to the export volume X_j. A similar restriction applies to the relative price variable, which compares the import prices PM_j to the final demand deflator PF_j and the export unit value index PX_i, respectively. For the macroeconomic country models the degree of capacity utilization also acts as an explanatory variable. Equation (2) gives the export unit value index as a function of competitors' prices PXC_i, to which domestic price indicators and other variables could be added. Given the two inputs from the country models, the trade linkage model functions as an independent, simultaneous system. The simultaneity comes from the (quasi-fob and cif) import price indices PMZ_j and PM_j: if these variables were known, the bilateral trade flow model was completely recursive. The recursive part of the model is first given, with the identities for PMZ_j and PM_j at the end, although this is an arbitrary choice.

In part B.1, cif imports are first expressed in current prices (MV_j) through multiplication of the cif import price index PM_j by cif import in constant prices M_j.

In order to impose the adding-up condition, which says that all bilateral exports to one country should equal total imports of that country,we have to transform the value of cif imports into the value of quasi-fob imports MZV_j. The latter variable is defined in the data as the sum of bilateral exports to country j. Since we use export (fob) data for the bilateral trade flows, this variable is defined as fob. In principle it should be equal to the value of cif imports corrected for cif/fob differences, but in reality this is seldom the case due to all kinds of statistical differences. The relationship between the two variables MZV_j and MV_j in equations (4) is therefore a purely empirical one, which can seldom be described in a satisfactory way through application of a fob/cif ratio to cif imports MV_j (cf. Box 5).

With total quasi-fob imports MZV_j being given, part C.1 determines first the bilateral trade flows without respecting the adding-up condition. This happens through equations (6), of which there are 605 (25 × 25 minus the intra-trade flows of the 20 individual countries, which are zero). As the specification shows, this equation is framed in terms of import volume shares ($XX_{ij}/PX_i)/MZ_j$, using the total export price index PX_i as a bilateral export flow deflator.[10] The specification in shares implies a unitary elasticity of the volume of bilateral exports with respect to the volume of imports, which is a sufficient condition to warrant the validity of the two-stage approach.[11] Because of this unitary elasticity with respect to imports, the import volume share is mainly a function of the export price PX_i (which, as the import volume, is an input into the bilateral trade flow model coming from the country models) relative to a weighted average of its competitors as represented by the quasi-fob import price index PMZ_j. Furthermore, structural shifts in import shares that cannot be explained by changes in relative prices are accounted for through the use of time trends and/or dummies.

The next step is to rescale, in equations (7), the values of bilateral exports such that they add up to total quasi-fob imports MZV_j. This is done by means of a simple proportional adjustment to all bilateral flows.[12] Having ensured the validity of the adding-up condition, it is a mere formality to calculate total exports in constant prices through identity (9). The bilateral trade flows in constant prices needed for this calculation have first been obtained in equation (8), using the total export price as deflator.

In this way, the volume of imports M_j which entered the trade linkage model as an input has been transformed, by means of the bilateral trade flow equations, into the volume of exports X_i. There is thus an explicit transmission of imports to exports, which is consistent because of the adding-up condition on total imports; this condition ensures that the value and volume of world imports and exports are equal, with the recognition that the world trade balance is not equal to zero through negative 'intra-trade' of the rest of world zone (cf. Box 3).

While the volume transmission is from imports to exports, the price transmission is from export prices into import prices, while export prices themselves may also be influenced by the competitors' price index PXC_i, which is calculated in equation (10) as a double-weighted average of the competitors' prices on a country's export markets, weighted by the shares of each market in total exports and the shares of the competitors on each market. The direct transmission of export prices takes place via the quasi-fob import price PMZ_j, which is calculated in equation (11) using the export prices indices PX_i and the bilateral trade flows XV_{ij} and X_{ij} ($=XV_{ij}/PX_i$) in value and volume. This equation may be interpreted as a weighted average of export prices since the bilateral trade flow value XV_{ij} is the product of a volume and a price:[13] the weights are then the volume shares in total quasi-fob imports. An increase in an export price will therefore lead to a change in the quasi-fob import price PMZ_j. The latter variable is only a quasi-fob price index because we use the weights for bilateral exports instead of imports. For most countries the differences in these weights are not too large, but for some countries they may be considerable due to differences in statistical coverage.[14]

The quasi-fob import price index PMZ_j is the main determinant of the (observed) cif import price index PM_j which is the last output from the model, after exports in constant prices and the competitors' index. The relationship between the two import price indices depends on the extent to which the quasi-fob index is a good proxy for the cif index. Analysis of the data showed that the correlation between the two is generally high although examples for 'overseas' countries such as the United States and Japan show that there may be a time lag involved before export prices are translated into import prices.[15] For these and other reasons which hamper a direct conversion from one price into the other, their relationship is (as for the value conversion) chosen to be determined empirically (cf. Box 5).

4.2. Structure of the trade linkage system

Before turning to the simulations in the next section, this section describes the structure of the trade linkage system, and notably the interactions between the country models and the bilateral trade flow model.

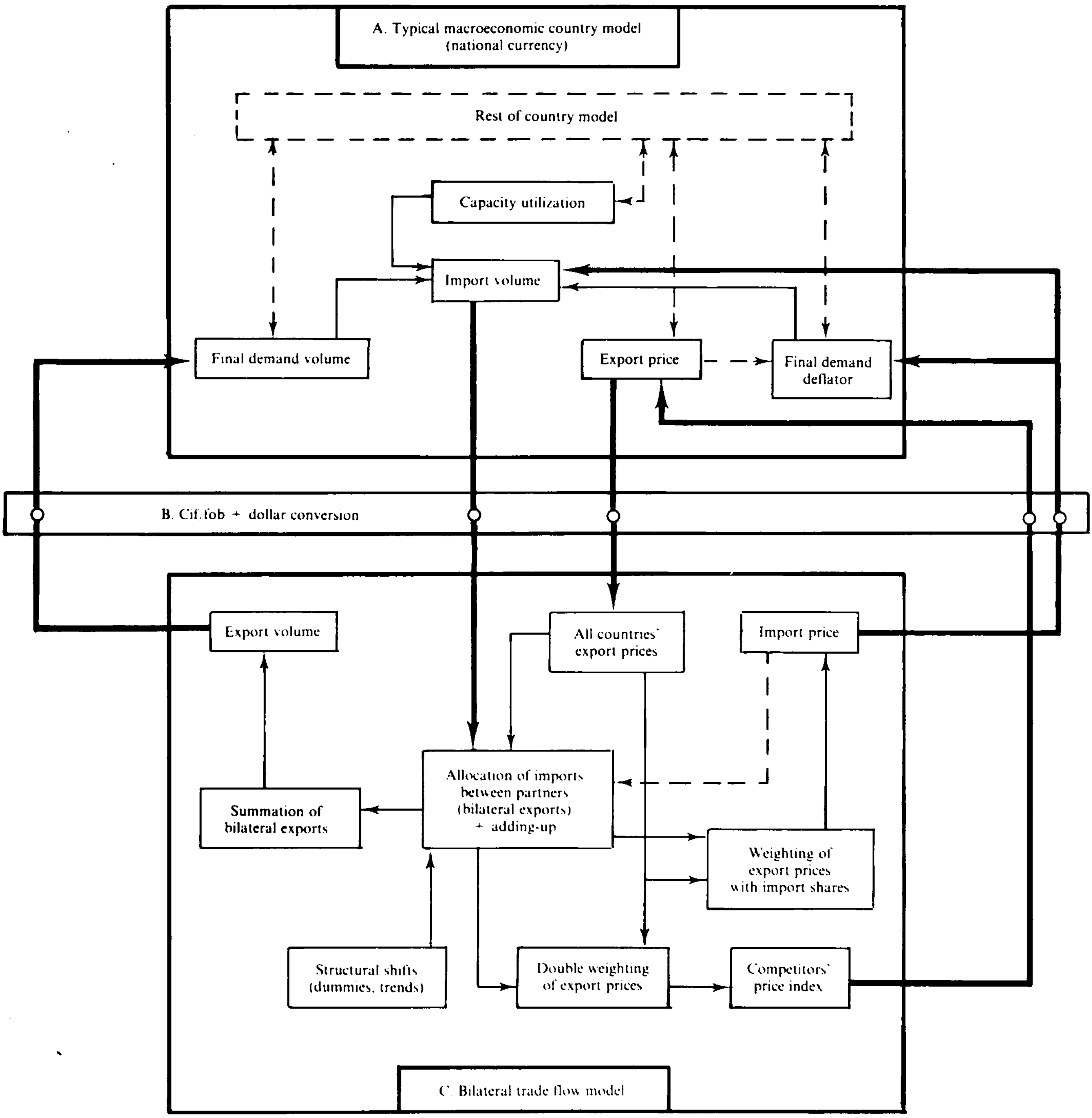
Figure 1 presents a flow-chart of the trade linkages in the QUEST model. Its mathematical equivalent is presented in Box 4. The flow-chart consists of three parts: A, B and C. Part A represents a typical macroeconomic country model. Straight lines indicate causal relationships that are of direct importance for the trade linkage, while the dotted lines represent the feedback to and from the rest of the model. The central variable (from the point of view of trade linkage) is the import volume, which is a function of final demand, capacity utilization and the import price relative to the final demand deflator. Together with the export price, the import volume feeds into the linkage model. The export price is determined as a function of domestic costs and competitors' prices, where the latter are an output of the linkage model, together with the import price and the export volume.

In Part A, all the variables are supposed to be measured in national currency. The linkage model treats variables measured in US dollars. Therefore there has to be an interface which converts the trade variables from national currency into US dollars and vice versa. This interface is represented by Part B, which also covers the cif-fob conversion (cf. Box 4). Bilateral trade flows in the linkage model are taken from bilateral export data, so fob imports have to be allocated between bilateral exports. This implies a conversion of import volume from cif into fob. In practice this happens through conversion of the value, with the volume calculated as the ratio between the value and the import price index, which, as an output from the linkage model, is a weighted average of (fob) export prices, using shares in fob imports as weights. The import price index has to be converted from fob to cif in order to feed back to the rest of the model. The specifications and estimation results for the cif/fob conversion equations are presented in Box 5.

After conversion into dollars, all countries' export prices and import volumes are inputs into the linkage model, represented in Part C. The fob import volume is next allocated over trade partners as a function of relative export prices. For the estimates this relative export price is defined for each bilateral trade flow as the ratio between the export price PX_i of the exporter and the fob import price index PMZ_j of the importer, but since the latter is a weighted average of the export prices, one might as well say that the fob import allocation is a function of the export prices of all countries supplying the importing country. This explains the dotted line from the fob import price to the allocation system. Next to relative prices, the allocation of fob imports between exporting countries may also be determined by structural shifts that cannot be explained by price movements. Here one may think of the effects of two (three) consecutive oil shocks plus the subsequent exploitation of North Sea oil, the accession of new countries into the Community, the strengthening or loosening of political ties between countries and so forth. All these influences are more or less exogenous and have in general been captured through the introduction of time trends or dummies. Furthermore the allocation takes place subject to a so-called adding-up constraint, i.e. it is ensured that all bilateral exports flowing to one importing country add up to given fob imports.[16] After this consistent allocation has taken place, the variables which feed back into the country models have to be calculated, i.e. export volumes, import prices and an index of competitors' prices. The export volumes of one country are calculated by simply adding up the bilateral trade flows originating in that country. Whether this happens in value or volume is indifferent since the bilateral exports are deflated by the total export price, bilateral prices being unavailable. The fob import price is calculated through division of the fob value of imports by the sum of the volumes of the bilateral exports flowing into the importing country. This is tantamount to weighting export prices by shares in fob import volume.[17] Using the export price indices and the bilateral trade flows again, finally a double weighted index of competitors' prices may be calculated as a by-product, which could feed into the export price equation. Having calculated these three outputs of the linkage model (export volume, import price and competitors' price index), they enter through the conversion interface of Part B as inputs into the country model as depicted in Part A.

It is clear from this description, that what are exogenous inputs for a country model (export volumes, import prices, competitors' price index) are endogenous variables in the linkage model and vice versa. Together these models therefore form a completely simultaneous system, although each type of model may be simulated independently with the outputs of the other as exogenous inputs. For linkage models it is the usual practice to assume in such an exercise that import volume and export price are given (exogenous), although it is clear from Figure 1 that both are directly influenced by the endogenous variables from the linkage model, namely the import price and competitors' price index, while the export volume also feeds back through final demand. Because of all other direct or indirect effects in the country model, a line has to be drawn somewhere. In a linkage model this line is usually drawn between Part A and Part B of Figure 1: in that way no domestic variables other than the trade variables in US dollars are needed, which

Figure 1 : **Structure of the trade linkage**



facilitates the maintenance and simulation of the linkage model. Another advantage of this approach is that it allows a 'consistency exercise' to be run. In such a Consistency Exercise the mutual consistency of independent forecasts for the volumes and prices of exports and imports are checked. Apart from statistical discrepancies there should be mutual consistency, since exports necessarily are (the sum of bilateral, fob) imports, and since import prices necessarily are (weighted) export prices. By taking the import volumes and export prices as exogenous inputs and simulating the linkage model, it can be checked whether the resulting export volumes and import prices (after allowing for cif-fob differences) are the same as those from the original forecasts and, if necessary, adjustments made to the latter (or the former, if the model is not believed).

A final remark concerns the trade-feedback models, whose structure is much simpler than that of the detailed country models, although essentially trying to capture the same phenomena. The differences between Part A in Figure 1 for a macroeconomic country model and a trade-feedback model are that for the latter, the arrow from export volume goes directly into import volume since there is no final demand variable, while the (dotted) arrow from the export price does not feed into the final demand deflator (which is also absent), but also directly in the import volume equation. In this way the inputs from the linkage model continue to influence the outputs of the trade-feedback model, which are then used as inputs for the linkage model and so on, without having to use other domestic variables for the trade-feedback models.[18]

Box 5: Cif/fob conversions

Two cif/fob conversions are needed to transfer variables from the country models to the bilateral trade flow model and vice versa: from fob to cif for import prices, and from cif to fob for import values. As discussed in Box 4, these conversions are not 'pure' in the sense that one could apply cif/fob ratios directly, but they rather have to be determined empirically. The specifications are presented first, followed by a brief discussion of the estimation results.

Specifications

For the equations which define the cif import price PM_j as a function of the quasi-fob import price PMZ_j, the following general specification is adopted (suppressing the country index j):

$$\ln PM = a + k_1.b(L).\Delta\ln PMZ + k_2.b(L).\ln PMZ_{-1} + (1 - k_2).\ln PM_{-1} \quad (1)$$

This equation is of the error correction type.[19] The most important parameters are those of the distributed lag function b(L), the sum of which represents the long-run elasticity of the cif index with respect to the quasi-fob index. Normally its value would be expected to be in the neighbourhood of 1. For stationarity, the value of the 'derivative control' parameter k_2 should be between 0 and 2, although an oscillating pattern may be avoided by constraining it to between 0 and 1. In principle values of the 'proportional control' parameter k_1 outside the (0,1) interval are also allowed, their only implication is an initial overshooting ($k_1 > 1$) or undershooting ($k_1 < 0$) of the target value instead of a gradual adjustment. Special forms of this equation are the partial adjustment model ($k_1 = k_2$) or the simple loglinear equation ($k_1 = k_2 = 1$). Finally correction of first and second-order autocorrelation has also been allowed for.[20]

If the quasi-fob import variable MZV_j were a true fob variable, the passage from cif to fob would simply consist of multiplication of the cif variable MV_j by a fob/cif ratio, and of treating this ratio as exogenous or a change in trends. For reasons sketched above this is not the case, however, and almost all attempts at such a type of quasi-identity failed to succeed. Therefore the same empirical approach as for the import price was adopted, with exactly the same error correction type specification:

$$\ln MZV = a + k_1.b(L).\Delta\ln MV + k_2.b(L).\ln MV_{-1} + (1 - k_2).\ln MZV_{-1} \quad (2)$$

Since all the comments following equation (1) also hold for this equation, they need not to be repeated.

Estimation results

Final estimation results for the quasi-identities (1) and (2) are given in Tables 25 and 26, respectively. As argued above, there were no particular reasons to favour one dynamic specification above the other, so starting from a general specification we have let the data determine the best result in terms of goodness of fit, significance of coefficients and expected coefficient ranges. In both tables the results are least satisfactory for Greece and Portugal, followed to a lesser extent by Spain, the rest of OECD zone (Turkey, Iceland, New Zealand) and the OPEC zone, with estimated standard errors above 4% for each estimation. This should be ascribed to the extreme variability of the data corresponding to these countries/zones relative to those of the other trade blocks. But for most other countries the results are quite acceptable in terms of the criteria cited above. The expected value 1 for the elasticity b is better respected in Table 26 than in Table 25. In the former table, the elasticity range is 0,88 – 1, 08, while in the latter table this range is exceeded in six cases. When the error correction specification (ECM) is adopted, the 'proportional control' parameter k_1 exceeds the value of 1 in several cases. As was noted above, this implies an initial overshooting of the target value. In two cases the sum of the autocorrelation parameters equals approximately one, pointing towards a loglinear model in first differences.

Tables 25 and 26 (see pages 119 and 120) belong to Box 5.

4.3. Simulations

The estimations of section 4.1 provided long-run bilateral relative price elasticities which all have the correct sign, usually are significant and fall into the *a priori* expected ranges. The speed of adjustment of the bilateral trade flows with respect to changes in relative prices, however, was high compared to expectations. In this section these properties of the bilateral trade flow model are further clarified and analysed with the help of the bilateral trade flow model as described in the previous section. First historical simulations within sample are presented, followed by simulations to calculate aggregate export price elasticities. Finally an out-of-sample simulation for 1985 is discussed.

4.3.1. Historical simulations within sample (1980-84)

Two sets of historical simulations within sample have been carried out: one to test the dynamic simulation properties of the quasi-identities (1) and (2) of Box 5 for which estimation results were presented in Tables 25 and 26, and a second to test the fit of the bilateral trade flow module, keeping these quasi-identities exogenous (i.e. equations (12) and (4) in Box 4).

Quasi-identities

The first test consisted of a dynamic simulation of equations (3), (4), (11) and (12) from Box 4 over the period 1980/I-1984/IV. For equation (12) this is tantamount to a single-equation dynamic simulation, while for equation (4) the errors from the quasi-fob import price PMZ of equation (12) are also transmitted and therefore cumulated with the errors, as is clear from Table 27, which gives the root mean-squared percentage errors (RMSPEs) for the two variables. The RMSPEs for the cif import price should be compared with the estimated standard errors (SER) of the estimated equations in Table 25. Differences between the two may be

Table 25

Estimation results for the cif import price index

$$\ln PM_t = a + k_1 . \Sigma_{i=0}^{2} b_i \Delta \ln PMZ_{t-i} + k_2 . \Sigma_{i=0}^{2} b_i \ln PMZ_{t-i-1} + (1-k_2) . \ln PM_{t-1}$$

Country	a	b_0	b_1	b_2	$\Sigma_i b_i$	k_1	k_2	$\bar{R}^2$	SER	DW	P(r)	Type	r_1	r_2
BLEU	0,061***	0,919*				1	1	0,998	2,44	1,861	0,214	Log	0,574*	0,238*
Denmark	0,032	0,964*				1	1	0,998	2,19	1,738	0,179	Log	0,527*	0,282**
FR of Germany	0,036***	0,948*				1	1	0,999	1,68	2,072	0,862	Log	0,812*	
Greece	0,322*	0,908*				1,376*	0,830*	0,982	6,56	2,060	0,118	ECM		
Spain	0,158*	0,944*				0,832*	0,584*	0,994	4,52	1,954	0,919	ECM		
France	0,002	0,567*	0,329*		0,849	1	1	0,997	2,42	2,109	0,427	Log	0,725*	0,262**
Ireland	0,043***	0,935*				1	1	0,998	2,28	2,106	0,856	Log	0,849*	
Italy	0,118*	0,914*				1	1	0,997	3,08	1,806	0,909	Log	0,363*	0,335*
Netherlands	0,059**	0,890*				1	1	0,999	2,10	2,162	0,492	Log	0,874*	
Portugal	0,588*	0,711*				1	1	0,945	9,83	1,959	0,849	Log	0,215***	0,340*
United Kingdom	0,232*	0,848*				1	1	0,997	2,75	1,978	0,967	Log	0,638*	
United States	−0,069*	1,050*				0,456*	0,456*	0,999	2,08	1,939	0,771	PA		
Canada	0,488*	0,753*				0,409*	0,422*	0,998	1,88	1,976	0,882	ECM		
Japan	0,303*	0,878*				0,771*	0,570*	0,998	2,57	1,779	0,123	ECM		
Australia	−0,038	1,032*				0,423*	0,270*	0,997	3,14	1,855	0,637	ECM		
Austria	−0,003	1,000*				1	1	0,998	1,99	2,141	0,295	Log	0,574*	0,353*
Finland	−0,304*	1,155*				1	1	0,997	3,17	1,960	0,132	Log	0,333*	0,240**
Norway	0,110*	0,899*				1,284*	0,262*	0,996	2,86	1,927	0,977	ECM		
Sweden[1]	0,011	0,996*				1	1	0,998	2,19	1,958	0,975	Log	0,541*	0,153
Switzerland	−0,101	1,032*				1,431*	0,452*	0,998	2,24	2,191	0,198	ECM		
Rest of OECD	−0,132	1,038*				0,511*	0,616*	0,993	4,76	1,966	0,862	ECM		
OPEC	0,262	0,940*				1	1	0,990	4,65	1,954		Log		
CPEs	0,177*	0,402*	0,204*	0,193*	0,799	1	1	1,000	0,75	1,963	0,600	Log	1,530*	−0,717*
NICs	0,055*	0,981*				0,821*	0,503*	0,999	1,98	2,075	0,554	ECM		
Rest of world	−0,080***	1,062*				1	1	0,995	3,82	1,919	0,893	Log	0,717*	

[1] For this equation a dummy for 1981/III-1984/IV was added with coefficient −0,045*.

Notes: Significance of coefficients: *** = 10%, ** = 5%, * = 1%.
$\bar{R}^2$ = R-squared, corrected for degrees of freedom, SER = estimated standard error of the regression (%).
DW = Durbin-Watson, P(r) = probability of no first-order autocorrelation using Durbin's (1970) m test.
Type: Log = log - linear ($k_1 = k_2 = 1$) PA = partial adjustment ($k_1 = k_2$), ECM = error-correction mechanism.
r_1 = first-order autocorrelation coefficient.
r_2 = second-order autocorrelation coefficient.
Estimation period: 1966/I-1984/IV.
Estimation methods: OLS, NLS.

Table 26

Estimation results for quasi-fob imports in current prices

$$\ln MZV_t = a + k_1 . \Sigma_{i=0}^{1} b_i \Delta \ln MV_{t-i} + k_2 . \Sigma_{i=0}^{1} b_i \ln MV_{t-i-1} + (1-k_2) . \ln MZV_{t-1}$$

Country	a	b_0	b_1	$\Sigma_i b_i$	k_1	k_2	$\bar{R}^2$	SER	DW	P(r)	Type	r_1	r_2
BLEU	0,124*	0,980*			0,877*	0,712*	0,999	2,34	1,996	0,942	ECM		
Denmark	−0,166*	1,029*			0,741*	0,554*	0,999	2,57	1,898	0,513	ECM		
FR of Germany	−0,43	0,996*			0,920*	0,562*	1,000	1,89	1,889	0,816	ECM		
Greece	0,076	0,952*			0,102*	0,102*	0,995	6,30	1,772	0,342	PA		
Spain	−0,057	1,006*			0,616*	0,563*	0,998	4,07	1,790	0,626	ECM		
France	−0,124*	1,018*			0,737*	0,644*	0,999	2,22	1,921	0,986	ECM		
Ireland	0,011	0,999*			0,745*	0,308*	0,997	4,69	1,963	0,942	ECM		
Italy	0,103**	0,600*	0,365*	0,965	0,866*	0,346*	0,998	3,79	1,881	0,393	ECM		
Netherlands	−0,009	1,018*			0,694*	0,473*	0,999	2,05	1,901	0,532	ECM		
Portugal	0,112***	0,880*			0,189*	0,189*	0,994	5,96	2,058	0,236	PA	0,369*	
United Kingdom	−0,147**	1,024*			0,752*	0,496*	0,999	2,76	1,960	0,966	ECM		
United States	−0,016	0,998*			0,629*	0,370*	0,999	2,92	1,881	0,620	ECM		
Canada	0,272*	0,950*			0,847*	0,766*	0,998	2,99	1,886	0,932	ECM		
Japan	−0,255	1,015*			1,012*	0,873*	0,999	3,11	2,068	0,644	ECM		
Australia	−0,204**	1,025*			0,868*	0,606*	0,997	4,33	1,951	0,793	ECM		
Austria	0,015	0,994*			0,833*	0,604*	1,000	1,80	2,026	0,950	ECM		
Finland	0,016	0,987*			0,739*	0,923*	0,998	3,91	1,871	0,785	ECM		
Norway	0,064	0,983*			0,710*	0,883*	0,997	3,79	1,912	0,511	ECM		
Sweden	−0,027	0,738*	0,260*	0,998	1,081*	0,559*	0,999	2,45	1,948	0,805	ECM		
Switzerland	−0,016	1,019*			0,703*	0,465*	0,998	3,19	1,751	0,739	ECM		
Rest of OECD	0,172*	0,662*	0,275*	0,937	0,741*	0,360**	0,996	4,83	1,895	0,364	ECM		
OPEC	0,063	0,664*	0,234**	0,898	0,881*	0,060	0,999	4,52	2,048	0,639	ECM		
CPEs	−0,049*	1,000*			1,025*	0,971*	1,000	0,92	1,978	0,986	ECM		
NICs	0,049	0,983*			0,820*	0,264*	0,999	2,48	1,981	1,000	ECM		
Rest of world	−0,168*	1,083*			1	1	0,999	2,94	2,098	0,552	Log	1,494*	−0,742*

Notes: Significance of coefficients: *** = 10%, ** = 5%, * = 1%.
$\bar{R}^2$ = R-squared, corrected for degrees of freedom, SER = estimated standard error of the regression (%).
DW = Durbin-Watson, P(r) = probability of no first-order autocorrelation using Durbin's (1970) m test.
Type: Log = log - linear ($k_1 = k_2 = 1$) PA = partial adjustment ($k_1 = k_2$), ECM = error-correction mechanism.
r_1 = first-order autocorrelation coefficient.
r_2 = second-order autocorrelation coefficient.
Estimation period: 1966/I-1984/IV.
Estimation methods: OLS, NLS.

for either of two reasons: one is that the equations, being estimated over the period 1966/I-1984/IV, perform less well over the 1980-84 period; the other is that autocorrelation may not have been removed effectively, and therefore errors accumulate because of the use of lagged dependent variables in the equations. *A priori* it is difficult to say which of these two reasons might apply. Moreover, the former cause may enhance the latter. Moreover, it is also possible that the former cause may exert positive influences on the fit: in that case the RMSPEs could be lower than the SER. As may be seen from the first two columns of Table 27, this happens for Spain, Finland, the OPEC, the NIC zone and the rest of the world zone. On the other hand, less satisfactory results are obtained for France, Austria and the zone for centrally planned economies, where the RMSPEs are more than double the SERs.

The third column of Table 27 gives the RMSPEs for the quasi-fob imports MZV of equation (4) in Box 4. Since they are a function of the cif import price PM, errors in the latter work through into the former, and the RMSPEs are therefore not directly comparable with the estimation results of Table 26. A proxy may be obtained if the RMSPE of the first column is subtracted from the third, even although this may become a negative number. On the basis of this evidence, comparatively large RMSPEs appear for Greece and the rest of the world zone.

Bilateral trade flow model

A second test consisted of a dynamic simulation, again over the period 1980/I-1984/IV, of the complete bilateral trade flow model (equations (3)-(12) from Box 4), keeping exogenous equations (12) and (4). In this way it is possible to concentrate on the fit of the bilateral trade flow equations alone. It should be remembered, however, that, as usual in a bilateral trade flow model, the export prices are also exogenous. The goodness of fit of the bilateral trade flows

Table 27

Root mean-squared percentage errors (RMSPEs) for the cif import price and quasi-fob imports, dynamic simulation of equations (3), (4), (11) and (12) of Box 4, 1980/I-1984/IV

(%)

	Cif import price PM		Quasi-fob imports MZV	
	RMSPE	SER	RMSPE	SER
BLEU	3,1	2,4	4,4	2,3
Denmark	2,8	2,2	3,4	2,6
FR of Germany	2,6	1,7	3,3	1,9
Greece	8,3	6,6	21,6	6,3
Spain	3,9	4,5	4,3	4,1
France	6,4	2,4	6,7	2,2
Ireland	4,4	2,3	10,7	4,7
Italy	4,0	3,1	5,3	3,8
The Netherlands	3,3	2,1	3,5	2,1
Portugal	13,1	9,8	16,0	6,0
United Kingdom	3,9	2,8	3,0	2,8
United States	3,1	2,1	6,2	2,9
Canada	2,2	1,9	2,7	3,0
Japan	3,2	2,6	4,1	3,1
Australia	3,8	3,1	7,4	4,3
Austria	4,8	2,0	4,5	1,8
Finland	2,3	3,2	3,7	3,9
Norway	4,8	2,9	4,3	3,8
Sweden	2,9	2,2	3,8	2,5
Switzerland	2,9	2,2	5,0	3,2
Rest of OECD	6,1	4,8	5,4	4,8
OPEC	4,1	4,7	7,4	4,5
CPEs	1,9	0,8	2,0	0,9
NICs	1,3	2,0	3,9	2,5
Rest of world	3,2	3,8	10,4	2,9

may be judged from the RMSPEs for the individual flow. Such results are presented in Table 28 for the flows between the four countries of Table 22: Germany, France, the United Kingdom and the United States. Compared to the SERs of Table 22, the RMSPEs of Table 28 generally perform well and are sometimes even better than the SERs.

Although the analysis of individual trade flows is of importance, it is perhaps more interesting to look at the goodness of fit of the outputs of the linkage model, i.e. export volumes and import prices. For the latter the quasi-fob import price PMZ has been taken, because analysis of the cif import price PM would also involve the errors of the quasi-identity (12), which was kept exogenous. The RMSPEs for export volumes and import prices are given in Table 29. Since the export prices are kept exogenous, the goodness of fit of the quasi-fob import price index PMZ is a good indication of how well the import shares are predicted. These are used to

Table 28

Root mean-squared percentage errors (RMSPEs) for the bilateral trade flows between Germany, France, the UK and the US, dynamic simulation 1980/I-1984/IV

(%)

From i	to j	RMSPE	SER (Table 22)
F	D	2,5	2,9
UK	D	6,1	5,8
US	D	5,4	7,0
D	F	2,4	2,0
UK	F	6,0	6,6
US	F	5,2	6,1
D	UK	3,4	4,0
F	UK	3,3	3,5
US	UK	6,3	6,4
D	US	5,4	5,0
F	US	7,0	5,9
UK	US	10,2	8,2

Table 29

Root mean-squared percentage errors for export volume and quasi-fob import price, dynamic simulation 1980/I-1984/IV

(%)

	Export volume X	Quasi-fob import price PMZ
BLEU	1,9	0,17
Denmark	1,7	0,32
FR of Germany	1,7	0,14
Greece	9,1	0,26
Spain	6,0	0,45
France	1,6	0,17
Ireland	4,2	0,41
Italy	3,8	0,30
The Netherlands	1,7	0,23
Portugal	5,4	0,41
United Kingdom	2,8	0,19
United States	2,1	0,14
Canada	2,5	0,19
Japan	5,3	0,13
Australia	3,6	0,22
Austria	1,6	0,14
Finland	3,1	0,27
Norway	3,5	0,33
Sweden	3,9	0,26
Switzerland	2,4	0,39
Rest of OECD	4,5	0,26
OPEC	3,8	0,26
CPEs	4,0	0,19
NICs	2,9	0,12
Rest of world	8,7	0,14

weight the export prices in order to obtain the import price index. As may be seen from the second column of Table 29, this seems generally to be satisfactory, with RMSPEs exceeding 0,4% only for Spain, Portugal and Ireland. The goodness of fit of exports is also satisfactory, especially if one looks at the countries for which detailed country models will be constructed: for them the RMSPEs are below 2% for the BLEU, Denmark, Germany, France and the Netherlands and below 3% for the United Kingdom and the United States. For countries outside this group the RMSPEs are of course somewhat higher but still not unacceptable given the statistical quality of the data. With only five countries having RMSPEs above 5% (of which Japan is perhaps the most worrying case), the overall picture regarding the goodness of fit of the bilateral trade flow model for the most recent part of the sample period therefore seems sufficient and only to call for marginal further improvements.

4.3.2. Aggregate export price elasticities

The bilateral relative price elasticities for the flows between the 25 countries and zones of the QUEST model as resulting from the preferred equations for all flows were given in Table 19. Although individual estimation results were only presented for the 12 trade flows between Germany, France, the United Kingdom and the United States, simulation of the complete trade flow model showed the satisfactory fit of the equations when aggregated into export volumes and quasi-fob import prices. In this subsection another aspect of the bilateral equations is analysed, again in an aggregate way, namely the total export price elasticities as they result from the bilateral relative price elasticities, and their dynamic profile.

As has been noted above, the speed of adjustment with which bilateral trade flows reacted to price changes increased if dummies, trends or other modifications were introduced in the bilateral trade flow equations (these modifications make it possible to obtain significant elasticities in *a priori* intervals, combined with an acceptable goodness of fit and lack of autocorrelation). Therefore it is of interest to see whether this tendency is indeed present for most bilateral trade flows. If so, the dynamic profile of the aggregate export price elasticities should indicate high speeds of adjustment of total exports to export price changes.

Table 30

Empirical export price elasticities for total exports of goods: long-run values and dynamic profile

	Cumulative effects[1]							% of 5-year effect					
	Q_1	Q_2	Q_3	year 1	year 2	year 5	CS	Q_1	Q_2	Q_3	year 1	year 2	year 5
BLEU	−0,37	−0,47	−0,52	−0,56	−0,60	−0,67	−1,07	55	70	78	84	90	100
Denmark	−0,60	−0,79	−0,89	−0,95	−1,06	−1,08	−1,14	56	73	82	88	98	100
FR of Germany	−0,47	−0,62	−0,70	−0,75	−0,82	−0,83	−1,19	57	75	84	90	99	100
Greece	−0,58	−0,72	−0,75	−0,76	−0,79	−0,73	−2,11	79	99	103	104	108	100
Spain	−0,54	−0,73	−0,82	−0,85	−0,89	−0,90	−1,04	60	81	91	94	99	100
France	−0,42	−0,56	−0,63	−0,67	−0,72	−0,73	−1,33	58	77	86	92	99	100
Ireland	−0,57	−0,80	−0,93	−1,01	−1,12	−1,18	−1,91	48	68	79	86	95	100
Italy	−0,71	−0,90	−0,97	−1,00	−1,03	−1,06	−1,44	67	85	92	94	97	100
The Netherlands	−0,43	−0,57	−0,64	−0,68	−0,76	−0,80	−0,77	54	71	80	85	95	100
Portugal	−0,32	−0,53	−0,67	−0,74	−0,93	−1,08	n.a.	30	49	62	69	86	100
United Kingdom	−0,55	−0,78	−0,90	−0,97	−1,07	−1,12	−0,87	49	70	80	87	96	100
United States	−0,56	−0,71	−0,79	−0,84	−0,92	−0,95	−0,51	59	75	83	88	97	100
Canada	−0,48	−0,59	−0,64	−0,66	−0,55	−0,65	−1,04	74	91	98	102	85	100
Japan	−0,51	−0,74	−0,87	−0,96	−1,04	−1,10	−1,13	46	67	79	87	95	100
Australia	−0,72	−0,90	−0,96	−0,99	−1,04	−1,05	n.a.	69	86	91	94	99	100
Austria	−0,29	−0,43	−0,52	−0,58	−0,71	−0,79	−1,54	37	54	66	73	90	100
Finland	−0,70	−0,85	−0,90	−0,91	−0,88	−0,93	n.a.	75	91	97	98	95	100
Norway	−0,57	−0,82	−0,97	−1,05	−1,16	−1,16	−1,54	49	71	84	91	100	100
Sweden	−0,51	−0,66	−0,72	−0,74	−0,77	−0,81	−1,54	63	81	89	91	95	100
Switzerland	−0,41	−0,56	−0,62	−0,66	−0,71	−0,73	n.a.	56	77	85	90	97	100
Rest of OECD	−0,82	−1,06	−1,17	−1,22	−1,51	−1,49	n.a.	55	71	79	82	101	100
OPEC	−0,38	−0,50	−0,59	−0,65	−0,76	−0,86	n.a.	44	58	69	76	88	100
CPEs	−0,46	−0,56	−0,59	−0,65	−0,74	−0,77	n.a.	60	73	77	84	96	100
NICs	−0,42	−0,64	−0,78	−0,88	−1,08	−1,30	n.a.	32	49	60	68	83	100
Rest of world	−0,95	−1,20	−1,31	−1,38	−1,53	−1,39	n.a.	68	86	94	99	110	100

[1] Percentage changes with respect to baseline simulation.

Note: CS gives the corresponding long-run export price elasticities of the consistency system of the Directorate-General for Economic and Financial Affairs, cf. Kröger (1985).

Table 30 presents the results of simulations in which quarterly export prices country after country have been shocked by 1%. The first six columns give the percentage changes with respect to the baseline simulation in each quarter of the first year, and the last quarters of years 2 and 5. It may be safely assumed that after 5 years (= 20 quarters) almost 100% of the long-run effect has taken place, so the results in the sixth column may be interpreted as the long-run effects. They show aggregate export price elasticities varying between −0,65 for Canada and −1,50 for the rest of OECD zone. The simple mean of the elasticities equals −0,97 with a standard deviation of 0,23. Knowing that a value of −1 for all bilateral relative price elasticities would imply constant import value shares, the value of −0,97 is to be interpreted as a confirmation of the fact that changes in import value shares caused by relative price changes should cancel each other out in the aggregate.

The aggregate export price elasticities of column 6 may be compared with those from the Consistency System of the Directorate-General for Economic and Financial Affairs,[21] given in column 7 (headed CS). These elasticities have been estimated on annual data over the period 1963-82 for manufacturing goods (SITC categories 5-9). The elasticities in this study are estimated on total trade data, and might therefore be expected to be lower than the elasticity for manufacturing goods of the consistency system. For most elasticities this is indeed the case, with the exception of the Netherlands, the United Kingdom and the United States. Comparison of the bilateral relative price elasticities in the two systems for the Netherlands shows that the elasticity in this study is higher because the bilateral relative price elasticities for exports from the Netherlands to other EUR 6 countries generally are lower in the consistency system. This might be due to the inclusion of the 1960s in the sample period for those flows. A similar comparison for the United Kingdom reveals higher elasticities in this study notably for exports from the United Kingdom to the EUR 6 countries (except Italy) and the United States. Inspection of Graphs 23, 26 and 33 suggests that this might be due to the strong correlations between the movements of import volume shares and relative prices in the last two years of the sample period. The four most important export markets for the United States are Canada, Japan, the NICs and the other developing countries (rest of world zone). The estimates for the corresponding relative price elasticities are higher than those for the consistency system, notably for US exports to Japan, where our elasticity equals −1,05, against −0,06 for the consistency system. Again differences in sample periods explain this discrepancy: while the import value share of the United States on the Japanese market remained fairly constant after the first oil shock (consistent with the QUEST elasticity of −1,05), the movements of import shares and price developments for the preceding decade usually went in directions contrary to theoretical expectations, biasing the relative price elasticity towards zero.

In the last six columns of Table 30 the cumulative effects on export volumes after the 1% increase in export prices are expressed as a percentage of the 5-year effect. As conjectured above, the high speeds of adjustment cause a large percentage of the effect to take place in the first year. On average, 88% of the total effect is realized in the course of the first year of the shock, which would correspond to a quarterly Koyck parameter of 0,59 ($=(1-0{,}88)^{1/4}$) and an annual parameter of 0,32 ($=(0{,}59/4).(1-0{,}59^4)/(1-0{,}59)$). For the consistency system, on the other hand, on average only 51% of the effect takes place in the first year, corresponding to an annual Koyck parameter of 0,49 ($=1-0{,}51$) only. Therefore, although the long-run total export price elasticities seem plausible, their dynamic profile suggests faster reactions of export volumes to prices than might be expected *a priori*. For the present, these dynamic profiles have been maintained in the bilateral trade flow model. In the future, notably when simulations involving relatively large price shocks have to be made (oil price shocks, currency revaluations/devaluations), it would perhaps be advisable, while maintaining the long-run relative price elasticities, to adjust the dynamic structure through a uniform or selective increase in the Koyck parameters, for instance such that the average value used in the consistency system is obtained. This would prevent world trade flows reacting more rapidly to changes in competitiveness than could be deemed realistic.

4.3.3. Historical simulations out of sample (1985)

As a final test for the QUEST trade linkage model, the model has been simulated over the period 1985/I-1985/IV, using as inputs interpolations of annual export prices and import volumes (obtained for 1985 by multiplying the 1984 figures by the annual growth rates for 1985). Given the procedure used, the only results presented are for ***annual*** growth rates for export volumes and quasi-fob import prices. These inputs (import volumes and export prices) and outputs (export volumes and import prices) are given, together with the actual values for the latter, in Table 31.

When analysing the results in the table, a first general remark concerns the development of export and import prices. While their growth rates are practically equal on a world scale for the historical values (−2,5% and −2,4%), the simulated world import price growth is, at −2,9%, lower than world export price growth. This implies a global gain in competitiveness which results in an overestimation of world export growth (5,0% versus 3,2%), even if corrected for differences in definition by not counting the intra-trade of the CPE zone for the world total.

Table 31

Inputs, outputs and actual growth rates[1] for a post-sample historical simulation of the trade linkage model, 1985/I-1985/IV

(average annual growth rates)

	Inputs		Outputs					
	Import volumes	Export prices	Export volumes			Import prices		
			Simulated		Actual	Simulated		Actual
BLEU[2]	1,7	0,1	7,0		2,2	−1,6		−0,9
Denmark	8,4	1,6	6,2		4,5	−1,2		0,7
FR of Germany	5,0	−0,4	6,1		7,9	−2,0		−1,1
Greece	13,3	−5,6	−2,5		−0,1	−2,2		−4,6
Spain	5,0	0,5	−3,9		2,9	−2,1		−2,1
France	5,8	1,3	4,4		2,8	−1,7		−2,0
Ireland	2,8	0,7	1,3		6,4	−0,7		0,2
Italy	8,8	−0,4	3,5		7,3	−2,3		−1,3
The Netherlands	5,9	−1,3	4,6		5,1	−1,7		−1,8
Portugal	3,7	−1,5	5,6		11,3	−0,8		−5,4
United Kingdom	3,2	1,8	6,0		5,4	−1,7		−0,5
EUR 12	5,5	0,1	5,0		5,6	−1,8		−1,3
United States	5,4	−4,5	7,5		2,1	−2,3		−3,2
Canada	9,2	−3,0	5,7		4,4	−3,7		−2,0
Japan	0,4	0,0	6,7		3,4	−4,0		−5,2
Australia	8,0	−11,1	12,8		10,2	−2,2		−7,7
Austria	5,6	−0,2	5,8		9,8	−2,6		4,4
Finland	6,1	3,3	−1,2		0,0	−3,3		2,7
Norway	11,4	1,8	1,7		2,5	−0,6		−2,1
Sweden	8,6	0,4	0,8		3,2	−1,0		−0,5
Switzerland	5,2	−7,5	9,9		12,0	−1,4		−4,3
Rest of OECD	4,0	−5,1	4,6		13,0	−3,4		3,0
OECD	5,3	−1,3	5,6		4,8	−2,2		−2,0
OPEC	−11,3	−2,6	0,7		−9,9	−2,4		−7,1
CPEs[3]	3,0	−11,4	10,3		5,7	−7,7		−1,6
NICs[4]	−1,5	−4,1 (NICs and Rest of world)	8,9	2,2 (NICs and Rest of world)	2,9 (NICs and Rest of world)	−2,9	−3,3 (NICs and Rest of world)	−2,6 (NICs and Rest of world)
Rest of world[4]	7,5		−8,0			−3,6		
World[3]	3,7	−2,5	5,0		3,2	−2,9		−2,4

[1] Source for inputs and actual values: Commission services.
[2] For inputs and actual values: Belgium.
[3] Excludes intra-trade of CPEs for inputs and actual values.
[4] Not distinguished individually for export prices and actual values.

Export volume growth for the Community countries is on average underestimated, except for the United Kingdom, Denmark and the BLEU. With a growth differential of 3,0 points between the growth of EUR 12 export prices and world import prices, certainly part of this underestimation may be due to the high speed with which this loss in competitiveness is translated into a negative effect on export volumes. Nevertheless this does not explain all of the observed differences in individual cases. For Belgium/Luxembourg, for instance, the difference between the simulated 7% growth and the market growth of approximately 5,5% (EUR 12 excl. BLEU + US) should rather be negative due to the fact that the export price growth of 0,1% implies a loss of competitiveness. For Spain, Portugal and Ireland, losses in competitiveness due to export price changes of 0,5%, −1,5% and 0,7% with concomitant fast price effects certainly explain part of the export growth differential between simulated and actual observations, but leave a part unexplained which could be ascribed to an autonomous positive trend following the export recovery of these three countries after the 1981-82 recession. The underestimation of the Italian export growth rate by 3,8 points is partly due to overestimation of the price effect, but might next also be explained by the explicit effect of the strong OPEC import volume decrease, −11,3%, as the OPEC zone took 12% of Italian exports in 1984.

Of the other countries, the most striking differences in growth rates for export volumes occur for the United States, Japan and the OPEC zone. For the United States, there is a growth differential of 5,4 points between simulated and historical values. This difference may be ascribed almost completely to the fact that the export price growth rate is based on a price index with base year 1982 instead of 1972 as used for the other US variables. The increase in export prices under the old definition is more than five points higher which, with an aggregate export price elasticity close to −1,0, accounts for the major part of the discrepancy. Also for Japan there is a growth differential, of 3,3%. With Japanese export prices being stable in 1985 and world import prices falling by 2,9%, the high bilateral relative price elasticities on Japan's most important export markets such as the United States (−1,65) and the rest of the world zone (−1,55) should be seen as the main cause behind this differential, together with the high adjustment speed of Japanese exports to price changes. Anecdotally, one might also think of voluntary export restraints as a source for overestimation. The growth differential between simulated and historical values for exports of the OPEC zone, finally, amounts to 10,6 points. The simulated growth rate of 0,7% is based on a marginal deterioration of competitiveness and a somewhat smaller export growth than that of its relevant export markets, due to the introduction of downward trends in some bilateral trade flow equations. The historical value of −9,9%, on the other hand, must be seen as the result of a long-term relative price effect still due to the two oil shocks and subsequent autonomous shifts in preferences away from OPEC oil to other energy suppliers, combined with the OPEC efforts to install a production quota.

There is no need to say much about the quality of the simulation results for import prices. The differences in growth rates usually do not exceed 1,0 point, especially for the larger countries, while they may be somewhat larger for the smaller countries. The seemingly large differences for the OPEC and CPE zones must be ascribed to the uncertainty surrounding their historical observations: for the countries belonging to these zones, import price developments are usually not reported by the countries themselves and can only be estimated on the basis of export price changes of their partner countries.

For the out-of-sample simulations the principal conclusion is that the high speed of adjustment of bilateral trade flows to price changes in the present version of the QUEST trade linkage model has caused most of the discrepancies between simulated and observed growth rates for export volumes and import prices. Apart from this feature, whose importance varies with the size of the relative price changes, the simulation results seem to track well historical developments in 1985.

5. Conclusions

The main feature of the approach to international trade linkages for the QUEST model described in this paper, is that bilateral trade flows between the 25 countries and zones of the model are determined in two steps. In the first step it is assumed that an aggregate national producer takes a decision, given his production technology, about the part of final demand to produce domestically and the part to import. This decision fixes a total amount of imports, which is then, in a second step, allocated between different foreign suppliers (exporters) as a function of their competitiveness as expressed in price differences. This leads to the need to estimate two types of behavioural equations: total import equations to determine the total amount of imports, and bilateral import equations which allocate these total imports over the different competing exporters.

An important implication of this two-step procedure is the assumption that the geographical distribution of total imports over foreign suppliers as exemplified in import shares is independent of the distribution between domestic production and total imports. For example, if a country increases its domestic oil production in order to substitute oil imports, it is assumed that the subsequent import decrease is spread evenly over all foreign suppliers. This hypothesis is not realistic if only some of the foreign suppliers are actually supplying oil, since, generally speaking, only oil imports from these suppliers would diminish, thus modifying the geographical distribution of total imports through their decrease in import shares. Although this is a microeconomic example of which there exist many more in reality, the importance of oil for most economies can almost be called 'macroeconomic', as is clearly illustrated in the case of the United Kingdom. The latter country is an oil producer itself, but even in a country where all oil is supplied by imports, if oil consumption were to fall (induced for instance by energy saving policy), then for the same reason the assumptions underlying the two-step approach would be incorrect.

The special nature of trade in energy/oil is the major cause of violations of the assumptions underlying the two-step approach. To deal with this total trade should ideally be split into two categories: one for energy/oil products (e.g. SITC categories 3 or 33), and the other for non-energy/oil trade. Limitations on the data available for bilateral trade flows means that, for the present version of the QUEST model, the split between energy/oil and other products must be limited to the total import equations. The bilateral trade flow model is therefore still based on total trade, although *ad hoc* provisions in order to deal with the energy problem have been made through the introduction of trends and/or dummies.

The total import equations, being based on a CES aggregate national production function, describe the demand for total imports as a function of final demand and the import price relative to the final demand deflator. In order to distinguish between economic behaviour, as represented by the elasticity of imports with respect to final demand, and forecasting properties, a trade integration variable has been introduced in the equations in a theoretically consistent manner. While thus recognizing the persistent positive growth difference of at least 2 percentage points between imports and final demand for forecasting purposes, the trade integration variable reduces the import volume elasticity that is implied for policy simulations to values in the range 1,0—1,5. Finally, disequilibrium elements enter the equation through the introduction of the degree of capacity utilization as explanatory variable. Estimation of a dynamic version of this equation for Germany, France, the United Kingdom and the United States over the period 1965/I-1984/IV based on total (i.e. including energy/oil) import data produced unsatisfactory results in terms of sign, size and significance of the coefficients for the three EC countries. A stability analysis of these equations suggested that more satisfactory results, especially concerning the elasticity of substitution, could be obtained if the sample were reduced to the post-1973 era. This proved indeed to be the case, except for the United Kingdom which in this period started its oil exploration and production. The elimination of energy/oil from the import concept as a next step to improve the equations led to a notable improvement in the estimation results, and in particular to more significant and higher elasticities of substitution. The only exception here is Germany, but this may have been caused by the fact that the category 'mining products' was used as a proxy for energy/oil products. The equations excluding energy/oil lead to volume elasticities in the range 1,1—1,6, elasticities of substitution between 0,3 and 0,8, and quasi-elasticities with respect to the degree of capacity utilization varying between 0,3 and 1,1. The adjustment of non-energy/oil imports to price changes is faster in the United Kingdom and the United States than in Germany and France, where it takes 1,5 quarter for 50% of the total effect to take place.

The bilateral import equations were derived in a theoretical framework consistent with that for the derivation of the total import equations. The basic equations give the volume of the trade flow from country/zone i to country/zone j as a function of the import volume of j and the export price of i relative to the prices of its competitors on market j. Although the incorporation of disequilibrium elements through the introduction of the degree of capacity utilization of exporter i is theoretically justified, the empirical results for this explanatory variable were such that it was decided not to include it in the equations in its present form.[1] The bilateral import equations being derived from a linear homogeneous (CRESH) function, the elasticity of bilateral imports with respect to total imports is *a priori* equal to one, such that the equations reduce to import volume share equations, in which the main coefficient is the elasticity on the relative price.

For the present version of the bilateral trade flow model, the bilateral import equations were estimated on aggregate trade (i.e. including energy/oil) data, with autonomous divergencies between import volume shares and relative prices being accounted for through the introduction of trends and/or dummies. This leads to bilateral relative price elasticities varying on average around − 1,0, which is the value imposed by the zero-sum nature of a relative price change in a model where exports should consistently add up to imports. Although the relative price effects are close to *a priori* expected values, the dynamics of the equation imply a very fast adjustment of bilateral trade flows to changes in relative prices, with on average almost 90% of the total effect on the quarterly variable being realized in the first year (almost 70% for the annual variable). Even though the adjustment lag of total imports delays the effects in the complete model, this still does not always seem to correspond to reality, certainly if relative price changes are large. Although a historical within-sample dynamic simulation over the period 1980-84 produced a satisfactory fit for export volumes and import prices, this aspect was illustrated in a simulation used to calculate aggregate export price elasticities, and also in a post-sample historical simulation for the year 1985. In the latter simulation, although the results were generally satisfactory, most of the larger differences occurring between actual and simulated values could be ascribed to the rapidity with which trade flows are estimated to react to price changes. For future work, therefore, it is proposed to reduce the speed of the relative price effects, e.g. through introduction of the values obtained from estimations on annual data, or through a uniform autonomous change in the parameters of the model governing this speed. At the same time it would be possible to start with the incorporation of explicit energy effects in the bilateral trade flow model, e.g. through the introduction of a dichotomy in the import volume variable depending on whether the exporter is a significant oil supplier or not.

Footnotes

Chapter 1

1 Cf. Dramais (1986). This model links models for the European Community, the United States, Japan and the rest of the world.

2 Cf. Barten *et al.* (1976, 1980) and Bucher and Rossi (1985). More detailed information about the Eurolink model is given in both national model documentation and Eurolink survey (Doc. II/226/84).

3 These models will mainly consist of import equations and export price equations. Increased export revenues would stimulate imports, while changing competitors' prices would affect export prices.

4 Cf. OECD (1985).

Chapter 2

1 Cf. Italianer (1986, Ch. 1).

2 For a treatment of a multi-good framework, cf. Italianer (1986, Ch. 2).

3 We assume that these also comprise imports of services.

4 In a disequilibrium framework this is the effective demand case.

5 A function $f(x_1,...,x_n)$ is weakly separable with respect to a mutually exclusive and exhaustive partitioning of its elements if the marginal rate of substitution F_i/F_j between any two elements x_i and x_j of any subset is independent of the quantities outside this subset: $\frac{\delta}{\delta x_k}(F_i/F_j) = 0$ with x_k not in the same subset as x_i and x_j.

6 Cf. Goldman and Uzawa (1964).

7 Cf. Gorman (1971).

8 Cf. Blackorby *et al.* (1974).

9 Cf. Italianer (1986, Ch. 2).

10 Not only the domestic utilization rate could appear as an explanatory variable in this framework, but also foreign utilization rates. The influence of the latter is however usually assumed to be zero in total import equations, cf. Catinat (1984).

11 Cf. Junz and Rhomberg (1965, 1973).

12 Almon lags were also tested, but did not improve the significance of the substitution elasticity.

13 In the bilateral import equations the index j is used to distinguish the importer j from the exporter i.

14 Cf. Italianer (1986, Ch. 9).

15 Cf. Italianer (1986, Ch. 5).

16 Cf. Hanoch (1971).

17 Cf. Italianer (1986, Ch. 2).

18 The bilateral import volume X_{ij} is obtained using the total export price PX_i as a deflator for the value flow XV_{ij}.

19 Cf. Catinat (1984).

20 The homogeneity assumption for the function in (3) implies that the value shares of bilateral imports in total imports are independent of the level of imports. If the domestic rate of capacity utilization were to appear in both the total and the bilateral import functions, a change in this rate would imply a change in aggregate imports and in bilateral import shares at the same time, thus violating the separability condition.

21 Cf. Dramais (1974/1975).

Chapter 3

1 Cf. Doc II/251/86 ('The QUEST data base on quarterly national accounts, monetary sector and balance of payments data. Germany, France, United Kingdom and United States') and Doc. 15.12.86/II/10997 ('Preliminary investigation of the investment block in the QUEST model').

2 There are differences in the periodicity of the data (Compact uses annual data, this study quarterly), the sample period (1958-82 for Compact, 1965-84 for QUEST), the use of oil price shock dummies (in Compact), the relative price index (Compact uses a domectic price deflator PD, this study a final demand deflator) and correction for autocorrelation (used in Compact, and not for Table 5, although this does not influence the coefficients greatly).

3 This number may be calculated, under the assumptions of no price discrimination and homogeneous bundles of goods, as $(51{,}4/45{,}6)^{1/19} - 1 = 0{,}6\%$.

4 This is standard practice, cf. Artus *et al.* (1980), Van der Windt *et al.* (1984), Haynes and Stone (1983) or Spencer (1984). Note, however, that these authors differ as to the use of the degree of capacity utilization in levels, logs or growth rates.

5 Although the relative price jumps from 1973/IV to 1974/I, the break is located in 1974/I-II. This is due to the Koyck lag on the relative price.

6 The points plotted in the graphs correspond to the last (first) observation included in the sample. So the first point in Graph 12 is the coefficient from the regression for 1965/I-1969/IV. The value of the Koyck parameter has been fixed at the value of Table 9.

7 Cf. Spencer (1975).

8 Preliminary tests with a specification similar to that for total imports have shown that acceptable results might be obtained in that way, save for the effect of the degree of capacity utilization. For the United Kingdom the relative price elasticity proved to be considerably stronger than for the other countries.

9 For the total import equation, the estimation results are (with standard errors in brackets):

$a = -2{,}567$,	$b = 1{,}138$,	$c = -0{,}310$,	$d = 0{,}318$,	$k = 0{,}583$,
(0,863)	(0,087)	(0,171)	(0,169)	(0,143)

$SER = 1{,}5\%$, $\bar{R}^2 = 97{,}7$, $DW = 2{,}15$.

10 Cf. previous footnote.

Chapter 4

1 One of the most extreme examples in this respect are the Netherlands, for which trade declared as imports only reaches about 80% of the exports declared as going to this country. This is due to the fact that a considerable percentage of the latter trade only stays in transit and is therefore not recorded as imports.

2 Cf. Docs 11.3.1986/II86 2149 ('Total import and export data (value, volume, prices) for the countries and zones of the new quarterly multi-country econometric model') and II/350/86 ('Bilateral trade flow data for Fortrade, the linkage block of the QUEST model').

3 Cf. footnote 1.

4 This may be due to differences in the timing of the recording of the flows, differences in classifications and recording systems, smuggling, theft, errors, omissions, etc.

5 For the moment, the distinction between total imports of energy/oil and non-energy/oil products as suggested in Chapter 3 has not yet been implemented in the bilateral trade flow model. The volume variable therefore comprises all imports of goods, incl. energy/oil.

6 Cf. Doc. II/430/86 ('The stability of the world trade allocation mechanism, 1961-84. Tests based on export demand functions for 25 countries/zones').

7 Tables 22 and 23 differ from Tables 20 and 21 in that they give for the coefficient b_{ij} the short-run elasticity; the long-run elasticity may be found in the column $b_{ij}/(1-c_{ij})$.

8 Cf. Dramais (1986, p. 160).

9 Let the variables w_t and y_t in the quarterly equation $\ln w_t = a.(1-c) + b.(1-c).\ln y_t + c.\ln w_{t-1}$ be stock variables, such as the import volume share and relative price variable in the bilateral trade flow equation. Then the corresponding annual equation approximately has the form $\ln w_T = a.(1-c^4) + b.(1-c^4).\ln Y_T + c^4.\ln w_{T-1}$, with w_T the annual average of w_t, and $\ln Y_T$ defined as $\ln Y_T = (1-c)/(1-c^4).(\ln Y_{T0} + c.\ln Y_{T1} + c^2.\ln Y_{T2} + c^3.\ln Y_{T3})$, with Y_{Tj}, $j = 0, 1, 2, 3$, the average of the values of y_t for the last j quarters of year $T-1$ and the first $4-j$ quarters of year T. Because this equation does not use the same definition for the relative price variables as the quarterly equation estimated on annual data ($\ln Y_T$ versus $\ln Y_{T0}$), the Koyck parameter corresponding to the latter does not equal c^4, as one would expect, but $(c/4).(1-c^4)/(1-c)$. This result is obtained if the first-year effects of a sustained stock in y_t are put equal to each other for the two equations.

10 This should be the bilateral export price. Under the assumptions of a homogeneous bundle of goods and no price discrimination, the bilateral price may be replaced by the total export price PX_i.

11 Cf. Italianer (1986, Ch. 2).

12 For a more elaborate approach in which the adjustments are endogenized, cf. Don (1982).

13 Cf. the defintion of PMZ_j in Box 4. If we assume each bilateral trade flow in value X_{ij} to consist of the export price PX_i multiplied by a volume X_{ij}, the definition of PMZ_j amounts to $PMZ_j = \Sigma_i v_{ij}.PX_i$, with v_{ij} the import volume share $v_{ij} = X_{ij}/\Sigma_h X_{hj}$.

14 Cf. Doc II/350/86 ('Bilateral trade flow data for Fortrade, the linkage block of the QUEST model').

15 Cf. previous footnote.

16 There is a stream of models in which this identity is not respected on a national level or even a world scale, using as main argument that the accounting discrepancy in practice cannot be distinguished from white noise in the data or estimations. Though this argument may be valid for forecasting purposes, it is a less desirable property for policy simulations. Cf. Courbis (1981).

17 Cf. footnote 13.

18 For some countries or zones, the introduction, in addition, of the volume of GDP and its deflator could be tried.

19 Cf. Davidson *et al.* (1978).

20 If r_1 and r_2 are the first and second-order autocorrelation parameters, and if we have $1 < r_1 < 2$ and $-1 < r_2 < 0$ with $r_1 + r_2 \approx 1$, this equation corresponds approximately to a loglinear equation in first differences with autocorrelation parameter $-r_2$. We have two such results (cf. Tables 25 and 26).

23 The Consistency System contains bilateral trade flow models for the SITC categories 0−1, 2+4, 3 and 5−9 for 22 countries/zones. The relative price elasticities for the first three categories are zero, and those for SITC 5−9 have been estimated on annual bilateral trade flow data for manufacturing goods, cf. Kröger (1985). The Consistency System is used for consistency exercises during the forecasting rounds at the Directorate-General for Economic and Financial Affairs.

Chapter 5

1 That is, in levels; if data on this variable become available for more of the 25 countries/zones, it could be introduced relative to the degrees of capacity ulitization of its competitors.

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