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The importance of rationing in international trade: A theoretical and econometric analysis for the Federal Republic of Germany

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Sonderforschungsbereich 178 "Internationalisierung der Wirtschaft"

Diskussionsbeiträge



Juristische Fakultät Fakultät für Wirtschaftswissenschaften und Statistik

Wolfgang Franz Gustav Heidbrink

The Importance of Rationing in International Trade: A Theoretical and Econometric Analysis for the Federal Republic of Germany

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THE IMPORTANCE OF RATIONING IN INTERNATIONAL TRADE: A THEORETICAL AND <u>ECONOMETRIC</u> ANALYSIS FOR THE FEDERAL REPUBLIC OF GERMANY

Wolfgang(Franz Gustav Heidbrink 6

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Abstract

This paper deals with the importance of rationing for international trade flows. The analysis is based on a macroeconometric rationing model for the Federal Republic of Germany. Besides a theoretical treatment of various channels through which rationing occurs, an estimation of a rationing model is carried out with special reference to the trade flows. A crucial question concerns the adequate variable which may be able to capture rationing. This paper discusses to what extent that answers from a business survey may be used as proxies for possible rationing.

The Importance of Rationing in International Trade: A Theoretical and Econometric Analysis for the Federal Republic of Germany

by

Wolfgang Franz and Gustav Heidbrink University of Konstanz

1 Introduction

The purpose of this paper is to investigate the importance of rationing schemes for international trade flows using a macroeconometric rationing model for the Federal Republic of Germany. There are several possible channels through which rationing may influence trade flows. An excess demand for domestic goods may induce additional imports to bypass this constraint while, on the other side, an excess demand on the world market may restrain imports into Germany. Moreover, domestic constraints may hinder foreign demand for domestic products while rationing prevailing on foreign markets may enhance German exports. Besides a theoretical analysis of these channels (and others) their importance is tested econometrically by estimating equations for exports and imports. A crucial question in this context is how to capture those rationing schemes. In this paper we analyze the adequacy of business survey data as indicators for possible rationing of firms. The data used are answers from a business survey in which firms respond to questions whether they feel rationed by different types of constraints. A first question, therefore, is to what extent such data perform better compared with capacity utilization rates otherwise used as proxies for rationing. Moreover, another important aspect of our paper is to test how robust the estimated regime shares are when alternative indicators for rationing are used. If these shares are very sensitive with respect to the use of different proxies, this would render the message of the rationing model less reliable.

The remainder of the paper is organized as follows. The next section provides a short summary of the basic philosophy of the model under consideration. This is followed by a discussion of important behavioural equations with a special reference to international linkages and by a presentation of the empirical results. The conclusion summarizes our findings and caveats and directs attention to further research.

2 Basic Structure of the Model

Since the basic philosophy of the model has been surveyed elsewhere¹ we can be very brief and concentrate on our own modifications and extensions.

To begin with output and employment decisions, their flexibility depends on the time span under consideration:²

¹See Franz and König (1990) and Drèze and Bean (1990), for example.

 $^{^{2}}$ The following considerations are partly based on Smolny (1990) where a more detailed analysis of various aspects is presented.

Table 1: Variables of the theoretical model
YT : Output transacted
YD : Demand for output
YC : Output determined by existing capacities
YS : Supply of output
$Y_{L^{\bullet}}$: Output produced with optimal labor demand L^{\bullet}
Y_{LS} : Output produced with full utilization of labor LS
K : Capital stock
LT : Employment
LD : Demand for labor
LS : Supply of labor
L_{YC} : Labor demand determined by YC
L^* : Optimal labor demand determined by expected goods demand $E(YD)$

(i) In the short run the firm's supply of output is fixed and the transacted quantities on the market (YT) are the minimum of the goods demanded (YD) and goods supplied (YS), i.e.,

$$YT = \min(YD, YS). \tag{1}$$

(ii) In the medium run employment can be subject to variations, whereas the capital stock is still a fixed factor of production. Employment (LT) is then the minimum of labor demanded (LD) and labor supplied (LS), i.e.,

$$LT = \min(LD, LS). \tag{2}$$

The demand for labor is either determined (as L^*) by expected goods demand (YD) or (as L_{YC}) by the optimal utilization of existing capacities (YC). Consider L_{YC} first and note that, by definition,

$$L_{YC} \equiv \frac{YC}{(Y/L)^*} \equiv K \cdot \left(\frac{Y}{K}\right)^* / \left(\frac{Y}{L}\right)^*, \qquad (3)$$

where the terms in brackets denote optimal capital and labor productivity, respectively. They can be derived from the first-order conditions of a cost minimizing firm given a CES-technology and depend on factor price ratios and efficiency terms reflecting labor and capital saving technical progress, respectively. The determination of L^* is best understood by recognizing that in the optimum marginal costs of labor (i.e., the wage rate W) should equal marginal returns from labor (P is the price of goods):

$$W = P \cdot \operatorname{prob} \left[YD > Y_{L} \cdot \right] \cdot \left(\frac{Y}{L} \right)^{\star}$$
(4)

The r.h.s. term of eq. (4) reflects the marginal returns from labor. Y_{L^*} is output produced by the optimal labor demand L^* . The second expression stands for the probability that expected goods demand exceeds those quantities (Y_{L^*}) which can be produced with optimal labor (L^*) . As can be shown³, from eq. (4) one can develop the following equation for labor demand by making use of a log-normal distribution of excess demand on micro markets and a logistic approximation of the cumulative distribution function:

$$L^* = E(YD) \cdot \left(\frac{L}{Y}\right)^* \cdot \left[\exp(-0.5 \cdot \sigma_{yd}^2) \cdot \left(\frac{1-sl}{sl}\right)^{\alpha}\right]$$
(5)

³See Franz, Heidbrink and Scheremet (1991), Appendix A.

where E is the expectations operator, σ_{yd}^2 is the logarithmic variance of goods demand, and

$$sl = \frac{W}{P} \cdot \left(\frac{L}{Y}\right)^*, \quad \alpha = \frac{\sigma_{yd} \cdot \sqrt{3}}{\pi}.$$

(iii) In the long run firms can adjust capacities (YC) by changing the capital stock (K) and/or the production technology. More specifically, YC is determined by the condition that the expected marginal return of capital should equal capital costs. The first-order condition for an optimal capital stock is given by equating the marginal revenue from capital minus the additional labor costs for a marginal investment with marginal capital costs (UC):

$$P \cdot \operatorname{prob}\left(Y^{A} > YC\right) \cdot \left(\frac{Y}{K}\right)^{\bullet} - W \cdot \operatorname{prob}\left(Y^{A} > YC\right) \cdot \left(\frac{L}{Y}\right)^{\bullet} \cdot \left(\frac{Y}{K}\right)^{\bullet} = UC \quad (6)$$

or:

$$\left[P - W \cdot \left(\frac{L}{Y}\right)^*\right] \cdot \left(\frac{Y}{K}\right)^* \cdot \operatorname{prob}(Y^A > YC) = UC$$
(7)

where Y^A denotes the minimum of Y_{LS}, Y_L and YD:

$$Y^A \equiv \min\left\{Y_{LS}, Y_{L^{\bullet}}, YD\right\}.$$
(8)

 Y_{LS} is output which can be produced with available labor supply. $YD, Y_{L^{\bullet}}, Y_{LS}$ are the possible constraints that may prevent the firm from full utilization of capacities.

$$Y_{LS} = LS \cdot \left(\frac{Y}{L}\right)^*, \qquad (9)$$

$$Y_{L^*} = L^* \cdot \left(\frac{Y}{L}\right)^* . \tag{10}$$

Solving for $(\operatorname{prob}(Y^A > YC))$ yields the expression:

$$\operatorname{prob}(Y^A > YC) = \frac{sk}{1-sl} \tag{11}$$

with

$$sk = \frac{UC}{P} \cdot \left(\frac{K}{Y}\right)^*$$

From this the following equation for YC can be developed by making use of the same methods as in step (ii):

$$YC = E(Y^{A}) \cdot \left[\exp(-0.5 \cdot \sigma_{Y^{A}}^{2}) \cdot \left(\frac{1 - sl - sk}{sk}\right)^{\beta} \right]$$
(12)

with

$$\beta = \frac{\sigma_{y^A} \cdot \sqrt{3}}{\pi}.$$

Capacities are chosen to be proportional to the expected minimum of goods demand YD and goods supply Y_{L^*} and Y_{LS} determined by L^* and LS. Further determinants are a measure of profitability and the variance of log Y^A .

Then K is obtained by:

$$K = \left(\frac{K}{Y}\right)^* \cdot YC. \tag{13}$$

We now turn to the aggregation of demand and supply quantities from the micro goods and labor markets to economy wide quantities. Following Lambert (1988) we assume the joint statistical distribution of micro level goods demand and supply to be described by a bivariate lognormal distribution. Aggregation over micro markets then yields a tractable functional form for goods transacted YT ("smoothing by aggregation"):

$$YT = \left\{Y_{LT}^{-\rho_1} + YD^{-\rho_1}\right\}^{-\frac{1}{\rho_1}}$$
(14)

The two variables Y_{LT} and YD in the CES-function have the following interpretation. Y_{LT} is output determined by employment times optimal producitivity, i.e. labor productivity at full utilization of labor. As mentioned before [(see the discussion of eq.(3)], the latter is obtained by regressing actual labor productivity on, among others, factor prices and capacity utilization. Using this regression and calculating labor productivity for full utilization gives the aforementioned optimal labor productivity.

In our model consumers and investors can bypass rationing on domestic markets by additional imports, i.e. parts of imports are due to domestic rationing barriers. "Structural imports" denote imports in the absence of domestic rationing. Similar arguments hold for structural exports which exceed actual exports because domestic constraints will hinder foreign demand. Only in a situation with no rationing on the domestic market, actual exports equal the structural exports.

A mismatch parameter ρ_1 enters the CES-function. It measures the mismatch of supply and demand on the goods markets. For $\rho_1 \rightarrow \infty$ equation (14) tends to the usual minimumcondition, i.e., now not only each micro market but also the aggregate economy is subject to only one of the constraints.

Similar arguments can be applied to the labor market. Transacted labor LT, i.e., employment, is determined either by labor supply LS or by labor demand LD. The latter is split into labor demand based on expected goods demand (L^*) and labor demand brought about by productive capacities L_{YC} . By the same way of reasoning we obtain:

$$LT = \left\{ LS^{-\rho_2} + (L^*)^{-\rho_2} + (L_{YC})^{-\rho_2} \right\}^{-\frac{1}{\rho_2}}.$$
 (15)

Eq. (15) can be transformed into elasticities of LT with respect to LS, L^* , and L_{YC} . Moreover, these elasticities can be shown to represent share of firms ("regimes") being constrained either by labor supply, goods demand, or capacities:

$$\epsilon_{LT,LS} = \left\{ LT/LS \right\}^{\rho_2}$$

$$\epsilon_{LT,L_{YD}} = \left\{ LT/(L^*) \right\}^{\rho_2}$$

$$\epsilon_{LT,L_{YC}} = \left\{ LT/L_{YC} \right\}^{\rho_2}$$
(16)

Similar elasticities can be derived from eq. (14) for the goods market. The elasticities of YT with respect to Y_{LT} and YD represent the shares of firms being constrained either by supply or by demand on the goods markets.

$$\epsilon_{YT,Y_{LT}} = \left\{ YT/Y_{LT} \right\}^{\rho_1} \\ \epsilon_{YT,YD} = \left\{ YT/YD \right\}^{\rho_1} \right\}$$
(17)

These regimes highlight the philosophy of the approach. While the micro markets are governed by the exact minimum- conditions, there is a gradual change of regimes on the aggregate level.

3 Trade Determination

This section is devoted to a discussion of the equations determining exports and imports of the FRG.

An important aspect is the question whether trade is subject to rationing. There are several channels through which rationing can affect exports and imports:

- (i) An excess demand for domestic goods may induce additional imports into Germany in order to bypass this constraint. It can also hinder German exports, especially if domestic firms prefer to deliver to domestic customers. This latter effect is mitigated if firms do not wish to give up foreign markets which have been built up in former times (for example, when conditions on the domestic market have been less favourable). Due to sunk costs of entering foreign markets firms prefer to stay in foreign markets even if domestic business improves as is put forward by the hypothesis of hysteresis in international trade [Baldwin (1990)].
- (ii) Rationing on foreign markets can also affect German exports and imports. An excess goods demand on the world market possibly restrains German imports which compete with the goods demand of other countries. On the other hand, German exports may be negatively influenced if an excess goods supply is observed on the world market where domestic firms compete with foreign ones.

In order to capture these possible barriers, we employ two different but not mutually exclusive variables. One proxy is capital utilization [see Franz, Heidbrink, Scheremet (1991)]. More specifically, we use the ratio of actual capital utilization to its minimum value during the sample period (1960-1988) or, in logs, $(q-q^{min})$ and $(q-q^{min})^i$, where q is the log of capital utilization, and the superscript min denotes its minimum value, whereas *i* denotes the foreign country under consideration (see below). The use of the q^{min} -variables assumes no rationing (excess demand) if capital utilization is at its minimum value.

In this paper for domestic constraints we make use of answers given by firms of the manufacturing sector in a quarterly business survey taken by the Ifo-institute in Munich. There are two questions which are relevant here:

- 1. Is your domestic production hindered?
- 2. If so, is it hampered by
 - lack of order,
 - shortage of workers,
 - shortage of materials, or
 - shortage of technical capacities?

For the purpose of this study there are two major problems associated with this data set. Before 1980 the Ifo-Institute has included these questions only three times per year (January, May, September) rather than quarterly (January, April, July, October) as afterwards. Average quarterly data for the first period are obtained by linear interpolation. Secondly, multiple answers are possible for the second question. Hence, shares do not add up to 100 per cent. Moreover, a non-negligible percentage of firms answered that their domestic production is not constrained at all. This, however, represents only a borderline case in the theoretical model. In order to tackle these problems we first treat firms as demand constrained if their domestic production is said to be soley hampered by lack of order. All other constraints are viewed as caused by supply including those firms who answered that they are hindered by lack of orders and by the remaining possibilities of question 2.⁴ This procedure is, of course, somewhat arbitrary but the motivation for it is that the combination of being constrained by shortages of labor and existing capacities is more likely than by a combination of these shortages and of a lack of orders. Even more tricky is the relevance of firms which declare not being constrained at all. With the recession of 1982 as an exception this share is increasing since the mid-seventies up to 80 per cent in the mid-eighties. There are several hypotheses about this time pattern. First, firms are in fact in an equilibrium situation; second, firms simply refuse to answer question 2 for reasons whatsoever; third, firms mistakenly view themselves as being in an equilibrium and do not identify, for example, an existing capacity constraint. In an earlier study Marnet (1988) regards all firms which give a negative answer to the first question as being in a "classical regime" in the sense of Malinvaud's terminology since they are neither constrained on the goods market nor on the labor market.⁵ Figure 1 displays our calculations of the regimes associated with the business survey. In this study two different procedures are tested, namely to consider



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Figure 1: Regime shares based on the Ifo-business survey

the share of firms regarding themselves in an equilibrium as a separate explanatory variable or to treat these firms as being constrained by the supply side. Although the latter hypothesis may result in an overestimation of the supply constrained regime it can be motivated by the idea that firms are less likely to be aware of supply constraints whereas demand constraints are much more easier to be identified. To some extent the estimated coefficients of the "equilibrium share" and the "supply constrained share" allow us to discriminate between both procedures. We expect the estimated coefficient associated with the "equilibrium share" to be considerably smaller than the coefficient associated with the "supply constrained share". If they are equal, however, then the appropriateness of the second procedure cannot be rejected.

The other explanatory variables of exports and imports are straightforward and deserve less attention. To begin with exports, a foreign income variable Y_i is measured as real foreign *GDP*. Moreover, a relative price variable enters the export equation. It is defined as the ratio

⁴ In the following the share of supply constrained firms is denoted by rc, while the share of firms which claimed not to be rationed is represented by nr.

⁵König and Entorf (1990) take a similar approach but in additon make use of informations about overtime hours and backlog of orders which are also contained in the survey. While the niveaus of the regimes differ compared with Marnet (1988) their change does not.

of German export prices (P_x) to the foreign *GDP* deflator, the latter being multiplied with the exchange rate (*E*, defined as Deutsche Mark per units of foreign currency). While this variable measures the competitiveness of German exports compared with prices prevailing in the importing country, the following variable reflects the competitiveness of German exports with those of other exporting countries: the ratio of German export prices (P_x) to export prices of other major industrial countries (P_x^w) .

Taken together, we obtain the following equations for exports to country i, where lowercase letters denote logs.

$$x^{i} = f_{x_{i}}(y^{i}, p_{x} - p^{i} - e^{i}, p_{x} - p^{w}_{x}, q, q^{i})$$
(18)

The signs below the explanatory variables denote the influence we expect on theoretical grounds. Moreover, in this paper the variable q is replaced by the shares of firms being either in an equilibrium and/or in a supply constrained regime.

The countries under consideration are five EC-member countries (Belgium, France, Italy, Netherlands, United Kingdom) and the USA. Trade with these countries covers nearly half of total exports and imports. Dynamics are taken into account by the following error correction form:

$$\Delta x_{t}^{i} = \Delta c_{t} \cdot \theta_{1} - \lambda \cdot \left(x_{t-1}^{i} - c_{t-1} \cdot \theta_{2} - Z_{t-1}^{i} \cdot \phi_{1} \right) + \sum_{k=0}^{n} \Delta Z_{t-k}^{i} \cdot \phi_{2,k}$$
(19)

where c denotes the vector of different rationing variables discussed before and Z is the vector of the aforementioned other explanatory variables.⁶ θ_1 and θ_2 represent the short-term and long-term influences, respectively, of the rationing variables. Testable hypotheses about the dynamics stemming from changes of the rationing barriers are

- (i) $\theta_{1,i} = \theta_{2,i}^{7}$: In this case an increase of domestic rationing affects exports immediately and negatively. This holds in the short run as well as in the long run.
- (ii) $\theta_{1,i} > \theta_{2,i}$: An increase of domestic rationing leads to an immediate rationing of German exports. To some extent, however, this increased rationing of exports is mitigated as time passes because firms do not ultimately give up export markets even if domestic rationing still holds. This may mean that firms have some preference of serving export markets.
- (iii) $\theta_{1,i} < \theta_{2,i}$: In contrast to the previous case the timing of the preferences is reversed. In this case firms favor export markets only in the short run.

Similar arguments hold for an increase in rationing barriers on foreign markets.

We now consider imports. The import equations basically exhibit the same structure as the export equations. Both rationing variables are included and we expect signs opposite to the export equations. Increasing excess demand on German goods markets should increase imports, whereas excess demand on foreign markets should have the opposite effect. As for exports we test two relative price variables, one reflecting the direct competition with German products and the other the competition with other imports. The first one is defined as the German price deflator divided by foreign export prices. This relative price is expected to have a positive coefficient while the competitive price with other imports should have a negative sign. This variable is calculated as the GDP index (excluding the imports from the country examined) divided by the export price index of the exporting country.

The import equations are also estimated in an error correction form. The structure of the equation is that of eq. 19.

$$\Delta m_{t}^{i} = \Delta c_{t} \cdot \psi_{1} - \lambda \cdot \left(m_{t-1}^{i} - c_{t-1} \cdot \psi_{2} - Z_{t-1}^{i} \cdot \phi_{1} \right) + \sum_{k=0}^{n} \Delta Z_{t-k}^{i} \cdot \phi_{2,k}$$
(20)

⁶Further, in some equations lagged endogenous variables are included.

 $^{^{7}}i = 1, 2$ is associated with the respective elements for domestic rationing.

Again we have testable hypotheses about the dynamics stemming from changes of rationing barriers:

- (i) ψ_{1,i} = ψ_{2,i} : Increases of the importance of domestic rationing barriers immediately lead to higher imports and the same amount of this change can be observed in the long run, too.
- (ii) $\psi_{1,i} < \psi_{2,i}$: In this case the increase of imports is spread over time due to adjustment costs and time lags which occur because domestic firms must find adequate foreign producers. Hence, in the short run domestic customers cannot bypass supply constraints by additional imports.

Similar arguments hold if foreign rationing gains importance.

4 Estimation Results of the Disequilibrium Model

4.1 Exports and Imports

Tables 2 and 3 display our empirical result for imports and exports, respectively. Starting with the import equations the first row for each country presents the results for an estimation where the short run and long run coefficients of the rationing variables are restricted to be equal. The second row replicates the results without this restriction. According to likelihood ratio tests the hypothesis of equal coefficients cannot be rejected. The main exception are the USA where in the non-restricted version the short-run coefficient was lacking any significance and, moreover, exports into the remaining countries where no short-run coefficient was significant. The explanatory variable nr represents the share of firms which claim not to be rationed. In most countries this variable is significant but only in the short-run. The exceptions are France and Italy. As has been outlined before, on theoretical grounds we expect the coefficient associated with the share of rationed firms to exceed that of the non-rationed firms. With three exceptions the estimated coefficients support this hypothesis, but again an equality of both coefficients cannot be rejected. This result corresponds with the procedures undertaken by König and Entorf (1990) and Marnet (1988) mentioned before. The foreign rationing variable shares some importance only in Italy in the long-run and in the restricted version in the USA.

The role of domestic rationing and non rationing for German exports is much less important compared with imports. This is in line with our previous results using other measures of rationing (such as capacity utilisation rates) and may reflect a hysteresis phenomenon in German exports.⁸ On the other hand, rationing on foreign markets measured by capacity utilisation seems to have a greater impact on German exports. This is most apparent in the restricted versions.

The other explanatory variables of exports and imports are not discussed here but their empirical importance can be seen in the appendix where all regression results are displayed. In general, the coefficients exhibit the sign theoretically expected and, with the import equation for the Netherlands as an exception, employing an error-correction approach seems appropriate.

4.2 Calculations of structural exports and imports

From the export and import equations we can calculate "structural" exports and imports, respectively, i.e., exports and imports in the absence of rationing. These variables are needed to measure YD which in turn is defined as non-rationed goods demand.

To begin with structural exports XD they are obtained on the basis of a dynamic simulation of the non-restricted export equations presented before. More specifically, spillover effects due to rationing in Germany are calculated as the difference between simulated exports without

⁸For a discussion of hysteresis in international trade see e.g. Baldwin (1990).

Country i		Δrc	rc	Δnr	nr	Δq^{i}	q^i
USA	Ι	0.319 (2.10)	0.319	$\begin{array}{c} 0.214 \\ \scriptscriptstyle (1.18) \end{array}$	0.214	-0.472 (1.74)	-0.472
	II	0	0.451 (3.02)	0.308 (1.84)	0	-0.274 (1.07)	0
UK	Ι	0.494 (3.62)	0.494	0.399 (2.57)	0.399	0	0
	Π	0.543 (3.48)	0.574 (0.95)	0.396 (2.41)	0.354 (0.41)	0	-0.203 (0.87)
F	Ι	0.210 (2.52)	0.210	0	0	0	0
	II	0.313 (2.55)	0.202 (2.06)	0	0	0	-0.687 (1.43)
I	Ι	0.213 (2.65)	0.213	0.254 (2.52)	0.254	0	0
	ΙI	0.451 (3.24)	0.292 (3.74)	0.300 (2.61)	0.269 (2.36)	0	-1.099 (3.19)
NL	Ι	0.202 (1.80)	0.202	0.285 (2.65)	0.285	0	0
	II	0.223 (2.45)	3.623† (0.94)	0.332 (3.45)	0	0	-5.984 (0.71)
В	Ι	0.373 (4.15)	0.373	0.213 (2.26)	0.213	0	0
	Π	0.388 (4.50)	0.800 (2.44)	0.286 (3.05)	0	0	0
	Ι	0	0	0	0	0	0
RoW	II	0	0.099 (1.06)	0	0.254 (1.92)	0	-0.585 (-2.46)

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Table 2: Coefficients of the rationing indicators in German import equations

I: Restricted regression, short-run and long-run coefficients are restricted to be equal.

II: Non-restricted regression.

t-values in parantheses

RoW: Rest of the World.

†: The high value of the long-run coefficient is not reliable. This may be due to the insignificance of the error-correction term.

Country i		Δrc	rc	Δnr	nr	Δq^i	q^i
USA	Ι	-0.140 (0.95)	-0.140	0	0	0.903 (2.81)	0.903
	II	-0.229 (1.15)	-0.04 (0.17)	0	0	$\begin{array}{c} 0.913 \\ (2.65) \end{array}$	1.031 (1.74)
UK	Ι	-0.136 (0.91)	-0.136	0	0	0.138 (2.55)	0.138
	II	-0.050 (0.34)	-0.370 (1.52)	0	0	0.141 (2.72)	0
F	Ι	0	0	0	0	0.658 (2.96)	0.658
	II	0	0	0	0	0.667 (2.91)	0.604 (1.57)
I	Ι	0	0	0	0	0.730 (2.76)	0.730
	II	-0.264 (1.78)	0	0	0	0.649 (2.76)	1.977 (3.97)
NL	Ι	0	0	0	0	0.443 (1.38)	0.443
	II	0	0	0	0	0.318 (0.98)	0
в	Ι	0	0	0	0	0.407 (1.46)	0.407
	II	0	0	0	0	0.616 (2.24)	0
RoW	Ι	-0.114 (-1.33)	-0.114	0	0	0.489 (2.85)	0.489
	II	-0.098 (-1.13)	-0.280 (-1.23)	0	0	0.502 (2.95)	1.82 (1.23)

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Table 3: Coefficient of the rationing variables in German export equations

I: Restricted regression, short-run and long-run coefficients are restricted to be equal.

II: Non-restricted regression.

t-values in parantheses

RoW: Rest of the World.

rationing variables and simulated exports with rationing variables. These spillovers plus actual exports yield structural exports.

Structural imports are calculated on the basis of the following equation:

$$MD_{i} = MT_{i} - \alpha_{i} \cdot rc - \beta_{i} \cdot (nr - nr_{\min})$$
⁽²¹⁾

The long-term influences α_i , β_i are used to determine the spillover effects on German imports stemming from domestic rationing. The short-run coefficients do no exhibit an influence on actual import demand. They mirror the dynamic adjustment of imports to changes in aggregate demand. Domestic rationing implies, however, an immediate and corresponding increase of imports and must therefore be captured by the long-run coefficients. The exception from this procedure are Dutch structural imports. The non-restricted version of actual imports has a rather high coefficient associated with rationing (= 3.6) which leads to implausibly high spillover effects. Therefore, in this case the restricted version is employed.

There is still another problem with structural imports. The variable nr stands for the share of firms which claim not to be rationed. In the time period under observation nr displays a positive trend. Hence, nr shares increasing importance in explaining imports. Moreover, if firms recognize correctly possible rationing they are confronted with, then the effect of rationing on imports should solely capture by the variable rc, i.e., by production constraints. In order to circumvent this difficulty, spillover effects are corrected by making use of the following assumption: The minimum share of firms (33 per cent) which, during the sample period, claim to be not rationed is treated as being non-rationed, indeed, and, hence, has no influence on imports. The following table reports the ratio of structural exports and imports to their actual values.

	USA	UK	F	Ι	NL	В	ROW
XD/XT	1.034	1.051		1.036			1.030
MD/MT	0.94	0.83	0.97	0.89	0.89	0.9	0.92

•

4.3 Exchange Rates

In order to take into account transmissions of monetary and/or fiscal measures which run via exchange rates, an attempt is made to model exchange rates.

Since in the Bretton Woods system exchange rates have been pegged for longer periods, we concentrate on the period following the breakdown of Bretton Woods. At least since the late seventies the time series of nominal and real DM/\$- and DM/ \pounds -exchange rates⁹ have moved in a close relation. Exchange rates of countries belonging to the "Snake" (1973-1979) or the EMS (since 1979) show a different pattern. While there have been only small movements of real rates nominal rates devalued until the beginnings of the eighties (the exception is the real Dutch guilder which exhibits a strong real appreciation between 1974 and 1977).

In a model based on quarterly data it is difficult to explain very short run exchange rate movements. Hence, only fundamental "trends" originated by basic economic variables are under consideration, where specific currencies correspond with the trade equations (with Belgium as an exception).¹⁰

It is needless to stress that estimates of exchange rates of different regimes are difficult because of possible misspecifications such as neglecting central bank interventions or ignoring the role of "news" or of non-linearities of exchange rates, to mention only a few objections. Of course, we think that central bank interventions influence actual rates and keep them within

⁹Real exchange rates are calculated by deflating nominal rates with the ratio of foreign consumer prices to domestic consumer prices.

¹⁰Over the whole period only rates for U.S. and United Kingdom have been floating while rates for France and Netherland have been fixed (or floating within definite small range) except for some small periods in the seventies. The rate for Italy floated in the seventies and has been fixed since the creation of the EMS.

ranges around their parities. To some extent, however, interventions seem only to delay necessary realignments.

Our exchange rate model is based on asset market models with sticky price adjustment developed by Dornbusch (1976) and Frankel (1979).¹¹ These models assume perfect capital mobility and perfect substitutability between foreign and domestic assets. They are extended by Hooper and Morton (1982) who allow for changes of the real exchange rate. Three aspects of exchange rate determination are taken into account. (i) Equilibrium exchange rates are determined by money market conditions in the countries under study and purchasing power parities hold in the long run. More specifically, money supply and GNP of the i-th country compared with the FRG and the interest rate (R) differential (which equals the inflation rate (Δpc) differential in equilibrium) determine the nominal exchange rate. (ii) Hooper and Morton (1982) add the real exchange rate as an additional explanatory variable. They argue that the equilibrium value of the real exchange rate determines the equilibrium current account. Unexpected movements in the current account (TB) lead the individuals to correct the equilibrium real exchange rate. Assuming regressive expectations, the real exchange rate is related to unexpected movements of the current account and to the real exchange rate of the base period (q_0) . In the presence of uncovered interest parity, the short run behaviour is determined by the expected change of the exchange rate which equals the interest differential. (iii) The adjustment to long run values is modelled by adaptive expectations. Combining these three aspects leads to the following exchange rate equation:

$$e^{i} = f_{e_{i}}(m1 - m1^{i}, y - y^{i}, \Delta pc - \Delta pc^{i}, R - R^{i}, \sum_{j=0}^{t} TB_{t-1}^{i}, q_{0})$$
(22)

•

The signs of the partial derivatives are denoted below the variables in question. The negative coefficient for the relative income variable is a result of the asset market approach, where the exchange rate is the relative price for money. Increasing domestic income raises the (transaction) demand for domestic money and, ceteris paribus, the price for domestic money rises relative to the price for foreign money. The inverse influence of the current account follows from the implications of expectations concerning the equilibrium value of the real exchange rate which in turn determines the equilibrium current account. Unexpected changes in the current account directly affect the expectations of the real exchange rate equilibrium value which moves according with the nominal rate.¹²

The estimation period is devided into two subperiods, the first period (1974/1-1979/2) starts after the breakdown of the Bretton Woods system and ends with the beginning of the EMS, the second subperiod covers the time span until 1988/4. Dynamics are captured by a partial adjustment model. Explanatory variables are: money supply M1, GDP for the UK and Italy, GNP for the U.S., France and Germany. In the absence of quarterly data for the Netherlands, we proxy GDP by industrial production data. Long term interest rates (government bond yield) R_l are used because they reflect the importance of long term rates for investment decisions abroad.¹³ Expected inflation rates are replaced either by actual inflation rates of consumer prices or by money growth rates.

The influence of cumulated foreign reserves is modelled either by trade account balances or by current account balances. The latter variable improves the regressions only for the French franc and the lira whereas the former is used for other regressions. We have also experimented with the total balances (rather than bilateral balances) of each country in order to take account

¹¹See also Gaab (1982).

¹²The negative sign of the relative income variable $(y - y^{i})$ follows from the monetary approach of the exchange rate determination. This approach regards the exchange rate solely as a relative price for domestic and foreign assets. The long run rate is then determined by the money market conditions using the assumption of purchasing power parity. An increase in domestic income causes an appreciation due to the growing demand for domestic money.

¹³Three-month interest rates were tested in serveral regressions but did not yield superior statistical results.

the international demand for a currency. Cumulated balances are deflated with German GNP data.¹⁴ Because of a possible endogenity of interest rates, we also used TSLS estimation rather than OLS but with negligible differences.¹⁵

The importance of each explanatory variables varies between countries. For the U.S. dollar the results of the first period (74/1-79/1) display a significant influence of total cumulated U.S. trade balances and the expected inflation differential. Bilateral balances have no impact which can be explained by the international importance of the U.S. currency. For the second period (79/2-88/4) we obtain the expected signs for all variables (except for balances).

The results for the UK currency improve for the first period if relative money supply is replaced by the relative price ratio.¹⁶ Only for the first sample the regression yields a long run coefficient of the price ratio which is not significantly different from unity corresponding with the purchasing power parity. In the eighties we observe a real appreciation of the DM/\pounds rate probably due to the exploration of North Sea oil.¹⁷ The results improve if a variable for North Sea oil prices p_{oil} is added. Moreover, two dummies (not reported) take into account the fall of oil prices and the dollar depreciation in 1985. Trade balances contribute to an explanation of the DM/\pounds rate only in the second period. Somewhat surprisingly, the coefficients of the interest differential yield a significant positive sign in both periods. This might result from an insufficient distinction between inflation differential and interest differential¹⁸ or from the endogenity of interest rates as a consequence of international interest links. For the franc and lira price ratios have a significant impact during the first period. For France we cannot reject the coefficient being different from unity, the coefficient for Italy is greater than one, however. For the franc current account balances display a stable influence on the exchange rate, while for the DM/lira exchange rate cumulated current account (balances for the first period) and cumulated trade account balances (for the second period) yield more plausible results.²² Similar to the regressions of the DM/\pounds rate, the nominal and real interest differentials have no significant influence on both exchange rates. This may result from financial restrictions but can also be due to the endogeneity of the interest rates.²³

The results for the Netherlands yield a stable influence of money supply ratios in both periods. Only in the EMS period the coefficient of the interest differential exhibits its expected sign.

4.4 Consumption and Investment

The equation for real consumption is formulated as a fairly standard textbook version. Besides real disposable income (DI), we use a short term interest rate and a labor market indicator as explanatory variables. The latter mirrors the expectations about future income according to the life-cyle hypothesis of consumption. We employ the change of the unemployment rate (ΔUR) as a proxy for this variable. A negative sign indicates that rising unemployment leads to a fall in consumption. The interest rate serves as an indicator for intertemporal consumption/savings decisions.

$$C = f_c(DI \ \Delta UR, R_r)$$

$$+ - - -$$
(23)

¹⁴When employing total balances we deflated with the corresponding GDP data.

¹⁵ In the regressions for EMS currencies we also used Bundesbank intervention data to take into account managed floating rates. The results are very sensitive with respect to different sample periods, therefore we view them as not reliable. This might reflect the inadequacy of the data for our model and the non-availability of corresponding foreign data. The employed data (changes in foreing exchange reserves, interventions in the DM/\$ market and in the EMS) are puplished in Geschäftsbericht der Deutschen Bundesbank.

¹⁶We employ consumer price indices.

¹⁷Regressions with price ratios yield coefficients which are statistically different from unity.

¹⁸The results do not change when using the real interest differential.

²²The coefficient does not change when the lagged endogenous variable is omitted.

²³See also Kirchgässner and Wolters (1990) who do not find support for the validity of uncovered interest parity between European countries.

Dependent Variable ei						
Country i	U.S	.A.	UK			
Period Variable	Ι	II	I	II		
$(m1-m1^i)_{t-1}$		$\begin{array}{c} 0.473 \\ \scriptscriptstyle (2.27) \end{array}$				
$(p-p^i)_{t-1}$			0.365 (1.94)			
$(\Delta pc - \Delta pc^i)$	0.016 (3.52)	0.014 (2.57)		0.637ª (4.40)		
$R_l - R_l^*$		-0.024 (-2.85)				
$y - y^*$		-0.890 (-1.43)				
$\sum_{t} TB_{t-1}$	$\frac{1.411^{b}}{(12.92)}$	-0.307 (-0.85)		-0.020 ^c (-2.71)		
Pöi				0.075 (2.22)		
e_{t-1}^i		0.769 (8.37)	0.660 (3.91)	0.546 (6.61)		
\tilde{R}^2	0.946	0.947	0.967	0.958		
SEE	0.026	0.045	0.033	0.030		
Q-Stat. (8 lags)	4.45	9.19	8.13	11.13		

Table 4: Exchange Rate Equations

See the following table for explanations.

^aGrowth rate differential of money supplies

^bCumulated total U.S. trade account

^cNon cumulated bilateral trade account

The dynamic adjustment is reflected by different lags of explanatory variables. The results show a consumption function with a long run marginal propensity to consume of 0.88. The real interest rate has a small negative effect on consumption. As expected, a rise in unemployment has a negative impact.

$$C = \text{const.} - 1.528 \ \Delta UR - 0.170 \ R_{\tau} + 0.482 \ C_{t-1} + 0.327 \ C_{t-4}$$

$$(-2.27) \qquad (-2.26) \qquad (5.56) \qquad (4.28)$$

$$+ 0.468 \ DI - 0.178 \ DI_{t-1} + 0.047 \ DI_{t-2} + 0.061 \ DI_{t-3} - 0.231 \ DI_{t-4}$$

$$(11.20) \qquad (-3.29) \qquad (1.40) \qquad (1.89) \qquad (-4.18)$$

 $\bar{R}^2 = 0.999$, SEE = 1.509, Sample 60/1 - 89/2, Q-Stat(8) = 6.69, Q-Stat(12) = 12.41, Q-Stat(16) = 16.90.

Investment is determined by the expected minimum of those constraints which may prevent firms from full the utilisation of capacities, $E(Y^A)$ (compare eq. 8), the share of labor and the share of capital, respectively. The capital stock k is then determined by:

$$k = f_k(E(Y^A), \frac{1-sl-sk}{sk})$$

$$+ + +$$
(24)

0

			<u>+</u>			
Dependent Variable e;						
Country i	I	?]	[NL	
Period Variable	Ι	II	Ι	II	I	II
$(m1-m1^i)_{t-1}$		0.077 (2.66)		0.173 (3.94)	0.150 (2.66)	0.090 (2.31)
$(p-p^i)_{t-1}$	0.319 (14.13)		1.403 (20.01)			
$R_l - R_l^i$						-0.012 (-4.63)
$\Delta pc - \Delta pc^i$			0.424 ^a (6.48)			
$\sum_{t} TB_{t-1}$	-0.062^{b} (-3.65)	-0.012° (-3.69)	-4.160^{d} (-1.93)	-0.808 (-1.96)		-0.791 (-1.84)
<i>e</i> _{<i>t</i>-1}	0.642 (4.93)	0.860 (26.44)		0.710 (8.33)	0.859 (7.06)	0.580 (5.18)
\bar{R}^2	0.924	0.992	0.992	0.9995	0.737	0.894
SEE	0.029	0.013	0.020	0.012	0.010	0.004
Q-Stat. (8 lags)	4.21	6.73	6.30	6.43	4.99	5.06

Table 5: Exchange Rate Equations-Continued

I: 74/1-79/1; II: 79/2-88/4

 R^2 : Adjusted R-squared; SEE: Standard error of regression

t-values in parentheses, dummies are suppressed.

^aGrowth rate differential of money supplies.

^bNon cumulated current account balance

^cNon cumulated current account balance

 d Cumulated current account

Both partial derivatives are positive.²⁸ A rising share of income of capital and of labor reduces investments due to a profit squeeze. The definiton of the share of labor is described in section 2. The main determinant of the share of capital is the real interest rate. Other determinants are the scrapping rate, the relative price for investment (PI/P) and the average productivity of the net real capital stock at full utilization of capacity.

We estimate the investment equation using an error correction specification including a time trend as a proxy for capital productivity.

0

²⁸See Franz, Heidbrink, Scheremet (1991) for a more detailed description of the calculation for the $E(Y^A)$ variable.

$$\Delta k = \text{const.} + 0.011 \Delta y_{t-1}^{A} + 0.001 \Delta L_{t-2}$$

$$(5.35) \qquad (1.77)$$

$$+ 0.667 \Delta k_{t-1} + 0.00005 \text{ Trend}$$

$$(11.39) \qquad (3.42)$$

$$- 0.012 (k_{t-3} - 0.590 y_{t-4}^{A} - 0.070 L_{t-4}]$$

$$(-4.29) \qquad (6.27) \qquad (2.43)$$
with $L = \frac{1 - sl - sk}{sk}$

 $\bar{R}^2 = 0.977$, SEE = 0.0006, Sample 60/1 - 89/2, Q-Stat(8) = 40.87, Q-Stat(12) = 62.35, Q-Stat(16) = 75.34.

The regression reveals a very slow adjustment to long run values. A one per centincrease of Y^A leads to a 0.6 per cent higher capital stock. The long run values for the share of capital and the share of labor indicate a rather strong impact on investment. According to our theory we obtain a small short run reaction of investment to changes in Y^A as well as to changes of the labor and capital shares.

4.5 Technology, Output, and Employment

For ex-ante substitution possibilities between production factors, the technical productivities of labor and capital are determined by the long run decisions of the firms with respect to capital stock and technology. The production function is modelled as a CES-technology with constant returns to scale and with labor-saving (γ_L) and capital-saving (γ_K) technical progress. Maximizing profits at given output prices (p) and factor costs (w, uc) gives for the technical productivities of labor $(yc - l)^*$ and of capital $(yc - k)^*$, respectively, the following equations:

$$(yc-l)^* = \text{const.} + \sigma(w-p) + (1-\sigma)\gamma_L(t) + \delta_1 \cdot h$$
(26)

and

$$(yc - k)^* = \text{const.} + \sigma(uc - p) + (1 - \sigma)\gamma_{\kappa}(t) + \delta_2 \cdot h$$
(27)

where σ denotes the elasticity of substitution. Hence, the productivities are determined by the factor-product-price ratios and technical progress.

Due to ex-post rigidities of substitution possibilities, actual productivities may deviate from technical values when production factors are not fully utilized. Therefore, actual productivities depend on the technology and on the degree of factor utilization. Moreover, both productivity equations contain hours h as an explanatory variable in order to capture the exogenous usage time of the capital stock due to different holidays.

The labor and capital utilization (Q) rates are measured by business survey data taken by the Ifo-Institut (Munich) which reflect the capacity utilization of the German industry. Both utilization rates are supposed to exhibit similar movements. Because employment decisions are taken in the medium run we employ a dynamic specification of the utilization rate of capital. Factor prices are hourly wages and the price of investment goods.

Actual labor and capital productivities are jointly estimated by OLS with the adjustment coefficients restricted to be equal. Labor- and capital-saving progress is modelled by linear and quadratic time trends. The equations (28) and (29) display our results for labor productivity and capital productivity, respectively. The estimates yield an elasticity of substitution of $\sigma = 0.46$.

Labor-saving technical progress decreases slowly during the period under consideration. The corresponding coefficient for capital productivity displays a negative time trend which might

result from the energy price shocks which rendered parts of the capital stock obsolete.

$$\Delta(yc-l) = \operatorname{const.} + 0.420 \cdot (\Delta q - 0.484 \cdot \Delta q_{t-1}) + 0.425 \cdot \Delta h$$

$$(28)$$

$$- 0.329 \cdot (\Delta(yc-l)_{t-1} - 0.420 \cdot (\Delta q_{t-1} - 0.484 \cdot \Delta q_{t-1}) - 0.425 \cdot \Delta h_{t-1})$$

$$- 0.416 \cdot (\Delta(yc-l)_{t-2} - 0.420 \cdot (\Delta q_{t-2} - 0.484 \cdot \Delta q_{t-2}) - 0.425 \cdot \Delta h_{t-2})$$

$$- 0.460 \cdot (\Delta(yc-l)_{t-3} - 0.420 \cdot (\Delta q_{t-3} - 0.484 \cdot \Delta q_{t-3}) - 0.425 \cdot \Delta h_{t-3})$$

$$+ 0.231 \cdot (\Delta(yc-l)_{t-4} - 0.420 \cdot (\Delta q_{t-4} - 0.484 \cdot \Delta q_{t-4}) - 0.425 \cdot \Delta h_{t-4})$$

$$(3.08)$$

$$- 0.291 \cdot \left((yc-l)_{t-1} - 0.455 \cdot (w-p)_{t-1} - 0.006 \cdot t_{t-1} + 0.000024 \cdot t_{t-1}^{2})$$

$$- 0.420 \cdot (q_{t-1} - 0.484 \cdot q_{t-2}) - 0.425 \cdot h_{t-1}\right)$$

 $\bar{R}^2 = 0.998$, SEE = 0.009, Sample 67/1 - 88/4, Q-Stat(8) = 6.18, Q-Stat(12) = 11.71, Q-Stat(16) = 14.19.

$$\begin{aligned} \Delta(yc - k) &= \operatorname{const.} + 0.496 \cdot \Delta q + 0.431 \cdot \Delta h \\ (12.71) & (5.93) \end{aligned} \tag{29} \\ &= -0.329 \cdot (\Delta(yc - k)_{t-1} - 0.496 \cdot \Delta q_{t-1} - 0.431 \cdot \Delta h_{t-1}) \\ &= -0.416 \cdot (\Delta(yc - k)_{t-2} - 0.496 \cdot \Delta q_{t-2} - 0.431 \cdot \Delta h_{t-2}) \\ &= -0.460 \cdot (\Delta(yc - k)_{t-3} - 0.496 \cdot \Delta q_{t-3} - 0.431 \cdot \Delta h_{t-3}) \\ &= -0.460 \cdot (\Delta(yc - k)_{t-4} - 0.496 \cdot \Delta q_{t-4} - 0.431 \cdot \Delta h_{t-4}) \\ &= -0.291 \cdot \left((yc - k)_{t-1} - 0.455 \cdot (pi - p)_{t-1} + 0.0004 \cdot t_{t-1} + 0.00002 \cdot t_{t-1}^2) \\ &= -0.496 \cdot q_{t-1} + 0.431 \cdot h_{t-1} \right) \end{aligned}$$

 $\bar{R}^2 = 0.988$, SEE = 0.010, Q-Stat(8) = 6.68, Q-Stat(12) = 9.18, Q-Stat(16) = 11.04.

Both regressions highlight the significant influence of capital utitilization on measured productivities. Optimal productivities are given by the following equations:

$$(yc - l)^* = (yc - l) - log(DUL)$$
 (30)

ø

$$(yc - k)^* = (yc - k) - log(DUC).$$
 (31)

The estimated values of DUC and DUL are given by:

$$duc = 0.496 \cdot (q - q^{\max}) \tag{32}$$

$$\hat{dul} = 0.420 \cdot \left[(q - q^{\max}) - 0.484 \cdot (q - q^{\max})_{t-1} \right].$$
(33)

Using our estimates of productivities, we can derive goods supplied determined by employment (Y_{LT}) , labor demand determined by expected goods demand (L^*) and labor demand brought about by capacity output (L_{YC}) .

We first turn to the estimations of the CES-functions of output (eq. 14) and of employment (eq. 15), presented in section 2. There are two possibilities to model the mismatch parameter. Firstly, the mismatch parameters can be treated as endogenous variables. This approach is not pursued here because at this stage no explanatory variables for the mismatch parameters turned out to be satisfactory. The second option is to estimate the equation together with an additional error term. We capture the mismatch parameter with a constants and time trends. This procedure is, of course, entirely a data analysis and must be replaced by economic analysis in the next step of this project.

Goods market

The mismatch parameter ρ_{σ} for the goods market in the CES-function is captured by a decreasing trend. Significant autocorrelation of residuals is corrected for by autoregressive schemes. Estimates are in logs.

$$\log YT = \log \{Y_{LT}^{-\rho_{G}} + YD^{-\rho_{G}}\}^{-1/\rho_{G}}$$
(34)

6

0.005 .2

with

$$\rho_{G} = 41.120 - 0.546 \cdot t + 0.005 \cdot t^{2}$$

$$(26.57) \quad (-8.33) \quad (7.11)$$

$$\rho(2) : 0.205 \quad \rho(4) : 0.145 \quad \rho(5) : -0.371$$

$$(1.39) \quad (-3.68)$$

0 F 10 .

 $\rho(i)$: correction term with respect to autocorrelation of order *i*. $\bar{R}^2 = 0.999, \text{ SEE} = 0.0022, \text{ Sample } 60/1 - 88/4, \\
Q-Stat(8) = 5.13, Q-Stat(12) = 6.93, Q-Stat(16) = 9.18.$

Labor market

Estimation of the CES-equation for the labor market is in logs, too. The mismatch parameter ρ_{LT} is captured by constant and a time trend.

$$\log LT = \log \{ LS^{-\rho_{LT}} + ((1 + 0.037) \cdot L_{YD})^{-\rho_{LT}} + L_{YC}^{-\rho_{LT}} \}^{-1/\rho_{LT}}$$
(35)
(12.10)

with

$$\rho_{LT} = 55.88 - 0.401 \cdot t$$
(14.12) (-8.44)

$$\bar{R}^2 = 0.916$$
, SEE = 0.0065, Q-Stat(8) = 89.96.

The static version of this equation is subject to considerable autocorrelation of residuals. The parameter associated with L_{YD} corrects labor demand derived from goods demand. More specifically, a positive coefficient means, that, at the minimum of labor utilization, actual goods demand is higher than calculated or, in other words, that the actual minimum of labor utilization falls short of utilization estimated by the productivity equations. Without such a correction



term standard errors nearly double. This worsening of explanatory power can also be seen by inspection of the employment time series (see figure 2): During recessions 1967, 1974-79, and 1981-85 employment exceeds labor demand L_{YD} . Hence, the strong minimum condition described by the CES-equation is no longer valid. This pattern therefore, points to the aforementioned measurement errors and/or calls for a dynamic specification of the CES-equation. Despite these shortcomings the figure 3 displays the regime shares on the labor market obtained from the static version of the CES-equation. As has been mentioned, a dynamic version of the CES-equation (see below) takes into account the dynamic character of employment. In addition to goods demand and capacities lagged employment enters the equation, too. In principle, this procedure allows for adjustment costs due to periods of notice, search activities, labor hoarding, and the like. Moreover, the minimum condition for the labor market now holds to a lesser extent. As a consequence, actual employment can exceed labor demand due to partial adjustment.

The following partial adjustment scheme is assumed to describe labor demand LD:

$$\log LT = \log \{ LS^{\rho_{LT}} + LD^{\rho_{LT}} \}^{1/\rho_{LT}}$$
(36)

with

$$LD = \lambda \cdot \{L_{VD}^{\rho_{LT}} + L_{VC}^{\rho_{LT}}\}^{1/\rho_{LT}} + (1-\lambda) \cdot LT_{t-1}$$

The disadvantage of this approach is that, due to the partial adjustment process, regime shares now cannot be interpreted in the straightforward manner as before.

The results of this estimation exhibit considerable autocorrelation of residuals which has been eliminated by introducing autoregressive transformations. The time trend in the equation for the mismatch parameter has been dropped due to a lack of significance. Various versions yield a rather stable coefficient of adjustment λ . About one quarter of adjustment of employment LT to warranted employment (which is the minimum of labor demand determined by capacities and goods demand, respectively) is fulfilled within one quarter. Correction terms associated



with labor demand determined by goods demand and capacities, respectively, have barely been significant or yielded implausible values. This is not surprising because a correction of the L_{YD} variable is unnecessary as long as dynamics are allowed for in the employment equation. More surprisingly is the reduction of the standard error of estimation which amounts to only one third of the respective figure in the static version.

The results are as follows:

$$\rho_{LT} = -56.937 \quad \lambda = 0.236$$

$$(-3.28) \quad (6.65)$$

$$\rho(1) : 0.441, \quad \rho(4) : 0.876, \quad \rho(5) : -0.387$$

$$(3.95) \quad (16.74) \quad (-3.55)$$

 $\bar{R}^2 = 0.990$, SEE = 0.0023, Sample 60/1 - 88/4, Q-Stat(8) = 2.22, Q-Stat(12) = 5.83, Q-Stat(16) = 9.31.

4.6 Interest Rates

Despite the difficulties of a period of 29 years with different monetary targets and exchange rate regimes, we estimate an equation with a three-month interest rate as dependent variable. This implies that we treat the German money supply as exogenous. This is, of course, an oversimplification since in the Bretton Woods-system money supply is more an endogenous variable determined by factors such as (domestic) inflation and the like. Although we experienced a mixed exchange rate system following Bretton Woods (the "Snake" and the EMS) we think that the German Bundesbank, by and large, was not totally unsuccessful in controlling the money supply.

In our model the short-term interest rate is determined by the real money supply (nominal

money deflated by the GNP deflator), real GNP (deflator as before), the foreign three-month interest rate and the expectation of its corresponding exchange rate changes (Δe^e) to cover international linkages between interest rates.²⁹ We use the short term U.S.-Euromoney market interest rate and the expected change of the U.S. exchange rate.³⁰

The following equation describes the functional form of the interest equation:

$$R = f_R(M, Y, R^{US}, \Delta e^{e, US}) \tag{37}$$

The sign of the partial derivative of the money supply is expected to be negative while all other signs should be positive.

The change of the exchange rate is used to proxy the expected change. In order to model the dynamics we test an error correction model against a partial adjustment version with superior results.³¹

$$\Delta r = \text{const.} + 1.277 \Delta y - 5.611 \Delta m + 0.451 \Delta r^{US} + 0.451 \Delta^2 e^{e_{t}US}$$
(38)
(2.43) (-6.56) (4.95) (0.89)
$$- 0.310 \left(r_{t-1} - 2.508 y_{t-1} + 2.395 m_{t-1} - 0.474 r_{t-1}^{US} - 0.450 \Delta e_{t-1}^{US} \right)$$

(5.17) (2.62) (-3.02) (2.87) (0.40)

 $\bar{R}^2 = 0.555$, SEE = 0.114, Sample 60/1 - 89/2, Q-Stat(8) = 11.80, Q-Stat(12) = 16.63, Q-Stat(16) = 18.40.

The regression reveals a slow adjustment process to long-term equilibrium values. Compared to domestic money demand regressions we measure fairly standard long-run elasticities (1.05) of money demand with respect to real GNP. The elasticity with respect to interest rate seems to be high (-0.42).^{32,33}

The insignificance of changes of the exchange rate might result from incorrect modelling of expectations Δe^e . Experiments with different lags of this variable did not yield plausible results.

4.7 Wages and Prices

The development of wages is mostly a result of a centralized bargaining by the two parties in the labor market, the labor unions and the employers. The main issues in the negotiations about the wage rate are the protection of real wages, the division of the produced surplus and the demand and supply conditions on the labor market.

Employers are willing to accept wage increases if they expect an expansion of profits. The development of profits is approximated in our estimates by the growth rate of unit labor costs $(\Delta w - \Delta (yc - l))$, where Δw denotes the growth rate of wages and $\Delta (yc - l)$ the growth rate of productivity. If the increase in productivity exceeds the growth rate of wages, the unions will claim higher wages for distributional reasons. Additionally, decreasing labor costs increase the margin for the employers to afford higher wages.

²⁹See Kirchgässner, Wolters (1990) who find strong support for domestic money market rates linkage between Europe and the U.S. and especially between the U.S. and Germany. While linkages are found for both exchange rate regimes, there is only weak support for the validity of uncovered interest parity.

³⁰We also estimate standard textbook versions of domestic money market equations including foreign interest rates but these estimations do not reveal a significant influence of the foreign interest rate on money demand.

³¹See Rüdel (1989) who tests the hypothesis of no-cointegration of money supply, GNP and short-term interest rate. The author estimates German money demand during the period 61/4 to 87/4 with an error correction specification.

³²See Rüdel (1989), p. 98, who finds higher semielasticities with respect to the interest rate when estimating error correction models compared to static LS regressions.

 $^{^{33}}$ In regression with non-log interest rate form we receive semielasticities of -0.092.

Since unions strongly refer to costs of living when demanding higher wages the development of the real consumption wage should be included in estimations which try to explain the development of the effective wage rate. On the other hand, the wage variable employers are interested in, is the production wage which includes their output price and non wage labor costs. In taking care of these aspects we use a wedge variable,

wedge =
$$\frac{W^T/P}{W^n/PC}$$
,

in the estimation where W^T denotes the total labor costs including employers non wage labor costs, P the GNP deflator, W^n net wages (effective wage net of payroll taxes and employees's payments to the social security system) and PC the consumer price index.

Some authors³⁴ argue that the sole consideration of price and productivity variables in wage equations is the most suitable form to describe the behaviour of the participants in the wage bargaining process, which implies, however, that the wage reacts independently to supply and demand conditions on the labor market. This independence results in an absence of an equilibrating mechanism in the labor market. Taking account of equilibrium forces we add a measure of the excess demand on the labor market as an explanatory variable to the wage equations, which is derived from the estimation of the employment function and is the proportion of firms constrained by actual labor supply.

In the Federal Republic of Germany wages are negotiated between unions and employers on the industry level and in most cases one industries's bargaining results become a reference point. The contracts of the leading industry are then the guiding principle in subsequent negotiations. We consider this leader-follower relationship by including fourth lags of the growth rate of wages into our wage equations. The preceding considerations yield the following specification:

$$W = f_W(P, (PM/P), wedge, (yc - l), \epsilon_{LT,LS})$$
(39)

where PM/P denotes the import price relative to the GNP price deflator and $\epsilon_{LT,LS}$ the regime of excess demand for labor. To discriminate between long and short run effects we use an error correction scheme. Finally seasonal dummies as well as two dummies for the autonomous wage push in 1969/4 and 1970/1 are introduced (not reported in the equation).

The price equation is formulated as a mark-up pricing rule. The change of prices is therefore mainly the result of the development of costs. The main determinants are the development of wages and productivity. Further relevant cost components are import prices relative to the GNP deflator and the value added tax rate. In addition, we suppose that the mark-up factor varies procyclically according to demand conditions on the goods market. This dependence is approximated by capacity utilization.³⁵

$$P = f_P(W, \text{TAX}, PM/P, DUC, (yc - l))$$
(40)

where TAX is the value added tax rate and DUC denotes the rate of capacity utilisation. We use an error correction specification, similar to the wage equation.

In what follows we present the estimates of the price and wage equations. Starting from the theoretical equations (39) and (40) we have tested several restrictions on the coefficients and added some more lagged variables in order to capture the dynamic properties of the equations using quarterly data. We obtained the following results:³⁶

³⁴See Lipsey (1981) for example.

³⁵In an alternative regression we used a measure of the regime of excess demand for goods which had been calculated form CES-function of the goods market as described above. This leads to comparable results in the coefficients but higher standard errors of the coefficients.

³⁶ The estimates of the coefficients of the price and wage equations stem from the full information maximum likelihood procedure provided by PC-TSP. See Franz, Heidbrink, Scheremet (1991) for the estimate of the labor supply regime $\epsilon_{LT,LS}$ (sample 60/1-88/4).

$$\Delta w = \text{const.} + 0.084 \Delta w_{t-1} + 0.925 \Delta w_{t-4} + 0.089 \Delta \text{wedge} + 0.081 \Delta (pm - p)_{t-1} (41)$$

$$- 0.146 (\Delta w - \Delta p - \Delta (yc - l))_{t-1} - 0.070 (w - p - (yc - l))_{t-1}$$

$$- 0.037 \text{wedge}_{t-1} + 0.021 \epsilon_{LT,LS_{t-1}} (1.78)$$

$$\rho(1) = 0.369, \quad \rho(4) = 0.377$$

$$(3.58)$$

 $\rho(i)$: correction term with respect to autocorrelation of order *i*. $\bar{R}^2 = 0.980, \text{ SEE} = 0.008, \text{ Sample } 60/1 - 88/4, \\
Q-Stat(8) = 10.10, Q-Stat(12) = 10.82, Q-Stat(16) = 12.22.$

Due to the strong seasonality in the data it is necessary to correct the equations for first and fourth order autocorrelation.

In the short run wage growth is mostly affected by the development of prices, unit labor costs and the wedge between product and consumption wage. Demand conditions on the labor market have no influence in the short run and are only of minor importance in the long run. Furthermore, in the long run there is a one to one correspondance between prices and unit labor costs. The same coherence can be found in the wage equation where a coefficient of unity for prices and productivity is estimated.

The low value of the error correction terms in both, the price and the wage equations, points out that wage and price behaviour is very sticky. As far as wages are not equal to their steady state values, only seven per cent of this deviations are reduced in the subsequent period. The corresponding figure in the price equation is three per cent.

$$\Delta p = \text{const.} + 0.145 \Delta w_{t-1} - 0.114 \Delta w_{t-4} - 0.130 \Delta w_{t-5} + 0.728 \Delta p_{t-4}$$
(42)
(2.01) (-1.84) (-1.71) (7.78)
$$+ 0.120 (\Delta w - \Delta (yc - l)) + 0.047 \Delta (yc - l)_{t-1} + 0.055 \Delta DUC_{t-1}$$
(2.85) (1.15) (1.32)
$$+ 0.064 \Delta (pm - p)_{t-4} + 0.569 \Delta TAX$$
(1.52) (1.04)
$$- 0.040 (p_{t-1} - (w - (yc - l))_{t-1}) + 0.036 DUC_{t-1}$$
(2.02)
$$\rho(1) = 0.268, \quad \rho(4) = 0.308$$
(1.87)

 $\rho(i)$: correction term with respect to autocorrelation of order *i*. $\bar{R}^2 = 0.819, \text{ SEE} = 0.006, \text{ Sample } 60/1 - 88/4, \\
Q-\text{Stat}(8) = 6.05, Q-\text{Stat}(12) = 9.06, Q-\text{Stat}(16) = 18.42.$

5 Conclusions

The main novelty of our paper is an econometric analysis of the importance of rationing in international trade. The crucial question is how to capture possible constraints by adequate data. This paper departs from previous work by introducing answers from a business survey as proxies for rationing barriers. At first glance, these data should outperform indicators such as capacity utilization rates because they are more closely related to what should be measured.

However, available business survey data are anything but straightforward tools to proxy rationing barriers. Their shortcomings for the present purpose are due to, among other problems, the possibility of multiple answers and, moreover, the great share of firms which declare not being rationed at all. There are several hypotheses about the relevance of the last observation. First, firms are in fact in an equilibrium position (which is, however, a special case in the theoretical model); second, firms refused to specify the type of rationing they are confronted with; third, firms mistakenly view themselves as being in an equilibrium and do not recognize, for example, an existing capacity constraint. In this study two different procedures are tested to overcome these problems.

Our regression results show that such business survey data are by no means superior to variables such as the aforementioned capacity utilization rate. The same impression is obtained by calculating the regime shares according to eq. (16). They are displayed in *figure 3*. While the period 1969–1974 is characterized by the preponderance of capacity and labor supply constraints, rationing from the demand side becomes dominant in recession periods with peaks in 1967, 1975, and 1982/83. In the course of a restrictive monetary and fiscal policy at the beginning of the 1980s an investment squeeze took place, and hence to a growing extent existing capacities gained importance as a limiting factor. The point here is, however, not the interpretation of the development of the regime shares but their robustness compared with previous studies which employed other rationing indicators, namely the degree of capacity utilization. It goes without saying that figure 3 is not a test of the adequacy of business survey data since we use such data as explanatory variables in order to obtain similar variables. But the experiment highlights that the time pattern of regime shares is not very sensitive with respect to different proxies for rationing barriers. This is, given all caveats, somewhat reassuring.

What, if anything, can be learnt from this exercise? Rationing barriers do influence trade flows to a non-neglible extent. Business survey data as indicators for possible constraints do not outperform other proxies such as the degree of capacity utilization.

Appendix

Variable	list:
Y :	gross national product, real
L :	employment
UR :	unemployment rate
K :	net capital stock, real
<i>DI</i> :	disposable income
C :	Consumption real
I_q :	gross investment, real
i :	index for country (U. S., UK: United Kingdom, F: France, I: Italy, NL: Nether-
	lands, B: Belgium,)
X^i :	German exports into country i, real
M^i :	German imports from country i, real
TB^i :	trade balance account with country i, real
P :	price of Y
PC :	consumer price index
P_r :	German export price
P_m :	German import price
P^{i} :	GDP deflator of country i
E^i :	exchange rate (DM/unit of currency of country i)
Δpc^{i} :	inflation rate (change in logs of consumer price index of country i)
R, R_l :	interest rate, short term/long term
W :	wages per hour
d :	scrapping rate
TAX :	value added tax rate
sl :	share of labor
sk :	share of capital
DUC :	degree of utilization of capital, Ifo–institut (Munich)
DUL :	degree of utilization of labor
yc - l:	labor productivity
yc - k:	capital productivity
<i>rc</i> :	share of firms which claimed to rationed by a lack of supply
nr :	share of firms which claimed not to rationed
TOT :	$= p_x - p^i - e^i$ Terms of trade in export equations
TOT :	$= p - p_x^i - e^i$ Terms of trade in import equations
Pk :	$= p_x^i - p_x^w$ Relative export price with other exporting countries

Sample period for the import and export regressions: 67/1 - 88/4, Dummies are supressed, Box-Pierce Q-Statistics are displayed with 8, 12 and 16 lags, t-values are shown in parentheses. All variables except the German rationing variables are defined in logs.

A Results of Export Equations

A.1 Exports to USA

with restrictions on rationing variables:

$$\Delta x^{\text{US}} = - \underbrace{0.140}_{(-0.95)} \cdot \Delta rc + \underbrace{0.903}_{(2.81)} \cdot \Delta q^{\text{US}}$$

$$- \underbrace{0.375}_{(-3.67)} \cdot \left(\Delta x^{\text{UK}} + 0.140 \cdot \Delta rc - 0.903 \cdot \Delta q^{\text{US}}\right)_{t-1}$$
(43)

$$\begin{array}{l} -0.199 \cdot \left(\Delta x^{\mathrm{UK}} + 0.140 \cdot \Delta rc - 0.903 \cdot \Delta q^{\mathrm{US}}\right)_{t-2} \\ +1.507 \cdot \Delta y_{t-2}^{\mathrm{US}} - 0.383 \cdot \Delta TOT_{t-1}^{\mathrm{US}} \\ -0.335 \cdot \left(x^{\mathrm{US}} + 0.140 \cdot rc - 0.903 \cdot q^{\mathrm{US}} - 2.169 \cdot y^{\mathrm{US}} + 1.148 \cdot TOT^{\mathrm{US}}\right)_{t-1} \\ -0.369 \end{array}$$

 $\bar{R}^2 = 0.677$, SEE = 0.083, Q-Stat(8) = 7.63, Q-Stat(12) = 11.66, Q-Stat(16) = 12.60.

without restrictions on rationing variables:

$$\Delta x^{\text{US}} = - \underbrace{0.229}_{(-1.15)} \cdot \Delta rc + \underbrace{0.913}_{(2.65)} \cdot \Delta q^{\text{US}}$$

$$- \underbrace{0.365}_{(-3.45)} \cdot \left(\Delta x^{\text{US}} + \underbrace{0.229}_{rc} \cdot \Delta rc - \underbrace{0.913}_{r-1} \cdot \Delta q^{\text{US}}\right)_{t-1}$$

$$- \underbrace{0.200}_{(-2.12)} \cdot \left(\Delta x^{\text{US}} + \underbrace{0.229}_{r-2} \cdot \Delta rc - \underbrace{0.913}_{r-2} \cdot \Delta q^{\text{US}}\right)_{t-2}$$

$$+ \underbrace{1.486}_{(1.26)} \cdot \Delta y^{\text{US}}_{t-2} - \underbrace{0.387}_{(-1.53)} \cdot \Delta TOT^{\text{US}}_{t-1}$$

$$- \underbrace{0.354}_{(-3.58)} \cdot \left(x^{\text{US}} + \underbrace{0.040}_{(-0.17)} \cdot rc - \underbrace{1.031}_{(1.74)} \cdot q^{\text{US}}_{(11.66)} \cdot y^{\text{US}}_{(-5.76)} + \underbrace{1.120}_{(-5.76)} \cdot TOT^{\text{US}}\right)_{t-1}$$

6

 $\bar{R}^2 = 0.670$, SEE = 0.084, Q-Stat(8) = 8.26, Q-Stat(12) = 12.49, Q-Stat(16) = 13.60.

A.2 Exports to the United Kingdom

with restrictions on rationing variables:

$$\Delta x^{\mathrm{UK}} = -\underbrace{0.136}_{(-0.91)} \cdot \Delta rc + \underbrace{0.138}_{(2.55)} \cdot \Delta q^{\mathrm{UK}}$$

$$- \underbrace{0.243}_{(-2.32)} \cdot \left(\Delta x^{\mathrm{UK}} + \underbrace{0.136}_{(2.55)} \cdot \Delta rc - \underbrace{0.138}_{t-1} \cdot \Delta q^{\mathrm{UK}}\right)_{t-1}$$

$$+ \underbrace{0.855}_{(2.65)} \cdot \Delta y^{\mathrm{UK}} - \underbrace{0.695}_{(-3.40)} \cdot \Delta Pk^{\mathrm{UK}}$$

$$- \underbrace{0.149}_{(-2.45)} \cdot \left(x^{\mathrm{UK}} + \underbrace{0.136}_{t-1} \cdot rc - \underbrace{0.138}_{t-1} \cdot q^{\mathrm{UK}} - \underbrace{4.314}_{(11.44)} \cdot y^{\mathrm{UK}} + \underbrace{1.373}_{(-3.05)} \cdot Pk^{\mathrm{UK}}\right)_{t-1}$$

$$+ \underbrace{0.243}_{(-2.45)} \cdot \left(x^{\mathrm{UK}} + \underbrace{0.136}_{t-1} \cdot rc - \underbrace{0.138}_{t-1} \cdot q^{\mathrm{UK}} + \underbrace{0.314}_{(11.44)} \cdot y^{\mathrm{UK}} + \underbrace{0.373}_{(-3.05)} \cdot Pk^{\mathrm{UK}}\right)_{t-1}$$

 $\bar{R}^2 = 0.595$, SEE = 0.056, Q-Stat(8) = 6.14, Q-Stat(12) = 7.74, Q-Stat(16) = 9.06.

without restrictions on rationing variables:

$$\Delta x^{\text{UK}} = - \underbrace{0.050}_{(-0.34)} \cdot \Delta rc + \underbrace{0.141}_{(2.72)} \cdot \Delta q^{\text{UK}}$$

$$- \underbrace{0.252}_{(-2.47)} \cdot \left(\Delta x^{\text{UK}} + 0.050 \cdot \Delta rc - 0.141 \cdot \Delta q^{\text{UK}}\right)_{t-1}$$
(46)

$$+ \underbrace{0.869}_{(2.75)} \cdot \Delta y^{\text{UK}} - \underbrace{0.639}_{(-3.21)} \cdot \Delta Pk^{\text{UK}} \\ - \underbrace{0.214}_{(-3.18)} \cdot \left(x^{\text{UK}} + \underbrace{0.370}_{(-1.52)} \cdot rc - \underbrace{4.328}_{(15.05)} \cdot y^{\text{UK}} + \underbrace{1.222}_{(-3.96)} \cdot Pk^{\text{UK}}\right)_{t-1}$$

 $\bar{R}^2 = 0.618$, SEE = 0.055, Q-Stat(8) = 5.89, Q-Stat(12) = 7.39, Q-Stat(16) = 10.22.

A.3 Exports to France

with restrictions on rationing variables:

$$\Delta x^{\rm F} = \underbrace{0.658 \cdot \Delta q^{\rm F}}_{(2.96)} (47)$$

$$+ \underbrace{2.312 \cdot \Delta y^{\rm F}}_{(3.36)} + \underbrace{1.057 \cdot \Delta y^{\rm F}_{t-3}}_{(-1.90)} - \underbrace{0.302 \cdot \Delta TOT^{\rm F}_{t-6}}_{(-3.68)} - \underbrace{0.520 \cdot \Delta Pk^{\rm F}}_{(-3.68)}$$

$$- \underbrace{0.551 \cdot \left(x^{\rm F} - 0.658 \cdot q^{\rm F} - \underbrace{1.932 \cdot y^{\rm F}}_{(30.89)} + \underbrace{0.539 \cdot TOT^{\rm F}}_{(-3.78)} + \underbrace{0.355 \cdot Pk^{\rm F}}_{(-3.92)}\right)_{t-1}$$

 $\bar{R}^2 = 0.843$, SEE = 0.040, Q-Stat(8) = 6.64, Q-Stat(12) = 11.07, Q-Stat(16) = 14.88.

without restrictions on rationing variables:

$$\Delta x^{\rm F} = \underbrace{0.667}_{(-2.91)} \cdot \Delta q^{\rm F}$$

$$+ \underbrace{2.317}_{(3.34)} \cdot \Delta y^{\rm F} + \underbrace{1.111}_{(1.50)} \cdot \Delta y^{\rm F}_{t-3} - \underbrace{0.306}_{(-1.90)} \cdot \Delta TOT^{\rm F}_{t-6} - \underbrace{0.514}_{(-3.51)} \cdot \Delta Pk^{\rm F}$$

$$- \underbrace{0.547}_{(-6.11)} \cdot \left(x^{\rm F} - \underbrace{604}_{(1.57)} \cdot q^{\rm F} - \underbrace{1.931}_{(30.47)} \cdot y^{\rm F} + \underbrace{0.535}_{(-3.67)} \cdot TOT^{\rm F} + \underbrace{0.351}_{(-3.70)} \cdot Pk^{\rm F} \right)_{t-1}$$

$$(48)$$

8

 $\bar{R}^2 = 0.841$, SEE = 0.040, Q-Stat(8) = 6.79, Q-Stat(12) = 11.36, Q-Stat(16) = 15.03.

A.4 Exports to Italy

with restrictions on rationing variables:

$$\Delta x^{I} = \underbrace{0.730}_{(2.76)} \cdot \Delta q^{I} - \underbrace{0.159}_{(-1.62)} \cdot \left(\Delta x^{I} - 0.730 \cdot \Delta q^{I}\right)_{t-2}$$

$$+ \underbrace{0.741}_{(1.86)} \cdot \Delta y^{I} + \underbrace{1.137}_{(3.20)} \cdot \Delta y^{I}_{t-1} + \underbrace{0.750}_{(1.94)} \cdot \Delta y^{I}_{t-4} - \underbrace{0.190}_{(-1.26)} \cdot \Delta TOT^{I}$$

$$- \underbrace{0.268}_{(-3.57)} \cdot \left(x^{I} - 0.730 \cdot q^{I} - \underbrace{1.500}_{(14.40)} \cdot y^{I} + \underbrace{0.722}_{(-3.24)} \cdot TOT^{I}\right)_{t-1}$$

$$(49)$$

 $\bar{R}^2 = 0.744$, SEE = 0.047, Q-Stat(8) = 3.83, Q-Stat(12) = 8.80, Q-Stat(16) = 9.64. without restrictions on rationing variables:

$$\Delta x^{I} = -0.264 \cdot \Delta rc + 0.649 \cdot \Delta q^{I}$$

$$- 0.211 \cdot (\Delta x^{NL} + 0.264 \cdot \Delta rc - 0.649 \cdot \Delta q^{I})_{t-2}$$

$$+ 0.921 \cdot \Delta y^{I} + 0.868 \cdot \Delta y^{I}$$

$$- 0.417 \cdot (x^{I} - 1.977 \cdot q^{I} - 1.584 \cdot y^{I} + 0.557 \cdot TOT^{I})_{t-1}$$
(50)

 $\tilde{R}^2 = 0.756$, SEE = 0.046, Q-Stat(8) = 2.61, Q-Stat(12) = 6.70, Q-Stat(16) = 8.80.

A.5 Exports to the Netherlands

with restrictions on rationing variables:

$$\Delta x^{\rm NL} = \underbrace{0.443 \cdot \Delta q^{\rm NL} - 0.310}_{(1.38)} \cdot \left(\Delta x^{\rm NL} - 0.443 \cdot \Delta q^{\rm NL}\right)_{t-1}$$
(51)
+
$$\underbrace{0.503 \cdot \Delta y^{\rm NL} - 0.705}_{(1.83)} \cdot \Delta TOT^{\rm NL} - \underbrace{0.490}_{(-1.93)} \cdot \Delta TOT^{\rm NL}_{t-1}$$

-
$$\underbrace{0.133}_{(-2.44)} \cdot \left(x^{\rm NL} - 0.433 \cdot q^{\rm NL} - \frac{1.867}{(5.59)} \cdot y^{\rm NL} + \underbrace{2.256}_{(-1.70)} \cdot TOT^{\rm NL}_{(-1.27)} + \underbrace{0.401}_{(-1.27)} \cdot Pk^{\rm NL}\right)_{t-1}$$

 $\bar{R}^2 = 0.621$, SEE = 0.036, Q-Stat(8) = 3.08, Q-Stat(12) = 7.42, Q-Stat(16) = 10.96.

without restrictions on rationing variables:

$$\Delta x^{\rm NL} = 0.318 \cdot \Delta q^{\rm NL} - 0.302 \cdot \left(\Delta x^{\rm NL} - 0.318 \cdot \Delta q^{\rm NL}\right)_{t-1}$$

$$+ 0.577 \cdot \Delta y^{\rm NL} - 0.659 \cdot \Delta TOT^{\rm NL} - 0.478 \cdot \Delta TOT^{\rm NL}_{t-5}$$

$$- 0.099 \cdot \left(x^{\rm NL} - 1.878 \cdot y^{\rm NL} + 2.618 \cdot TOT^{\rm NL}\right)_{t-1}$$

$$(52)$$

 $\bar{R}^2 = 0.615$, SEE = 0.036, Q-Stat(8) = 2.42, Q-Stat(12) = 8.32, Q-Stat(16) = 12.76.

A.6 Exports to Belgium

with restrictions on rationing variables:

$$\Delta x^{B} = \underbrace{\begin{array}{l}0.407 \cdot \Delta q^{B} \\ (1.46) \end{array}}_{(1.46)} + \underbrace{\begin{array}{l}1.168 \cdot \Delta y^{B} + 0.618 \cdot \Delta y^{B}_{t-1} - 0.486 \cdot (\Delta x^{B} - 0.407 \cdot \Delta q^{B})_{t-1} \end{array}}_{(4.32)}$$
(53)

$$\begin{aligned} & - 0.183 \cdot \left(\Delta x^{\rm B} - 0.407 \cdot \Delta q^{\rm B} \right)_{t-2} - 0.171 \cdot \left(\Delta x^{\rm B} - 0.407 \cdot \Delta q^{\rm B} \right)_{t-5} \\ & - 0.108 \cdot \left(x^{\rm B} - 0.407 \cdot q^{\rm B} - 2.019 \cdot y^{\rm B} \right)_{t-1} \\ & - (-1.44) \left(5.38 \right)^{-1} \\ \bar{R}^2 &= 0.807, \quad \text{SEE} = 0.039, \end{aligned}$$

Q-Stat(8) = 7.95, Q-Stat(12) = 8.82, Q-Stat(16) = 13.92.

without restrictions on rationing variables:

$$\Delta x^{B} = \underbrace{0.616 \cdot \Delta q^{B}}_{(2.24)}$$

$$+ \underbrace{1.065 \cdot \Delta y^{B} + \underbrace{0.580 \cdot \Delta y^{B}_{t-1} - \underbrace{0.245 \cdot \Delta y^{B}_{t-3} - \underbrace{0.211 \cdot \Delta y^{B}_{t-5}}_{(-1.22)}}_{(-1.43)} \cdot \underbrace{(\Delta x^{B} - \underbrace{0.616 \cdot \Delta q^{B}}_{t-1})_{t-1}}_{(2.04)} \cdot \underbrace{(\Delta x^{B} - \underbrace{0.616 \cdot \Delta q^{B}}_{t-2})_{t-2}}_{(-1.79)} \cdot \underbrace{(x^{B} - \underbrace{2.074 \cdot y^{B}}_{(8.71)})_{t-1}}_{t-1}$$
(54)

 $\bar{R}^2 = 0.806$, SEE = 0.039, Q-Stat(8) = 10.11, Q-Stat(12) = 11.38, Q-Stat(16) = 16.87.

A.7 Exports to the Rest of the World

with restrictions on rationing variables:

$$\Delta x^{\text{RoW}} = -0.114 \cdot \Delta rc + 0.489 \cdot \Delta q^{\text{RoW}}$$

$$(55)$$

$$-0.301 \cdot \Delta TOT^{\text{RoW}} - 0.170 \cdot \Delta TOT^{\text{RoW}}_{t-2}$$

$$-0.263 \cdot (\Delta x^{\text{RoW}} + 0.114 \cdot \Delta rc - 0.489 \cdot \Delta q^{\text{RoW}})_{t-1}$$

$$-0.236 \cdot (x^{\text{RoW}} + 0.114 \cdot rc - 0.407 \cdot q^{\text{RoW}} - 0.877 \cdot y^{\text{RoW}} + 0.464 \cdot TOT^{\text{RoW}})_{t-1}$$

$$(-3.32)$$

 $\bar{R}^2 = 0.753$, SEE = 0.035, Q-Stat(8) = 5.35, Q-Stat(12) = 9.87, Q-Stat(16) = 13.19.

without restrictions on rationing variables:

$$\Delta x^{\text{RoW}} = - \underbrace{0.098}_{(-1.13)} \cdot \Delta rc + \underbrace{0.502}_{(2.94)} \cdot \Delta q^{\text{RoW}}$$

$$- \underbrace{0.354}_{(-2.34)} \cdot \Delta TOT^{\text{RoW}}_{(-1.11)} - \underbrace{0.342}_{(-2.91)} \cdot \left(\Delta x^{\text{RoW}} + \underbrace{0.098}_{(-1.11)} \cdot \Delta TOT^{\text{RoW}}_{t-3} \right)_{t-1}$$

$$- \underbrace{0.176}_{(-1.93)} \cdot \left(x^{\text{RoW}}_{(-1.23)} + \underbrace{0.280}_{(1.22)} \cdot rc - \underbrace{1.82}_{(6.94)} \cdot q^{\text{RoW}}_{(-1.66)} + \underbrace{0.884}_{(-1.66)} \cdot TOT^{\text{RoW}}_{t-1} \right)_{t-1}$$

 $\tilde{R}^2 = 0.755$, SEE = 0.035, Q-Stat(8) = 3.81, Q-Stat(12) = 7.83, Q-Stat(16) = 11.10.

B Results of Import Regressions

B.1 Imports from USA

with restrictions on rationing variables:

$$\Delta m^{\text{US}} = \underbrace{0.319 \cdot \Delta rc + 0.214 \cdot \Delta nr - 0.472 \cdot \Delta q^{\text{US}}}_{(2.10)} (57)$$

$$- \underbrace{0.234 \cdot (\Delta m^{\text{US}} - 0.319 \cdot \Delta rc - 0.214 \cdot \Delta nr + 0.472 \cdot \Delta q^{\text{US}})}_{(-2.38)} (57)$$

$$+ \underbrace{2.076 \cdot \Delta y + 0.754 \cdot \Delta y_{t-3} - 0.352 \cdot \Delta Pk^{\text{US}}}_{(-2.11)} (57)$$

$$- \underbrace{0.398 \cdot (m^{\text{US}} - 0.319 \cdot rc - 0.214 \cdot nr + 0.472 \cdot q^{\text{US}} - 0.933 \cdot y + 0.973 \cdot Pk^{\text{US}})}_{(4.72)} (-5.14)$$

 $\bar{R}^2 = 0.792$, SEE = 0.065,

 $Q-Stat(8) = 4.19, \ Q-Stat(12) = 5.02, \ Q-Stat(16) = 9.80.$

without restrictions on rationing variables:

$$\Delta m^{US} = 0.308 \cdot \Delta nr - 0.274 \cdot \Delta q^{US}$$

$$- 0.290 \cdot \left(\Delta m^{US} - 0.308 \cdot \Delta nr + 0.274 \cdot \Delta q^{US}\right)_{t-1}$$

$$+ 2.285 \cdot \Delta y + 0.574 \cdot \Delta y_{t-3} + 0.426 \cdot \Delta TOT^{US}$$

$$- 0.413 \cdot \left(m^{US} - 0.451 \cdot rc - 1.133 \cdot y + 1.012 \cdot Pk^{US}\right)_{t-1}$$

$$- 0.413 \cdot \left(m^{US} - 0.451 \cdot rc - 1.133 \cdot y + 1.012 \cdot Pk^{US}\right)_{t-1}$$
(58)

 $\bar{R}^2 = 0.824$, SEE = 0.060, Q-Stat(8) = 7.57, Q-Stat(12) = 9.68, Q-Stat(16) = 14.92.

B.2 Imports from UK

with restrictions on rationing variables:

$$\Delta m^{\mathrm{UK}} = 0.494 \cdot \Delta rc + 0.399 \cdot \Delta nr$$

$$(59)$$

$$+ 0.454 \cdot (\Delta m^{\mathrm{UK}} - 0.494 \cdot \Delta rc - 0.399 \cdot \Delta nr)_{t-1}$$

$$- 0.156 \cdot (\Delta m^{\mathrm{UK}} - 0.494 \cdot \Delta rc - 0.399 \cdot \Delta nr)_{t-2}$$

$$+ 0.346 \cdot \Delta TOT - 0.283 \cdot \Delta Pk_{t-1}$$

$$- 0.128 \cdot (m^{\mathrm{UK}} - 0.494 \cdot rc - 0.399 \cdot nr - 3.360 \cdot y)_{t-1}$$

$$(59)$$

 $\bar{R}^2 = 0.678$, SEE = 0.068, Q-Stat(8) = 2.20, Q-Stat(12) = 10.43, Q-Stat(16) = 11.78.

without restrictions on rationing variables:

$$\Delta m^{\mathrm{UK}} = \frac{0.543 \cdot \Delta rc + 0.396 \cdot \Delta nr}{(3.48)} (60)$$

$$- \frac{0.440}{(-3.85)} \cdot (\Delta m^{\mathrm{UK}} - 0.543 \cdot \Delta rc - 0.396 \cdot \Delta nr)_{t-1}$$

$$- \frac{0.150}{(-1.40)} \cdot (\Delta m^{\mathrm{UK}} - 0.543 \cdot \Delta rc - 0.396 \cdot \Delta nr)_{t-2}$$

$$+ \frac{0.342}{(1.82)} \cdot \Delta TOT - \frac{0.258}{(-1.32)} \cdot \Delta Pk_{t-1}$$

$$- \frac{0.145}{(-2.49)} \cdot (m^{\mathrm{UK}} - 0.574 \cdot rc - 0.354 \cdot nr + 0.203 \cdot q^{\mathrm{UK}} - 3.453 \cdot y)_{t-1}$$

 $\bar{R}^2 = 0.670$, SEE = 0.069, Q-Stat(8) = 2.31, Q-Stat(12) = 8.02, Q-Stat(16) = 10.07.

B.3 Imports from France

with restrictions on rationing variables:

$$\Delta m^{\rm F} = \underbrace{0.210 \cdot \Delta rc}_{(2.52)} \qquad (61)$$

$$- \underbrace{0.224}_{(-4.13)} \cdot \left(\Delta m^{\rm F} - 0.210 \cdot \Delta rc \right)_{t-1}$$

$$+ \underbrace{0.840}_{(3.26)} \cdot \Delta y + \underbrace{0.542}_{(2.65)} \cdot \Delta TOT - \underbrace{0.257}_{(-1.48)} \cdot \Delta Pk - \underbrace{0.379}_{(-2.20)} \cdot \Delta Pk_{t-1}$$

$$- \underbrace{0.463}_{(-4.40)} \cdot \left(m^{\rm F} - 0.210 \cdot rc - \underbrace{1.621}_{(10.60)} \cdot y - \underbrace{0.918}_{(4.64)} \cdot TOT + \underbrace{0.428}_{(-2.46)} \cdot Pk \right)_{t-1}$$

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 $\bar{R}^2 = 0.805$, SEE = 0.046, Q-Stat(8) = 13.90, Q-Stat(12) = 16.33, Q-Stat(16) = 19.02.

without restrictions on rationing variables:

$$\Delta m^{\rm F} = \underbrace{0.313 \cdot \Delta rc}_{(2.55)} (62)$$

$$- \underbrace{0.232 \cdot (\Delta m^{\rm F} - 0.313 \cdot \Delta rc)}_{(-2.30)} (62)$$

$$+ \underbrace{0.726 \cdot \Delta y}_{(3.22)} + \underbrace{0.653 \cdot TOT}_{(-1.43)} - \underbrace{0.385 \cdot \Delta Pk}_{t-1} - \underbrace{0.253 \cdot \Delta Pk}_{t-2} (-1.40)$$

$$- \underbrace{0.482 \cdot (m^{\rm F} - 0.202 \cdot rc}_{(2.06)} + \underbrace{0.689 \cdot q^{\rm F}}_{(-1.43)} - \underbrace{1.135 \cdot TOT}_{(4.91)} + \underbrace{0.427 \cdot Pk}_{(-2.51)} \underbrace{Pk}_{t-1} (-1.43) + \underbrace{0.411}_{(-2.51)} + \underbrace{0$$

 $\bar{R}^2 = 0.811$, SEE = 0.045, Q-Stat(8) = 10.90, Q-Stat(12) = 12.49, Q-Stat(16) = 13.76.

B.4 Imports from Italy

with restrictions on rationing variables:

$$\Delta m^{I} = 0.213 \cdot \Delta rc + 0.254 \cdot \Delta nr$$

$$(63)$$

$$+ 1.021 \cdot \Delta y + 0.843 \cdot \Delta TOT$$

$$- 0.414 \cdot (m^{I} - 0.213 \cdot rc - 0.254 \cdot nr - 1.498 \cdot y - 0.920 \cdot TOT + 0.444 \cdot Pk)_{t-1}$$

$$(63)$$

$$(63)$$

$$(63)$$

 $\bar{R}^2 = 0.648$, SEE = 0.039, Q-Stat(8) = 16.17, Q-Stat(12) = 19.49, Q-Stat(16) = 26.12.

without restrictions on rationing variables:

$$\Delta m^{I} = 0.451 \cdot \Delta rc + 0.300 \cdot \Delta nr \qquad (64)$$

$$+ 0.131 \cdot (\Delta m^{I} - 0.210 \cdot \Delta rc - 0.451 \cdot \Delta rc + 0.300 \cdot \Delta nr)_{t-2}$$

$$+ 1.053 \cdot \Delta y + 0.750 \cdot \Delta TOT \qquad (5.91)$$

$$- 0.546 \cdot (m^{I} - 0.292 \cdot rc - 0.269 \cdot nr + 1.099 \cdot q^{I} - 1.460 \cdot y - 0.981 \cdot TOT + 0.225 \cdot Pk)_{t-1} \qquad (-5.92) \qquad (3.74) \qquad (2.36) \qquad (-3.19) \qquad (15.18) \qquad (12.52) \qquad (-1.54)$$

 $\tilde{R}^2 = 0.707$, SEE = 0.035, Q-Stat(8) = 12.66, Q-Stat(12) = 14.64, Q-Stat(16) = 16.47.

B.5 Imports from the Netherlands

with restrictions on rationing variables:

$$\Delta m^{\rm NL} = \underbrace{0.202 \cdot \Delta rc + 0.285 \cdot \Delta nr}_{(1.80)} (65)$$

$$- \underbrace{0.375 \cdot (\Delta m^{\rm NL} - 0.202 \cdot \Delta rc - 0.285 \cdot \Delta nr)}_{(-3.57)} + \underbrace{1.062 \cdot \Delta y + 0.437 \cdot \Delta y_{t-1} - 0.253 \cdot \Delta Pk}_{(4.63)} (1.74) - \underbrace{0.202 \cdot rc - 0.285 \cdot nr - 0.079 \cdot y}_{(-1.28)} \Big|_{t-1}$$

 $\bar{R}^2 = 0.729$, SEE = 0.041, Q-Stat(8) = 4.73, Q-Stat(12) = 5.89, Q-Stat(16) = 7.63.

without restrictions on rationing variables:

$$\Delta m^{\rm NL} = \underbrace{\begin{array}{c} 0.223 \cdot \Delta rc + 0.332 \cdot \Delta nr \\ (2.45) \end{array}}_{(3.45)} (66)$$

$$\begin{array}{l} - \begin{array}{c} 0.497 \cdot \left(\Delta m^{\rm NL} - 0.222 \cdot \Delta rc - 0.332 \cdot \Delta nr \right)_{t-1} \\ - \begin{array}{c} 0.202 \cdot \left(\Delta m^{\rm NL} - 0.222 \cdot \Delta rc - 0.332 \cdot \Delta nr \right)_{t-2} \\ + \begin{array}{c} 0.912 \cdot \Delta y + 0.453 \cdot \Delta y_{t-1} - 0.193 \cdot \Delta Pk \\ (3.77) & (1.84) \end{array} \right) \\ - \begin{array}{c} 0.040 \cdot \left(m^{\rm NL} - 3.623 \cdot rc + 5.984 \cdot q^{\rm NL} - 0.421 \cdot y \right)_{t-1} \\ (0.21) \end{array} \right)$$

 $\bar{R}^2 = 0.755$, SEE = 0.039, Q-Stat(8) = 5.42, Q-Stat(12) = 6.55, Q-Stat(16) = 8.93.

B.6 Imports from Belgium

with restrictions on rationing variables:

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$$\Delta m^{B} = \underbrace{0.373 \cdot \Delta rc + 0.213 \cdot \Delta nr}_{(4.15) (2.26)}$$

$$- \underbrace{0.405 \cdot (\Delta m^{B} - 0.373 \cdot \Delta rc - 0.214 \cdot \Delta nr)}_{(4.57)}_{t-1}$$
(67)
(67)
(68)

$$+ \underbrace{0.586}_{(2.82)} \cdot \Delta y_{t-1} + \underbrace{0.954}_{(5.93)} \cdot \Delta TOT - \underbrace{0.409}_{(-2.76)} \cdot \Delta Pk_{t-2} - \underbrace{0.375}_{(-2.46)} \cdot \Delta Pk_{t-3}$$
(69)

$$- \underbrace{0.116}_{(-2.38)} \cdot \underbrace{\left(m^B - 0.373 \cdot rc - 0.213 \cdot nr - 0.353 \cdot y - 1.957 \cdot TOT\right)_{t-1}}_{(0.62)}$$
(70)

$$\bar{R}^2 = 0.843$$
, SEE = 0.037,
Q-Stat(8) = 5.84, Q-Stat(12) = 13.95, Q-Stat(16) = 14.20.

without restrictions on rationing variables:

$$\Delta m^B = \begin{array}{c} 0.388 \cdot \Delta rc + 0.286 \cdot \Delta nr \\ (4.50) & (3.05) \end{array}$$
(71)

$$-0.429 \cdot (\Delta m^{B} - 0.388 \cdot \Delta rc - 0.286 \cdot \Delta nr)_{t-1}$$
(72)
(4.93)

$$+ \underbrace{0.457 \cdot \Delta y_{t-1}}_{(2.18)} + \underbrace{0.917 \cdot \Delta TOT}_{(5.85)} - \underbrace{0.386 \cdot \Delta Pk_{t-2}}_{(-2.65)} - \underbrace{0.399 \cdot \Delta Pk_{t-3}}_{(-2.69)}$$
(73)

$$- \underbrace{0.136}_{(-2.61)} \cdot \underbrace{\left(m^B - \underbrace{0.800}_{(2.44)} \cdot rc - \underbrace{0.831}_{(2.11)} \cdot y - \underbrace{1.762}_{(3.52)} \cdot TOT\right)_{t-1} (74)$$

 $\bar{R}^2 = 0.852$, SEE = 0.036, Q-Stat(8) = 7.04, Q-Stat(12) = 15.76, Q-Stat(16) = 16.04.

B.7 Imports from the Rest of the World

with restrictions on rationing variables:

$$\Delta m^{\text{RoW}} = -0.127 \cdot \left(\Delta m^{\text{RoW}}\right)_{t-1} - \frac{0.211}{(2.24)} \cdot \left(\Delta m^{\text{RoW}}\right)_{t-3}$$
(75)

 $+ 0.536 \cdot \Delta TOT + 0.205 \cdot \Delta TOT_{t-5}$ (5.82) $- 0.356 \cdot (m^{\text{RoW}} - 1.91 \cdot y)_{t-1}$ (-5.53) (25.78)

 $\bar{R}^2 = 0.0.561$, SEE = 0.039, Q-Stat(8) = 5.85, Q-Stat(12) = 10.32, Q-Stat(16) = 11.58.

without restrictions on rationing variables:

$$\Delta m^{\text{RoW}} = -0.143 \cdot \left(\Delta m^{\text{RoW}}\right)_{t-1} - \frac{0.219 \cdot \left(\Delta m^{\text{RoW}}\right)_{t-3}}{(2.29)} (76)$$

$$+ 0.491 \cdot \Delta TOT + 0.157 \cdot \Delta TOT_{t-5}$$

$$(5.35) \qquad (1.63)$$

$$- 0.436 \cdot \left(m^{\text{RoW}} - 0.099 \cdot rc - 0.254 \cdot nr + 0.585 \cdot q^{\text{RoW}} - 1.861y\right)_{t-1}$$

$$(76)$$

 $\bar{R}^2 = 0.580$, SEE = 0.038, Q-Stat(8) = 6.79, Q-Stat(12) = 14.37, Q-Stat(16) = 15.18.

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