4

Estimating Trade Elasticities

This chapter discusses the estimation of the model outlined in chapter 3 for the United States, Japan, Germany, France, the United Kingdom, Italy, and Canada. It also spells out our assumptions about exogenous inputs such as trend output. In chapter 5, we use these assumptions to calculate estimates of FEERs.

The first section of this chapter discusses the two main econometric techniques used to obtain the estimates of trade elasticities necessary for the FEER analysis. The reader may omit these technicalities of the estimation techniques without impairing his or her ability to understand the main points of the chapter. The next section summarizes the estimation results for the trade volume elasticities using a traditional, single-equation approach, as well as Johansen's cointegration technique (Johansen 1988, 1991) (see appendix C for details of the estimation). We then discuss the determination of trade prices (see appendix C for details). The final section examines our assumptions about trend output.

Estimation Techniques

The results presented in this chapter are based on two well-known (and mutually compatible) estimation techniques. The first is the estimation by OLS of a simple error correction mechanism (ECM). The second is cointegration analysis, using Johansen's technique. These are compatible in the sense that Granger's Representation Theorem shows that for any set of I(1) variables, error correction and cointegration are equivalent representations (see Engle and Granger 1987).

As we are not interested in short-term dynamics, reflecting the medium-term nature of the model, in theory it would be possible to use only cointegration techniques. However, cointegration estimation sometimes gives problematic results, perhaps because our sample period is brief. Therefore, ECM estimates provide a useful alternative. We also compare both estimates with those obtained by previous studies, which may have been based on more data or alternative explanatory variables.

An ECM model is a reparameterization of an unrestricted autoregressive distributed lag, or dynamic linear regression, model, such as the one given in equation 4.1:

$$Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{k=1}^{m} \sum_{i=0}^{n} B_{ki} X_{kt-i} + u_t. \tag{4.1}$$

Consider a model with two independent variables (m = 2) and with each variable lagged once (n = 1). Equation 4.1 can be rearranged so that it becomes:

$$\begin{aligned} \Delta Y_t = \alpha_0 + (\alpha_1 - 1)Y_{t-1} + B_{10}\Delta X_{1t} + (B_{10} + B_{11})X_{1t-1} \\ + B_{20}\Delta X_{2t} + (B_{20} + B_{21})X_{2t-1} + u_t, \end{aligned} \tag{4.2}$$

where Δ denotes the difference operator. This reparameterization is intuitively appealing because it allows for an adjustment process toward a long-term equilibrium. In static equilibrium, this long-term solution is:

$$Y_t = \frac{\alpha_0}{(1-\alpha_1)} + \frac{(B_{10} + B_{11})}{(1-\alpha_1)} X_1 + \frac{(B_{20} + B_{21})}{(1-\alpha_1)} X_2. \tag{4.3}$$

This is the solution of interest here. It can be derived from the coefficients obtained by estimating a model of the form given in equation 4.2.

The results of the ECM estimation include a variety of diagnostic tests to check for misspecification in the equations. These tests are for serial correlation, functional form, normality, and heteroskedasticity. The tests are all distributed as χ^2, and the null is accepted when the test statistic is less than the critical value.[1] The test for serial correlation is a Lagrange multiplier test distributed χ^2 (4)—the null is no serial correlation and the alternative is fourth-order autocorrelation. The test for functional form is Ramsey's RESET test, which tests the null hypothesis of linearity against the simple alternative, where the squared predicted values from the original regression are included within the regression. Ramsey's RESET test is distributed χ^2(1) (see Ramsey 1969). Bera and Jarque's (1981) normality

1. For a type I error of 5 percent, the critical value for $\chi^2(1)$ is 3.841, for $\chi^2(2)$ is 5.991, and for $\chi^2(4)$ is 9.488. When appropriate, the results from modified F-statistic versions of these tests, which perform better in small samples, are discussed.

test looks at the third and fourth moments of the residuals. The null is normality and the test is distributed $\chi^2(2)$. Finally, the test for heteroskedasticity tests the null of homoskedasticity and is distributed $\chi^2(1)$. In some cases, it is also necessary to perform a Wald test on parameter restrictions for the ECM models. This test is distributed $\chi^2(1)$.

Many techniques have been developed to test for the existence of cointegration between nonstationary series. Probably the most popular technique currently used by applied econometricians is the maximum-likelihood methodology developed by Johansen (1988, 1991). Johansen's methodology is the second approach used in this study.

The Johansen methodology has several advantages for applied research. For example, the existence of more than one cointegrating vector is allowed for, with two tests (the maximal eigenvalue statistic and the trace statistic) to help to establish the number of cointegrating vectors. Similarly, once the number of cointegrating relationships has been established, a series of likelihood-ratio tests can be performed to test different hypotheses about them. More importantly, the Johansen procedure, which is based on full-system estimation, has greater power and can help to eliminate simultaneous-equation bias and raise efficiency relative to single-equation methods. The Johansen technique has problems, however. In particular, if there is more than one cointegrating vector, then the cointegrating relationships identified are not unique—and it will not be easy to interpret the relationships in relation to economic theory.

The methodology developed by Johansen (1988, 1991) involves estimating a vector error correction model (VECM), for a $p \times 1$ vector of stochastic variables $\boldsymbol{X_t}$, of the form:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \Psi D_t + \mu + \varepsilon_t, \quad t = 1, \ldots T, \tag{4.4}$$

where $\boldsymbol{D_t}$ are deterministic variables such as dummies[2] and μ is vector of constants. The hypothesis of reduced rank, r, of the long-term impact matrix $\Pi = \alpha\boldsymbol{\beta}'$ is then used to formulate the hypothesis of cointegration. Estimates of $\boldsymbol{\beta}$ are found by solving the eigenvalue problem, so that the eigenvectors corresponding to the r largest eigenvalues form the estimated $\boldsymbol{\beta}$ matrix. The size of the eigenvalues provides a measure of how large the correlation between the cointegrating relationship and the stationary part of the model is.

The next step is to establish how many cointegrating vectors exist for each of the relationships. Two test statistics are employed, the λ_{max} statistic and the λ_{trace} statistic. The λ_{max} statistic is of the form:

$$\lambda_{\text{max}} = -T \ln(1 - \lambda_{s+1}), \tag{4.5}$$

2. All such dummy variables, except centered seasonal dummies, will affect the underlying distribution of the test statistics. Therefore, in cases where they are introduced, published critical values will only be indicative.

where T is the sample size, the λ's are the eigenvalues (ordered in descending order), r is the number of cointegrating vectors (which lies between zero and p), p is full rank, and s is the hypothesized number of cointegrating vectors. The λ_{max} statistic tests the null hypothesis of $r = s$ cointegrating vectors against the alternative that $r = s + 1$. The λ_{trace} statistic is:

$$\lambda_{trace} = -T \sum_{i=s+1}^{p} \ln(1-\lambda_i) \tag{4.6}$$

It tests the null hypothesis that there are $r = s$ cointegrating vectors against the alternative that $r \geq s + 1$. In each case, the null hypothesis is rejected if the test statistic is greater than the critical value. Cheung and Lai (1993) indicate that the λ_{trace} statistic is more robust to skewness and excess kurtosis than is the λ_{max}.

Critical values for these tests are tabulated in Johansen and Juselius (1990) and, with greater precision, in Osterwald-Lenum (1992) (reported in Banerjee et al. 1993). The appropriate critical values vary depending on what assumptions are made about the deterministic components, such as constants and trends, and on how these assumptions relate to the true data generating process (DGP). The test for the inclusion of these variables is therefore undertaken jointly with the test of the rank of the cointegrating vector. A constant and trend could be part of either the short-term or the long-term model so that the VECM model (ignoring all other deterministic components) becomes:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha \begin{bmatrix} B \\ \mu_1 \\ \delta_1 \end{bmatrix} Z_{t-k} + \alpha_1 \mu_2 \delta + \alpha_2 \delta_2 t + u_t, \tag{4.7}$$

where $\boldsymbol{Z}'_{t-k} = (\boldsymbol{X}'_{t-k}, 1, t)$, and δ is a vector of ones. Here, μ_1 is a vector of intercepts in the cointegrating relationships, μ_2 is a vector of linear trends in the data, δ_1 is a vector of linear trends in the cointegrating relations, and δ_2 is a vector of quadratic trend coefficients in the data. If there are no deterministic components, then $\delta_1 = \delta_2 = \mu_1 = \mu_2 = 0$. However, this is unlikely to occur in practice, because, for example, an intercept is likely to be needed to account for differences in the units of measurement. For the purposes of this analysis, two main models are considered.

In the first model, the first differenced series have a zero mean, so that $\delta_1 = \delta_2 = \mu_2 = 0$. There are no linear trends in the levels of the data, because each of the series under investigation can be characterized by a pure random walk. Therefore, the intercept is restricted to the long-term model, or cointegrating space, and it simply accounts for differing units of measurement. This model is labeled model 2 for consistency with other work (see Harris 1995), and the Osterwald-Lenum (1992) critical values for the tests for the number of cointegrating vectors can be found in Banerjee et al. (1993, 276, table 8.7). In the alternative considered (which is labeled model 3), there are linear trends in the levels of the data. Therefore, one or more of the data series can be characterized as a random walk with drift. The restriction $\delta_1 = \delta_2 = 0$ is imposed, and the nonstationary relationships in the data are allowed to drift. In estimation, μ_1 combines with μ_2, so that the intercept in the cointegrating vectors is canceled with that in the short-term model, leaving only the intercept in the short-term model. The Osterwald-Lenum (1992) critical values for the tests for the number of cointegrating vectors associated with model 3 are provided in Banerjee et al. (1993, 274, table 8.5). For the same estimated model, table 8.6 of Banerjee et al. (1993, 275) provides the Osterwald-Lenum (1992) critical values for the case where the DGP is given by $\delta_1 = \delta_2 = \mu_2 = 0$, so that the model is over parameterized (this overparameterized model is denoted model 3^*).

Johansen (1992) proposes using the Pantula principle to test the joint hypothesis of the rank of the cointegrating vector and the form of the deterministic components. This involves testing both models and comparing the results, starting with the most restrictive ($r = 0$ for model 2) and moving across the models, for both the λ_{max} and the λ_{trace} statistics. The chosen model and number of cointegrating vectors is the first combination for which the null hypothesis cannot be rejected. This is the approach used here.

Once the number of cointegrating relationships is established, we examine the form of the model and the unrestricted, normalized $\boldsymbol{\beta}$ matrices. At this stage, these matrices are not fully identified, as $\alpha \boldsymbol{H}^{-1}\boldsymbol{H}\boldsymbol{\beta}' = \alpha\boldsymbol{\beta}'$, where $\boldsymbol{H}$ is any nonsingular $r \times r$ matrix. However, they provide some initial indication of whether or not the relationship between trade volume and prices is of the expected sign. In addition, tests can be performed to check hypotheses about the relationships within the $\boldsymbol{\beta}$ matrices. For example, it is possible to test if goods exports are a constant proportion of world trade. A test of a unitary coefficient on world trade can be performed by imposing a unitary coefficient and then testing whether this reparameterization is statistically significant. Johansen and Juselius (1992) discuss three main variants of testing linear hypotheses within the Johansen framework. The least restrictive of these tests, H_6, tests the hypothesis that there exists some vector in the cointegrating space that combines the variables in the hypothesized manner. It is a likelihood ratio test of the form:

$$-2\ln Q = T\left(\sum_{i=1}^{r_1}\ln(1-\rho_i) + \sum_{i=1}^{r_2}\ln(1-\Lambda_i) - \sum_{i=1}^{r}\ln(1-\lambda_i)\right), \qquad (4.8)$$

where r_1 is the number of cointegrating relationships assumed known, ρ_i are their associated eigenvalues, Λ_i are the eigenvalues of the remaining r_2 cointegrating vectors ($r = r_1 + r_2$), and λ_i are the eigenvalues from the original unrestricted model. The test statistic is distributed χ^2 with

$(p - s - r_2)r_1$ degrees of freedom. In the case where $r_1 = s$, so that r_1 of the r cointegrating relations are assumed known but the remaining r_2 are chosen without restrictions, this hypothesis reduces to H_5, which is distributed χ^2 with $(p - r)r_1$ degrees of freedom. Finally, if $r_2 = 0$, the hypothesis reduces to H_4, which tests whether the restrictions can be placed on all the cointegrating vectors spanning $\boldsymbol{\beta}$ and is distributed χ^2 with $(p - s)r$ degrees of freedom.

Estimates of Trade Volume Elasticities

For each of the trade-volume equations, we present a summary table of the estimates of income and relative price elasticities for the G7 countries. We also present the results using different estimation techniques, as well as the parameters actually chosen for the model. Detailed estimation results for both the error correction specification and Johansen estimates are presented in appendix C. The estimation period is generally 1980 to the third quarter of 1995.[3] This estimation period is shorter than we would wish, particularly for cointegration analysis. However, structural change seems endemic to trade equations, and in these circumstances, extending the data back in time might cause problems. In addition, we have been careful to compare our estimates to earlier studies that use earlier data, and in a number of cases we have revised or overridden our results to reflect this additional evidence.

The choice of parameter values is determined by a desire to have a plausible parameterization of each country for all the G7. Therefore, the first thing we do is investigate the cointegrating properties of the data using the Johansen methodology. If a single, plausible cointegrating relationship exists, then it is used in almost all cases. Occasionally, the ECM results are used although the two methods produce parameters of similar size, simply because the ECM results are closer to existing results and to the parameters of other countries. Where the Johansen results are unsatisfactory, because either the number of cointegrating vectors is ambiguous or the parameter estimates are implausible, the ECM results are used. However, in three cases, where both estimation strategies fail to yield sensible parameter values, elasticities based on existing work are imposed.

Goods Exports

Table 4.1 summarizes the results from estimation of the goods-exports volume equations. In the estimation of these equations, we allow (at least

3. The data span is limited by the use of real effective exchange rates in calculating the real exchange rate for services.

Table 4.1 Normalized elasticity estimates for goods exports

	Method	Price[a]	Income
United States	*ECM*	*−0.96*	*1.12*
	Johansen	−0.65	1.21
Japan	ECM	−1.22	0.81
	Johansen	*−1.36*	*0.91*
	Constrained Johansen	−1.57	1.00
Germany	ECM	−0.22	0.74
	Constrained ECM	*−1.15*	*1.00*
	Johansen	0.16	0.58
United Kingdom	*ECM*	*−1.26*	*0.91*
	Johansen	−1.52	0.93
France	ECM	−0.02	0.74
	Constrained ECM	*−0.67*	*1.00*
	Johansen	−0.03	0.77
Italy	ECM	−0.34	1.00
	Constrained ECM	−0.34	1.00
	Johansen	−0.27	0.96
	Constrained Johansen	*−0.44*	*1.01*
Canada	ECM	0.44	1.32
	Constrained ECM	−0.16	1.00
	Assigned Value	*−0.83*	*1.00*

Note: Italics indicate the method, price, and income chosen for the FEER calculation.

a. Price elasticities are presented here as minus the actual estimated coefficient, for consistency with the theoretical model.

initially) for a nonunitary elasticity of world trade, which enables a country's export share to vary with the level of world trade.[4] In general, the estimated world trade elasticities are close to one, and in some cases, a unit elasticity is imposed. Allowing for a nonunitary elasticity is an alternative to subsequently including deterministic trends in the relationship.

For two reasons, the elasticities chosen for the United States are the ECM estimates. First, the decision on the number of cointegrating vectors in the Johansen approach is not entirely clear cut. Second, both sets of estimates for the price elasticities are at the lower end of the scale of the estimates reported in Hooper and Marquez (1995). Therefore, it seems sensible to take the higher estimate.

For Japan, Johansen estimates are close to the mean of those reported in Hooper and Marquez (1995). Although a unit elasticity on world trade could easily be imposed, there does not appear to be any compelling rea-

4. We use total world trade here for simplicity. One possible improvement would be to exclude own-country exports from this measure, while another possibility would be to derive country-specific world trade measures by weighting imports according to the share of own-country exports.

son to do so. (A test that the normalized income elasticity for Japan estimated by the Johansen procedure can be set to unity has a value of 0.102.) The unconstrained Johansen estimates of the price and income elasticities are chosen as the parameters for Japan.

For Germany, the Johansen estimates of the price elasticity are of the wrong sign and the income elasticity is very low. The chosen elasticities for the German goods-exports equation are taken, therefore, as the constrained ECM parameters. (The constraint that the parameter on world trade is unity cannot be rejected at the 5 percent level in the ECM.)

For the United Kingdom, the number of cointegrating vectors in the Johansen approach is uncertain. Therefore, the results from the ECM model, which is less prone to misspecification, are taken. For France, the choice of model within the Johansen approach is also uncertain, and, therefore, the ECM results are again used. However, within the unconstrained ECM model, the resulting estimates of the elasticities on both prices and world trade are very low. Although the imposition of a unit coefficient on world trade is only accepted at the 4 percent level (with a test statistic of 4.1778), these results seem preferable and are therefore chosen as the parameters.

For Italy, each method produces coefficients of similar magnitude. The choice of model using the Johansen methodology is unambiguous. However, in each case the estimated price elasticity is rather low. Therefore, we impose the highest elasticity that does not conflict with the data, −0.44. This restriction is accepted at the 5 percent level (with a test statistic of 3.62).

For Canada, Johansen estimation does not yield a satisfactory outcome, and, therefore, only the ECM results are presented. The initial model produces unsatisfactory results—the price elasticity is of the wrong sign. However, a unit coefficient on world trade can be accepted, and imposing this produces a price elasticity of the requisite sign. Nevertheless, this price elasticity is extremely low. In the absence of a better alternative, the price elasticity for Canadian goods exports is the value obtained by Marquez (1990), which is the most recent estimate reported in Hooper and Marquez (1995).

Services Exports

In the case of services exports, the demand variable is world output, and a unit coefficient would not necessarily be expected. Table 4.2 summarizes the estimation results for services exports and appendix C offers the details of those estimation results.

For the United States, the unconstrained estimates of the price elasticities in both cases are very low, while the estimates of the income elasticities are high. Tests of linear restrictions on the $\boldsymbol{\beta}$ matrix of the Johansen estimation show that a coefficient of unity on world income cannot be

Table 4.2 Normalized elasticity estimates for services exports

	Method	Price[a]	Income
United States	ECM	−0.32	1.71
	Johansen	−0.21	1.95
	Constrained Johansen	*−0.40*	*1.50*
Japan	ECM	−0.31	0.49
	Constrained ECM	*−0.33*	*1.00*
Germany	ECM	−1.33	−0.70
	Constrained ECM	*−0.82*	*1.00*
	Johansen	−1.28	−0.65
United Kingdom	ECM	−0.71	−0.57
	Constrained ECM	*−0.72*	*1.00*
	Johansen	−0.85	−0.80
France	ECM	−3.45	−1.79
	Johansen	0.01	0.63
	Constrained Johansen	0.36	1.00
	Assigned Value	*−0.50*	*1.00*
Italy	ECM	−0.72	0.85
	Johansen	−0.98	0.67
	Constrained Johansen	*−0.71*	*1.00*
Canada	ECM	−0.80	0.51
	Johansen	*−0.68*	*0.62*

Note: Italics indicate the method, price, and income chosen for the FEER calculation.

a. Price elasticities are presented here as minus the actual estimated coefficient, for consistency with the theoretical model.

accepted at the 5 percent level ($\chi^2(1) = 10.235$) but that a coefficient of 1.5 can be accepted ($\chi^2(1) = 3.601$). Although there is no theoretical justification for the imposition of a coefficient of 1.5, it is a sensible compromise that does not conflict with the data and brings the US parameters more in line with those observed elsewhere. For this reason, we chose the constrained Johansen estimates as the elasticities for the United States.

For Japan, no cointegrating vector exists, and the unconstrained ECM estimates produce a very low coefficient on world income. Therefore, we chose parameter estimates taken from the constrained ECM equation for Japan. A unit coefficient is accepted at the 5 percent level, with a test statistic of 1.891. For Germany, both the unconstrained ECM and the unconstrained Johansen estimations produce a negative coefficient on world income. The chosen parameters for Germany, therefore, come from the constrained ECM equation discussed in appendix C.

The results of the estimation for the United Kingdom from both of the econometric methodologies are somewhat less than satisfactory. The basic ECM model and the Johansen methodology produce a negative coefficient on world income. However, through the addition of deterministic variables, it is possible to obtain an ECM model that estimates elasticities

Table 4.3 Normalized elasticity estimates for goods imports

	Method	Price	Income
United States	ECM	−0.38	2.43
	Johansen	−0.18	2.36
	Assigned Value	*−1.35*	*2.00*
Japan	ECM	−1.77	0.71
	Constrained ECM	*−1.16*	*1.20*
Germany	*ECM*	*−0.37*	*1.20*
	Johansen	(−0.39)	(1.16)
United Kingdom	ECM	0.003	2.16
	Constrained ECM	*−0.22*	*2.00*
France	ECM	−0.40	1.88
	Johansen	*−0.36*	*1.93*
Italy	ECM	−0.01	2.39
	Johansen	−0.12	2.20
	Constrained Johansen	*−0.34*	*1.90*
Canada	ECM	−0.48	3.25
	Constrained ECM	*−1.15*	*2.50*

Note: Italics indicate the method, price, and income chosen for the FEER calculation.

of the correct sign (see appendix C for details). The imposition of a coefficient of unity on world income is accepted within this model (with a test statistic of 1.391). Therefore, the chosen coefficients have this restriction imposed. The results for France are also unsatisfactory, and neither methodology produced a model that estimated coefficients of the requisite sign. As such, a plausible but ad hoc set of coefficients is imposed.

For Italy, using the Johansen methodology the choice of model is unambiguous. The imposition of a unit coefficient on world income is easily accepted at the 5 percent level (with a test statistic of 2.8773), and, therefore, the chosen coefficients are for the Johansen model with this restriction imposed. For Canada, both models produce a low coefficient on world income, although statistically, both models produce acceptable results. The choice of model using the Johansen methodology is again unambiguous. However, a unit coefficient on world income is not accepted. Therefore, the initial Johansen results are chosen, partly because they embody a higher coefficient on world income.

Goods Imports

Table 4.3 presents the results of the estimation of the goods-imports equations, while appendix C provides the details of the estimation.

The results from the estimation of elasticities for the goods-imports volume equation are not particularly satisfactory. Although results from

Johansen estimation are displayed for Germany, these results are obtained by ignoring the model-choice criteria. Nevertheless, the results reinforce the ECM results. For Germany, therefore, the straight ECM results are the elasticities chosen. Although the price elasticity chosen, −0.37, is very low, it is not far from the mean price elasticity of −0.5 observed for those studies surveyed in Hooper and Marquez (1995, 131, table 4.2). For Japan, the elasticities chosen are from the constrained ECM estimation, which imposes an arbitrary income elasticity of 1.20.

For the United States, the results are also unsatisfactory—the price elasticities are very low and the income elasticities high. As the model choice for the Johansen results is uncertain and the price elasticity lower than the ECM estimate, it seems more sensible to attempt to improve on the ECM results. However, for the ECM results, the hypothesis that the coefficient on lagged income can be constrained to be twice the coefficient on lagged goods imports cannot be accepted at the 5 percent level. The Wald statistic that results from a test of this hypothesis for the United States is 14.604. Even if this restriction is imposed, the price elasticity only rises to −0.55. The mean import price elasticity for the United States is −1.35 for the studies surveyed in Hooper and Marquez (1995, 131, table 4.2). We decided to base our competitiveness parameters on this mean, rather than our own unsatisfactory empirical results, and set the income elasticity to 2.0.

For the United Kingdom, the Johansen methodology would suggest that there are no cointegrating vectors. Using the ECM methodology, the initial estimate of the coefficient on prices is of the wrong sign. Including a dummy variable removes misspecification but does not alter the sign of the price coefficient. However, using this model, a coefficient of two on income can be accepted (with a test statistic of 2.365), and the coefficient on prices is now of the requisite sign. This coefficient on prices is chosen.

For France, all the models produce coefficients of similar size and of the correct sign. As the choice of model using the Johansen methodology is unambiguous, it is these coefficients that are used in the simulations. For Italy, all models produce coefficients of similar size and of the correct sign. However, the coefficients on prices in each case are very small. Using the Johansen methodology, therefore (for which the choice of model is unambiguous), progressively smaller coefficients on income are arbitrarily imposed in an attempt to increase the size of the coefficient on prices. A coefficient of 1.8 on income cannot be accepted by the data (with a test statistic of 5.868), but a coefficient of 1.9 can (with a test statistic of 3.654). The chosen coefficients are, therefore, those for the Johansen methodology with a coefficient of 1.9 imposed on income.

For Canada, like the United Kingdom, no cointegrating vector can be found using the Johansen methodology. The ECM results (not reported) over the full sample are subject to misspecification. This is mostly eliminated by estimation over a truncated sample period. These values are shown here. The unconstrained estimates produce a very high value for

Table 4.4 Normalized elasticity estimates for services imports

	Method	Price	Income elasticity
United States	ECM	−1.24	2.24
	Johansen	*−0.95*	*1.72*
Japan	*ECM*	*−1.20*	*0.97*
	Johansen	−0.45	1.06
Germany	ECM	−1.24	0.98
	Johansen	*−1.51*	*1.10*
United Kingdom	ECM	−0.67	0.45
	Constrained ECM	*−0.99*	*1.00*
	Johansen	−0.61	0.29
France	ECM	−1.46	1.89
	Constrained ECM	*−1.79*	*2.00*
	Johansen	−2.02	2.41
Italy	ECM	−0.34	2.12
	Constrained ECM	*−1.00*	*2.91*
	Johansen	0.18	1.54
	Constrained Johansen	−0.08	2.00
Canada	*ECM*	*−1.15*	*1.83*

Note: Italics indicate the method, price, and income chosen for the FEER calculation.

the coefficient on income. The imposition of a coefficient on income of 2.5 can be accepted by the data (with a test statistic of 3.042). The resulting price elasticity is very close to the value of −1.02 from Marquez (1990) reported in Hooper and Marquez (1995). Therefore, the parameters chosen have the restriction on the income elasticity imposed.

Services Imports

Table 4.4 summarizes the results of the estimation of the services-imports volume equations, while appendix C provides a detailed description of the estimation.

The Johansen estimation for the United States is not entirely clear cut, but the λ_{trace} statistic suggests that there should be one cointegrating vector. As the results are of a sensible size, they are chosen as the final parameters. For Japan, the ECM estimation of the parameters is chosen. It is chosen because the Johansen estimation for Japan is problematic. In addition, both methods obtain similar income elasticities, but the price elasticity obtained from the ECM estimation is preferable. For Germany, the Johansen estimates of the elasticities are chosen, but the ECM results are very similar.

For the United Kingdom, the results from the Johansen methodology are not clear cut. Therefore, the ECM approach is used. The basic ECM

Table 4.5 The impact of world prices within trade price equations

	Import prices		Export prices	
	Estimated A_2	Chosen A_2	Estimated B_2	Chosen B_2
United States	0.16	0.55	0.19	0.19
Japan	1.49	0.78	0.16	0.16
Germany	0.69	0.69	0.61	0.61
United Kingdom	0.75	0.75	0.71	0.71
France	0.86	0.86	0.41	0.41
Italy	0.87	0.87	0.34	0.34
Canada	−4.21	0.50	−0.55	0.50

model is not subject to misspecification, but the coefficient on income is very low. The imposition of a unit coefficient on income are not rejected at the 5 percent level (with a test statistic of 2.265), and, therefore, the parameters chosen are those for the ECM model with a unitary coefficient on income imposed.

For France, the choice of model using the Johansen methodology is uncertain. The basic ECM model is subject to misspecification that is eliminated by the addition of a dummy variable (see appendix C for details). The resulting coefficients are, however, very high. The parameters chosen have a coefficient of two on income imposed, because the imposition of such a coefficient is not rejected (with a test statistic of 0.282).

For Italy, the Johansen methodology produces a coefficient on prices of the wrong sign. Although imposing a higher income elasticity improves this, the size of the price elasticity is still very low. The basic ECM model has both coefficients of the right sign. A price elasticity of −1.0 is imposed because it can be accepted by the data. In addition, there is no evidence of misspecification. For Canada, the Johansen methodology indicates that there are no cointegrating vectors. The basic ECM results seem sensible, and these are used.

Trade-Price Equations

This section examines the choice of elasticities for the trade-price equations. The estimates presented in table 4.5 are of the elasticities of import and export prices with respect to world trade prices for each country. These are obtained using only error-correction-mechanism techniques. In each case, the models are estimated using quarterly data from 1981:Q2 to 1995:Q3. Homogeneity is imposed in the estimates presented in table 4.5, so that an equal percentage increase in world prices (in domestic currency) and domestic prices (measured in terms of wholesale prices) will lead to the same increase in trade prices.

Table 4.6 Coefficients on commodity prices

	United States	Japan	Germany	United Kingdom	France	Italy	Canada
Exports: B_1	0.17	0.02	0.08	0.18	0.21	0.10	0.31
Oil: b_1	0.13	0.32	0.14	0.45	0.13	0.20	0.35
Food: b_2	0.44	0.26	0.53	0.28	0.59	0.55	0.22
Beverages: b_3	0.09	0.05	0.09	0.16	0.16	0.12	0.03
Nonfood: b_4	0.02	0.01	0.03	0.01	0.01	0.04	0.01
Metals: b_5	0.32	0.36	0.21	0.10	0.11	0.09	0.39
Imports: A_1	0.18	0.49	0.21	0.20	0.23	0.30	0.13
Oil: a_1	0.55	0.42	0.37	0.27	0.38	0.32	0.30
Food: a_2	0.23	0.30	0.38	0.44	0.41	0.38	0.42
Beverages: a_3	0.05	0.03	0.05	0.08	0.05	0.04	0.03
Nonfood: a_4	0.01	0.01	0.01	0.02	0.02	0.02	0.01
Metals: a_5	0.16	0.24	0.19	0.19	0.14	0.24	0.24

For import prices, the parameter estimate for the United States is considerably smaller than the coefficient of 0.55 reported in Hooper and Marquez (1995, 144), which is based on a longer, but earlier, sample period. In addition, if homogeneity is not imposed in estimation, then the restriction that it should be imposed cannot be accepted by the data, and the resulting unconstrained estimate is 0.245. As our estimate is much lower than the estimated coefficients for the other G7 economies (except Canada), 0.55 is the parameter estimate chosen for the United States. For Japan, the estimated import-price equations do not produce sensible values. The value of 0.78 chosen corresponds to the coefficient on foreign labor costs (in yen) in the import-price equation reported in Hooper and Marquez (1995, 146). We also overrode the estimated parameter for Canada.

For export prices, all the estimates are plausible except that for Canada, where 0.5 is imposed. As we would expect, world prices are significantly less important for the two large, relatively closed economies (the United States and Japan). Within Europe, the relative ranking is slightly surprising, because the coefficient for Germany is above those for France and Italy.

The remaining coefficients for the trade-price equations are derived from the actual proportion of trade accounted for by commodities, and for each country the totals are for 1993 (OECD, *Annual Foreign Trade by Commodities, Series C,* 1994). The commodity categories correspond to the Standard International Trade Classification (SITC) codes as follows: oil corresponds to SITC class 3, for mineral fuels, lubricants, and related materials; food to SITC class 0, for food and live animals; beverages to SITC class 1, for beverages and tobacco; agricultural nonfood commodities to SITC class 4, for animal and vegetable oils; and metals and minerals to SITC class 2, for crude materials (except oil). Table 4.6 gives the resulting coefficients, including the totals for commodity trade.

Table 4.7 Trend output assumptions

	United States	Japan	Germany	United Kingdom	France	Italy	Canada
Output gap (1995)	1.5	−2.8	−1.1	−1.0	−2.6	−1.4	−1.7
Trend growth	2.5	3.0	2.8	2.3	2.1	2.0	2.9

Source: Giorno et al. (1995).

Assumptions about Trend Output

Our partial equilibrium model requires two key inputs: an assumption about trend output and the medium-term current account. The latter is provided by Williamson and Mahar in appendix A. For trend output, we need assumptions about both the output gap in a particular year and the trend rate of growth for output. Our assumptions on both are presented in table 4.7.

In nearly all cases, we have used figures based on the OECD's preferred method of calculating trend output (see Giorno et al. 1995). These are derived using an estimated production function, actual data for the capital stock, estimates of the labor force derived from estimates of the non-accelerating inflation rate of unemployment (NAIRU), and estimates of total factor productivity growth derived from smoothed residuals. Their estimates apply to business-sector output rather than total GDP. In addition to the figures derived using this methodology, Giorno et al. (1995) present figures derived using the Hodrick-Prescott filter and the split time-trend method.

Our calculations for the FEER in 1995 depend only on the output gap assumption for that year. A positive figure indicates that output is above trend. This is only true for the United States. The other G7 economies (and the G7 as a whole) are assumed to be operating below trend in 1995. The only country for which the output gap assumption has been adjusted is the United Kingdom. Giorno et al. (1995) quote an output gap of −2.9 for the United Kingdom using their production-function methodology. This figure seems high, and this is the only case for the G7 where the OECD's production-function methodology yields an estimated output gap for 1995 that is out of line with both alternative methods. Therefore, the UK output gap for 1995 has been set to 1.0 percent, which is the figure obtained by Giorno et al. (1995) using the Hodrick-Prescott filter.

The assumptions about trend output growth become important when we calculate FEERs for 2000. Other things being equal, a high-growth country will tend to import more than will a low growth country, so its FEER will tend to depreciate over time. However, for reasons discussed in chapters 3 and 5, high growth is often accompanied by favorable demand elasticities or trends. Figures 4.1–4.7, which compare actual GDP with the calculated trend GDP for each of the G7, show the implications of the output gap and trend growth rate assumptions.

Figure 4.1 US GDP, March 1981–December 2000

billions of 1990 US dollars

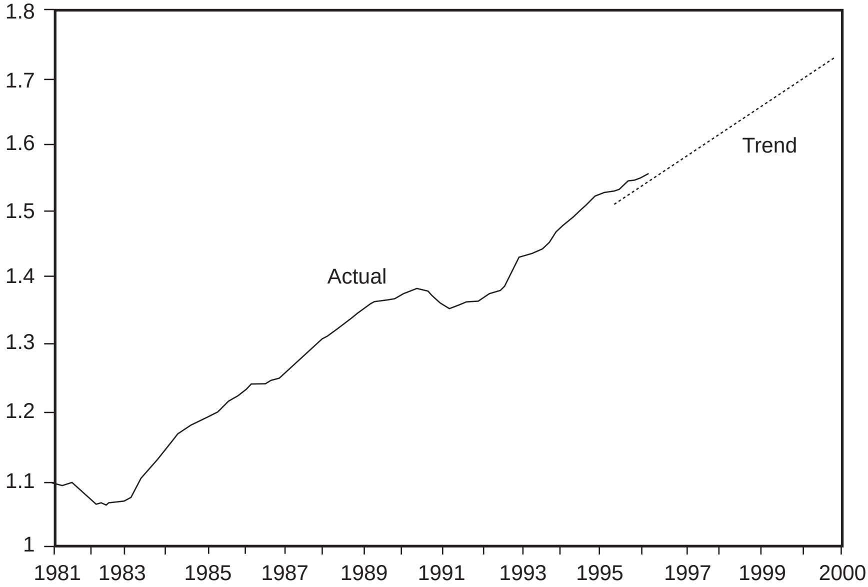

Figure 4.2 German GDP, March 1981–December 2000

millions of 1990 deutsche mark

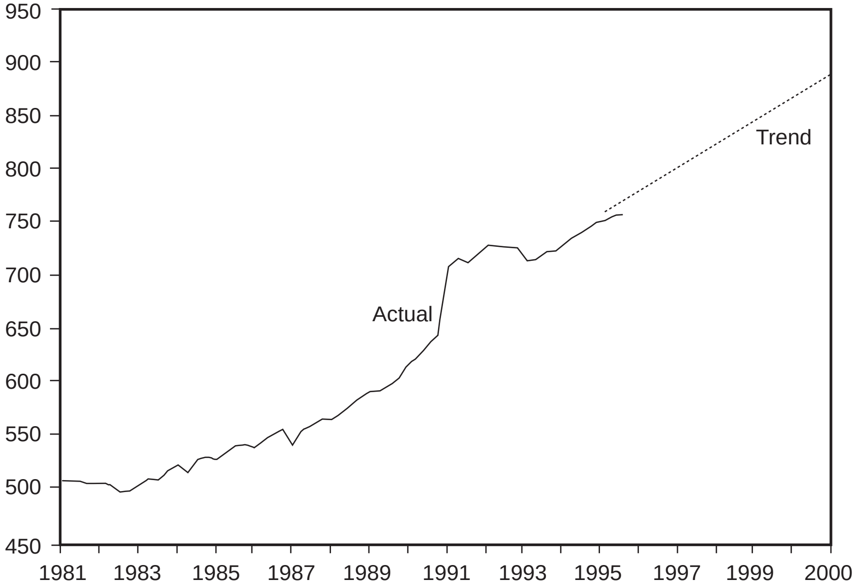

Figure 4.3 Japanese GDP, March 1982–December 2000

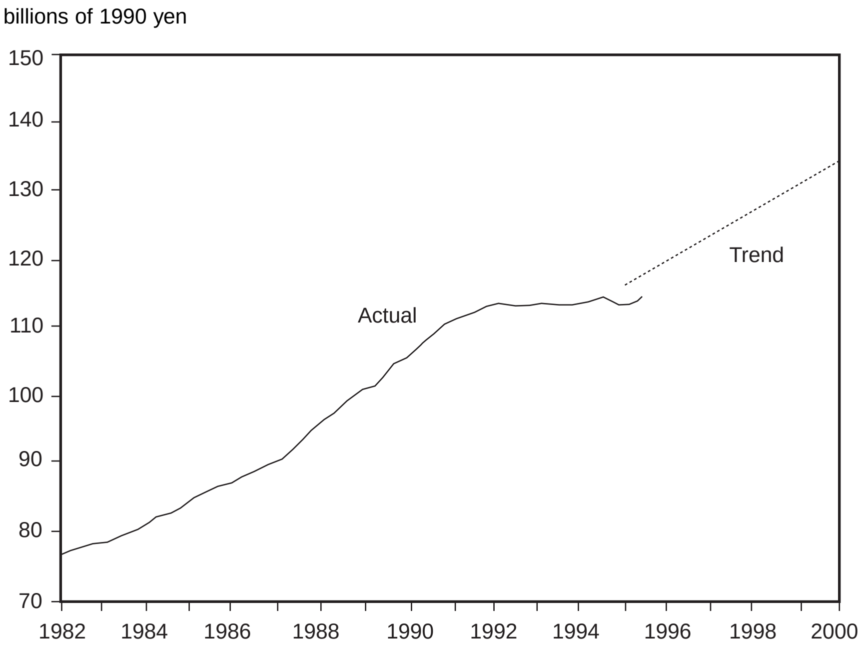

Figure 4.4 UK GDP, March 1982–December 2000

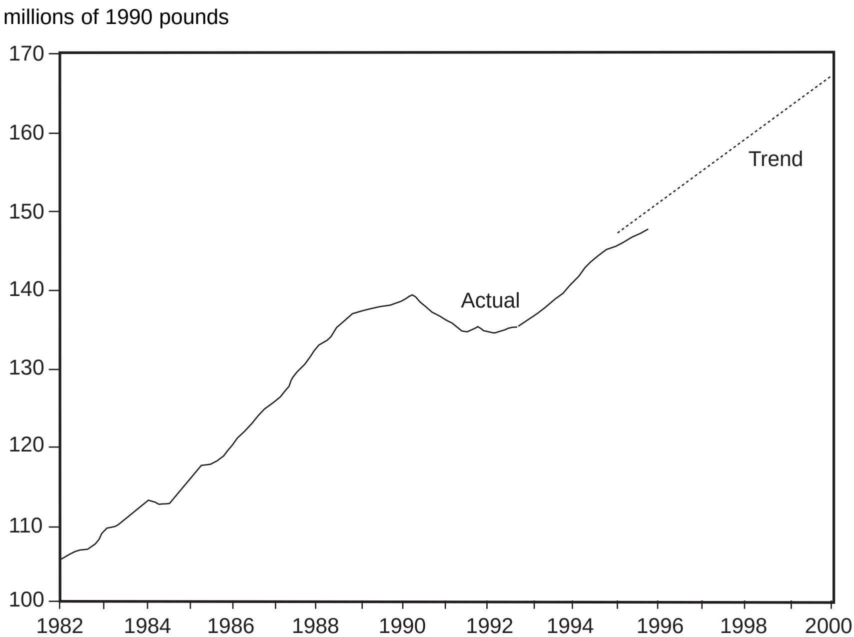

Figure 4.5 French GDP, March 1982–December 2000

billions of 1990 francs

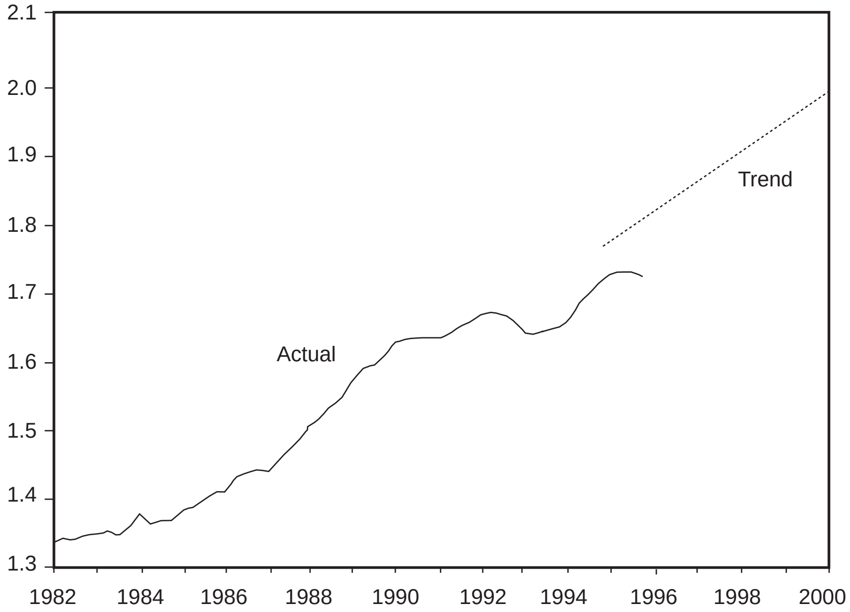

Figure 4.6 Italian GDP, March 1982–December 2000

billions of 1990 lira

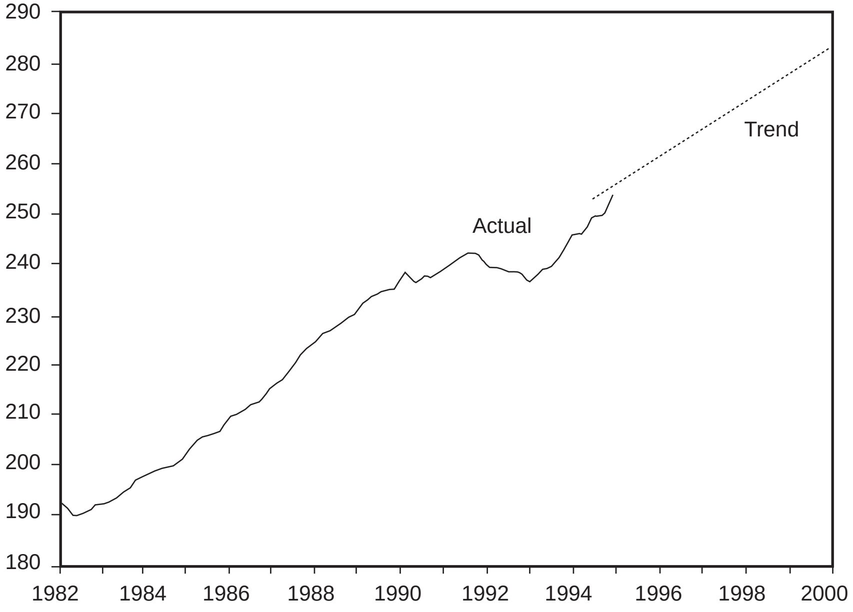

Figure 4.7 Canadian GDP, March 1981–December 2000