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The HWWA Econometric Model for Economic Forecasts

Econometric models are often used to forecast economic developments. Does the use of computer-based econometric procedures help sharpen our view of the future or are we blinkered by the supposed 'precision' of such models? What problems arise when building national economic models and when these models are used for forecasting purposes? These issues are examined with reference to the HWWA model.

A variety of procedures are used for analysing and forecasting economic developments. Alongside the traditional methods which concentrate primarily on the comparative descriptive-statistical and graphic analysis of individual series of principal economic statistics on the basis of certain theoretical conceptions regarding the economic process, highly complex computer-based econometric procedures are also used.[1] The most comprehensive are econometric models which represent the entire national economy and which are based on a mathematically formulated and theoretically founded stochastic system of economic relationships.

The HWWA also uses a national economic model for its analyses and forecasts. This model, which originated in a joint effort of the economic research institutes involved in the joint report on the economic situation in the 1970s,[2] is conceived as a forecasting model for short-term national economic developments in the Federal Republic of Germany; the economy of eastern Germany has been included since autumn 1995. Work is currently in progress to extend the model to cover the entire EMU area.

In the following, problems involved in the construction of national economic models and their implementation for forecasts and simulations are demonstrated on the basis of the HWWA model. In addition, the authors touch upon the difficulties involved in extending the model to cover the EMU area.

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Structure of the HWWA Model

An econometric model is a mathematical depiction of certain relationships within the economic process which are assumed to exist and which, on the chosen level of abstraction, are considered relevant for the analysis in question. The depiction takes place in the form of a system of mathematical equations which, in addition to a set of interrelated economic variables, also includes purely random variables (irregular residuals). However, in the sense of critical rationalism according to Popper, the question of whether and with how great a degree of precision the mathematical depiction succeeds in reproducing the causal or interdependent relationships found in reality – assuming, of course, that they do actually exist – always remains open.[3]

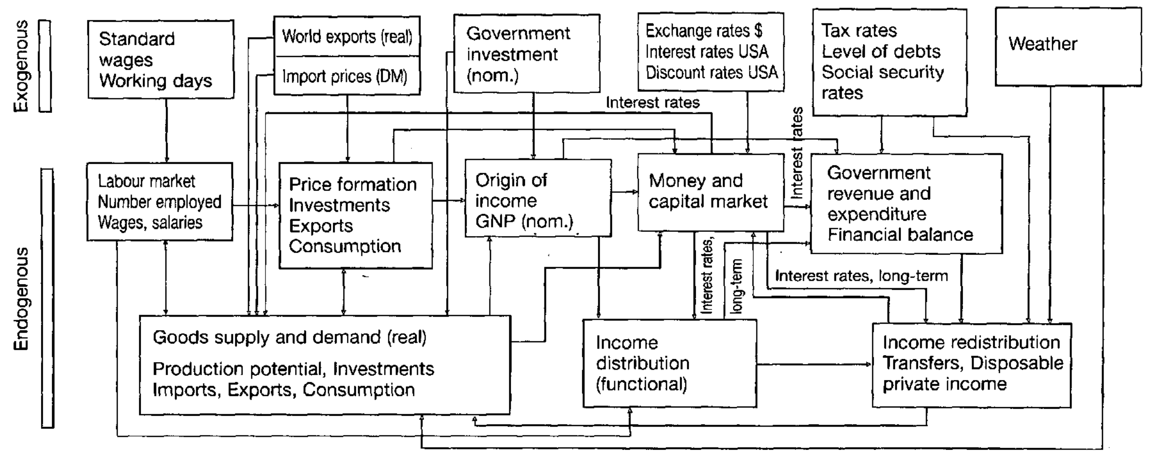
Formal characteristics such as the scope of the system and the type of functional equations used depend on the purpose of the analysis, on theoretical conceptions of the economic process, and on the available statistical data. The formal characte-

[1] For an overview of the various methods of economic forecasting see *inter alia* G. Tichy: Konjunktur, 2nd edition, Berlin, Heidelberg 1994, chapters 8, 9; J. Hinze: Konjunkturprognosen: Was sie leisten können und was nicht, in: Hamburger Jahrbuch für Wirtschafts- und Gesellschaftspolitik, Vol. 32 (1987), pp. 37-47.

[2] German Institute for Economic Research, Berlin (DIW); Hamburg Institute for Economic Research (HWWA); ifo Institut für Wirtschaftsforschung, Munich; Kiel Institute of World Economics (IfW), Rhine-Westphalia Institute for Economic Research (RWI).

[3] U. Westphal: Makroökonomik, 2nd ed., Berlin, Heidelberg et. al. 1994, pp. 20 f.

HWWA Econometric Forecasting Model



Block diagram

ristics and the economic relationships to be reproduced determine the structure of the model.

The structure of the HWWA model is geared to delivering a short-term forecast of the development of the German national economy for a period of up to two years. Input is provided by national accounts statistics, and historical data is taken from the ten-year period (base period) immediately prior to the forecasting period. Given the high level of aggregation and the short forecasting period, it appears appropriate to use a model of moderate scope and simple structure.[4] Neither macroeconomic theory, nor the tradition of econometric modelling[5] require the abundance of economic interactions on a microeconomic or industrial level to be taken into consideration when formulating a macroeconomic system of relationships.[6] This is valid as long as the sectoral structure of the economy can be assumed to be more or less constant for the duration of the forecasting period.

The forecasting model currently consists of a total of 128 equations. Of these, 58 are stochastic behavioural functions while the rest define identity or equilibrium relationships (definition equations). This modest scope guarantees both the clarity of the model and its practical implementation where resources are limited. A further contribution is made by the fact that – wherever neither theory nor empirical statistics prove otherwise – linear relationships are assumed to exist between most of the economic aggregates included in the model, taking time lags into account, or at least between their logarithmic transformations. For the short, twelve-year period of the model's validity – ten years of historical data and a two-year forecasting period – these linear relationships can also be interpreted as reasonable approximations of possible non-linear relationships.

However, in the interests of paying sufficient heed to economic theory regarding the inclusion of economically relevant factors, it is impossible to forego the application of non-linear relationships entirely. Formally speaking, the model thus consists of a system of linear and non-linear interdependent stochastic difference equations, whose variables represent the statistical data available for the macroeconomic elements included. This kind of model is more complex than the well-known VAR (vector autoregressive) models which – in recursive form – make do with a linear structure as far as their dependent variables are concerned.

Linear transformation of the HWWA model is possible neither in a reduced or autoregressive form

[4] Cf. W. Assenmacher: Konjunkturtheorie, 7th ed., Munich, Vienna 1995, p. 50.

[5] A summary of econometric models can be found in G. Uebe: World of Economic Models: A Catalogue of Typical Specifications of Economic Models, Aldershot et al. 1995.

[6] Cf. W. Assenmacher, op. cit, p. 21; U. Westphal, op. cit., chapter 2.

nor in an error correction form (error correction model, ECM). It represents a theory-oriented interdependent structural model. Experience so far has shown that, in spite of the model's non-linearity, the Gauss-Seidel method can be applied to determine the fixed points of dependent variables.

Design Details

The model's design, which includes the choice of economic aggregates covered, possible time lags and model parameters, is geared to the aim of recording on a macroeconomic level the influences and interdependent relationships of the principal determining factors in the economic process for a two-year forecast. The theoretical basis is provided by generally accepted macroeconomic conceptions of interactions within the economic process. Within the scope of model's relevance, there are no serious differences among recognised theories either with regard to the macroeconomic reproduction of the network of relationships found within the transmission mechanism of the market economy and in their explanation of the course of the economic cycle with its complex combinations of external and internal impulses or to differing expectations and rates of adjustment. The differences which do exist lie primarily in the nature of stimulating impulses, in the relative weighting of the various real and monetary factors, and in the rates of and restrictions to reactions.[7] In addition to aspects of relevance to the economic cycle such as capacity utilisation, the model also comprises factors which determine longer term growth, for instance production capacity.

In practice, the detailed design of the model is carried out in two stages. The first stage involves the establishment of a class of model which is so extensive that the models of this class are capable of representing simultaneously any presumably significant dependencies and interdependencies found within the macroeconomic process. The individual models of a particular class are distinguished only by the values of their parameters. In the second stage, an optimising procedure based on available statistical data is used to select a model of the established class. This procedure determines the parameter values which, in accordance with a given criterion, achieve the best adjustment of the model to the statistical data. The second stage of model selection is alternatively referred to as the specification or estimation of model parameters as well as statistical model adjustment. This selection determines all the characteristics of the model which also include, in particular, the assumed weights, time lags and rates of reaction of all the factors which are of significance for the macroeconomic process.

Theoretical Substantiation

With regard to the combination of process determinants, the class from which the HWWA model is selected encompasses both neo-classical and neo-Keynesian macroeconomic models. In both of these types of model exogenous or unexpected shocks, which, in economic theory, play an important role in the development of an economy, can be represented just as readily as cyclical and seasonal fluctuations. Given a constant selection procedure, the selection of a model of the first or the second type will depend on the relevant underlying statistical data.

Despite the consideration of supply-side factors, the model selected (via parameter estimation) tends to be of a neo-Keynesian rather than a neo-classical character.[8] The pre-eminence of Keynesian models for economic forecasting purposes could possibly be due to the more differentiated assimilation of the demand side compared to the supply side, as well as to the omission of portfolio theory dependencies and the real cash balance effect. Above all, however, a major role is probably played by the problems surrounding the realistic inclusion of the formation of expectations – an important element of neo-classical macroeconomics, especially in the theory of rational expectations – into a highly aggregated econometric model. Correct modelling of the supply side is a general problem in the macroeconomic forecasting models used today.

The selection of a particular model by means of parameter specification is carried out using the OLS method on the basis of quarterly statistical data for the ten years prior to any forecasting period (moving ten-year base period). Despite its simplicity, the OLS method is expedient for large-scale, non-linear models with trend-linked macroeconomic variables. Only under very particular conditions, which are not given here, do more complex procedures tend to deliver unequivocally superior model adjustments. Nor would a possible reversible linear transformation of individual model equations to the ECM form be of

[7] Cf. P. A. Samuelson, W. D. Nordhaus: Economics, 15th ed., New York et al. 1995, p. 571; R. J. Barro: Introduction, in. R. J. Barro (ed.): Modern Business Cycle Theory, Oxford 1989, p. 4; G. Tichy, op. cit., pp. 144 f; A. Woll: Allgemeine Volkswirtschaftslehre, Munich 1996, p. 566, 568.

[8] Cf. G. Tichy, op. cit., p. 211.

any benefit, since, following reverse transformation, the results would be identical with those of the direct OLS procedure as far as parameter estimation is concerned.[9] Integration and cointegration of the variables are of no significance in this respect.

When evaluating the method of parameter determination it should be taken into account that when formulating practical econometric models it is less important to attempt to improve parameter determination with the help of complex, sophisticated methods[10] than to determine the right class of model from which the model is to be selected, possibly by means of a trial and error process. The moving base period for the specification of the parameters guarantees a constant adjustment of the model to currently available statistical data. Thus an attempt is made to bear witness to the gradual processes of structural change taking place in the economy. Usually, however, it is not sufficient to merely redetermine the model parameters; the class of model must also be re-established.

Model Variables

The variables used in the model are defined as being exogenous or endogenous according to the nature of their dependency within the model. The exogenous variables are independent both of each other and of the endogenous variables. The endogenous variables on the other hand are unilaterally dependent on the exogenous variables and multilaterally or unilaterally dependent on each other. The number of endogenous variables is always equal to the number of model equations. From a mathematical point of view, the lagged endogenous variables belong to the independent variables in the system of simultaneous equations. The forecasts generated by the model refer to the endogenous variables only. The

[9] J. Johnston, J. DiNardo: Econometric Methods, 4th ed., New York 1997, p. 246, 263.

[10] Cf. G. Tichy, op. cit., p. 224.

forecasts are determined by the exogenous variables and by the values of the lagged endogenous variables in the base period. To the extent that a model contains exogenous variables, the model forecast is dependent on the forecast of the exogenous variables which takes place outside the model.

Exogenous Variables

With the help of exogenous variables it is possible to take into consideration not only important non-economic factors, but also those economic factors which are either completely unaffected or which are only marginally and not inevitably influenced by the economic process depicted in the model. The first group of factors covers in particular the effects of natural phenomena, while the second group includes the effects of global markets and the consequences of discretionary economic policy decisions. The exogenous variables in the HWWA model include *inter alia* the annual number of working days, seasonal effects, extreme weather conditions, autonomous technological progress, world exports, import prices, the exchange rate of the US dollar, the US discount rate as well as the long-term and short-term interest rates in the USA, nominal government investment, the various tax rates, and discretionary measures such as changes in the system of taxation.

In the case of short-term forecasts (but not where the simulation of economic policy measures is concerned) it has also proved expedient to treat the national standard wage level as an exogenous factor; experience has shown that it can be forecast more accurately using traditional methods than with an econometric model. Another exception is sometimes made with regard to the treatment of real investments in housing construction. Given the frequent changes in support programmes for residential building in particular – which models tend to be incapable of accommodating and quantifying in a satisfactory manner – an exact model forecast of construction investments is often very difficult. A further exception in recent years concerns short-term and long-term interest rates, as is explained below.

A particular problem was posed by the inclusion of the eastern German economy, primarily because of the structural differences between the eastern German and western German economies and because of the lack of sufficiently long, homogeneous time series for eastern Germany. On the assumption that the differences in behavioural parameters between eastern Germany and western Germany are small, and that the weight of the eastern German economy is relatively small compared to that of western Germany, it appeared justifiable to take account of the inclusion of the eastern German economy into the model simply by adding a dummy variable to the stochastic behavioural equations in order to register a one-off shift in the level of statistical data when the area covered by the model was extended to include the whole of reunified Germany.

Endogenous Variables

The endogenous variables of the HWWA model can be classified into eight groups: 'labour market', 'goods supply and demand', 'price formation', 'origin of income', 'income distribution', 'income redistribution', 'government revenue and expenditure' and 'money and capital market'. Since each endogenous variable has a model equation assigned to it as an explanatory formulation in the form of a behavioural function or a definition equation, it is also appropriate when classifying the variables to divide the model into eight corresponding sections (blocks).

Due to the limited space available it is not possible to present all 128 endogenous variables and their explanatory approaches here.[11] The block diagram provides a general overview. The core of the model is formed by the first six blocks, between which close interdependencies exist. The core covers the explanatory formulation for the real economic aggregates on both the supply and the demand side as endogenous variables. These aggregates include *inter alia* the production potential of the national economy, the utilisation of capacity in the economy, employment, gross domestic product, private and public consumption, exports and imports, fixed asset investment, relevant prices (deflators) and disposable income. These factors form the main focus of interest when forecasting.

The government revenue and expenditure which form the seventh section of the model are largely dependent on the core variables. In the case of the money and capital market, the eighth block, on the other hand, the dependency tends to be reversed. This block, however, the money section for short, affects the core only via the determination of short-term or long-term interest rates. Since the growing internationalisation of the money and capital markets means it is scarcely possible to explain interest rate developments with the course of events in individual economies, and thus it is scarcely possible to forecast

[11] A list of all the model's equations can be provided by the HWWA on request.

them with national models any more, the money section is usually separated from the rest of the model. Interest rates are then treated as exogenous factors to be estimated in advance outside the model itself.

Problems of Model Forecasts

A model forecast takes place in two stages. In the first stage, the values of the exogenous variables are estimated in advance, and in the second stage the values of the endogenous variables are ascertained as forecast values. Both stages are characterised by specific problems. As far as the exogenous factors are concerned, forecasters tend to fall back on well-tried traditional procedures. The selection of individual methods and their handling are subject to a certain amount of subjective discretion. Since the accuracy of the entire model forecast is largely determined by the precision with which the exogenous variables are estimated, it is necessary to carry out a thorough analysis of the development of all the important exogenous factors. Thus in the HWWA model the development of world exports in particular – which has to be provided as an exogenous variable – has a considerable influence on the results of the forecast. Nonetheless, mistakes in the model forecast which result from false advance estimates of the exogenous variables do not imply a falsification of the model itself.

In theory, arriving at the forecast values of all the model's endogenous variables in the second stage of the procedure appears relatively simple at first. For in a specified model, having established the exogenous factors for the forecasting period and having set the irregular residual items to zero, all that should need to be done is to determine a fixed point for the equation system. Yet years of experience with model forecasts at the HWWA demonstrate that such a simple procedure often delivers unsatisfying results. The reason lies in the fact that even if the model describes the past course of economic events with sufficient precision, it is not necessarily capable of representing future developments in a satisfactory manner.

Notwithstanding the fact that correction is required for any misspecifications which already exist for the base period but which do not come clearly to the fore until the forecasting period itself, corrections are also necessary to take into account in particular recent behavioural changes among economic subjects, the influence of new economic policy measures or the effects of exceptional factors. These model corrections – often called fine tuning – are usually carried out by changing the values of exogenous variables to account for exceptional effects, by adding new variables, by changing the form of an equation (linear, non-linear) or by modifying model parameters. From a methodological point of view – with the exception of changing the values of exogenous variables – this means nothing less than re-designing the form and/or content of the model.

As a rule, there is a great deal of discretionary scope for deciding which fine tuning measure is the most suitable in a particular case; this is also true of the evaluation of results. How this scope is used depends on the preferred theoretical assumptions regarding the effect of those factors which are to be either re-examined or considered as new variables. It is not unusual to test a number of possibilities. The final choice of procedure is, in turn, subject to a certain degree of subjective evaluation.

Varying Forecast Quality

The quality of model forecasts varies considerably. Experience has shown that, in general, their accuracy is no greater than that of forecasts which have been made on the basis of traditional analytical methods. As could be demonstrated by subsequent calculations, the errors made in model forecasts are not solely due to an incorrect estimation of the development of exogenous variables. They also result from the fact that the model specifications carried out for the base period are sometimes no longer adequate for the forecasting period itself. Both the form of certain equations as well as some parameter values can prove to be no longer suitable. Fine tuning, on the other hand, is responsible for very few errors. As a rule it improves the accuracy of the forecast. This experience largely corresponds with known results which have been established in practical forecasting work with other, both much larger and smaller, econometric models.[12]

The difficulties which arise when using the model to forecast economic developments also occur when it is used to establish the effects of planned or already implemented economic policy measures. In the case of simulation computations it is even more important than in forecasting that the model be correctly specified, because in the simulation – by definition – no development trends can ensure that the effects of misspecifications on the result are in part insignificant. This is because error reduction based on trend

[12] Cf. G. Tichy, op. cit., pp. 213, 245.

relationships – which is known as the effect of cointegration of non-stationary stochastic variables – is based solely on the passage of time and not on the extent of the changes made exogenously to variables or parameters for the simulation.

Given the experience gathered in many model forecasts in recent years to the effect that model specification – even for the purpose of predicting economic developments – is still in need of improvement, it seems particularly prudent to exercise extreme caution when interpreting the results of simulations. Especially critical observation is required when situations are simulated for which during the base period there have been no comparable combinations of those factors which are effective in the economic process. In the case of simulations of this nature, misspecifications caused by stochastic collinearities in the movements of economic aggregates pose a particularly serious problem.[13]

Useful Instrument of Analysis

In spite of the problems outlined above, the econometric forecasting model proves to be a useful instrument for the analysis and prediction of short-term economic developments. As a rule, the problems are no greater than those of traditional time series analyses or informal forecasting procedures. The advantage of the model lies in the logically consistent and theory-based simultaneous inclusion of the information contained in a multitude of relevant statistical data series. In this way, the complex interaction of a large number of factors is taken into account in the forecast. All the assumed conditions and hypotheses are disclosed, formulated in mathematical terms. The model (as a representation of the assumed hypotheses) can thus be scrutinised and is subject to the risk of falsification. It thus fulfils the Popper criterion for a scientific method of empirical research. The informal methods, for example, cannot lay claim to this characteristic. The model's uncertainty – which is inherent to the method itself – concerning the need to depict with a sufficient degree of accuracy those relationships which actually exist in the base period, should not be considered a disadvantage, for no other method achieves a comparable level of precision in this regard.

The model's limitations become apparent when it comes to including new occurrences (e.g. German reunification) or developments (e.g. European Monetary Union, EMU) whose effects on the economic process cannot be deduced from historical statistical data. The frequently encountered practical difficulty of processing the abundance of available information and of transforming it into a quantifying form suitable for modelling purposes should not be regarded as a fundamental failing of the model itself, but rather as an inadequacy in the construction and utilisation of the model. This inadequacy is usually due to the vast amount of resources required when working with the model - resources which are often just not available. It is thus understandable that from a cost-benefit point of view more simple, traditional procedures are often preferred in practice.

Extension of the Model to Cover the EMU

As the economies of Europe grow closer together and become a single economic area, the economies of the individual participating countries are increasingly losing their independent character. For these countries, as for the world economy, the economic development of the area as a whole is becoming increasingly important. This has consequences for the observation and forecasting of the course of economic developments. The focus of observation is shifting from national economies to the economy of the region as a whole. This is particularly true of the European Monetary Union. It is thus becoming necessary to adapt the applicable instruments of econometric analysis to this shift of focus.

There are two different concepts for the econometric modelling of an economic area which spans several countries. In the country-confederation concept, models are constructed for the individual countries which are then connected to one another either via the countries' bilateral foreign trade relationships or via a common trade matrix. In this way a multinational model emerges such as the one used by the German Bundesbank.[14] The block concept, on the other hand, no longer distinguishes between individual countries, but constructs a single model for the entire region. This concept is based on the assumption of very close economic interrelationships between the countries.

With a view not only to the future situation regarding statistical data, but also to the increasing level of European integration which has gained impetus since the Maastricht resolutions at the end of 1991, the block concept for modelling the euro area appears the

[13] Known in the case of cointegrated variables as the problem of determining the cointegration vector to be selected.

[14] Cf. Deutsche Bundesbank: Makro-ökonometrisches Mehr-Länder-Modell, Frankfurt, November 1996.

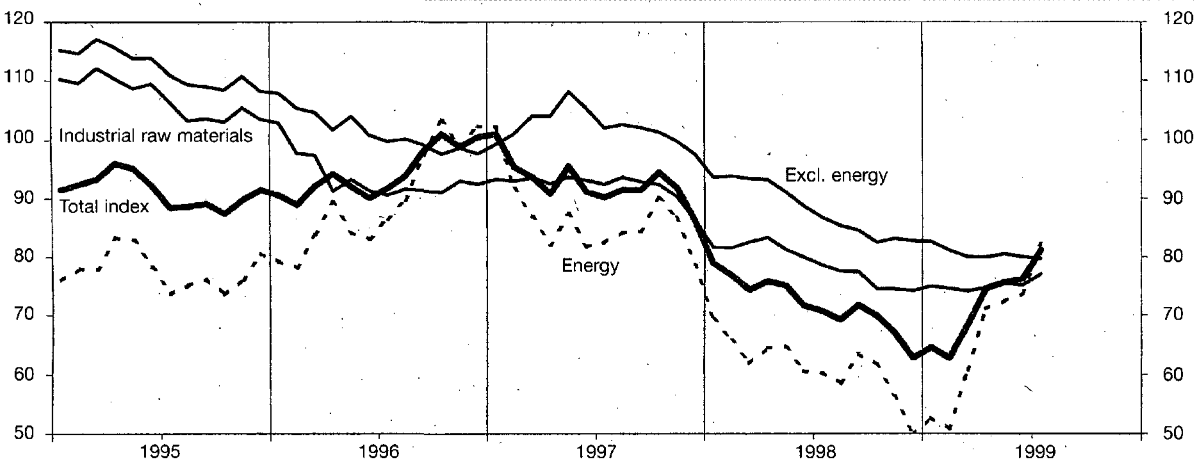
more suitable. When summarising national economies within a single model, it is less important for the countries to have identical economic structures than it is for similarities to exist in the economic process depicted in the model, a contribution to which is made by the transition to a common monetary policy. Since the responsibility for monetary policy was transferred to the European Central Bank at the start of the year, monetary policy has become an exogenous variable for all the member countries.

The transformation of the German model into a block concept model for the euro area (EMU model) is already in progress. In order to limit the resources required for the transformation – including the software system – the new model is to be achieved primarily by modifying the content of the existing model. While the simplest method would be to merely substitute German statistical data with data for the entire region of the eleven euro countries, this approach is applicable in only a small number of subsections. Indeed, extensive modifications are necessary in order to take account both of new structures and of changes in the situation regarding statistical data; this is particularly true where the financial part and the money and capital markets are concerned.

Particular problems are posed by the preparation of data and the specification of the new model parameters for the initial base period, which spans the period 1989-1998. Due to numerous gaps in the statistical data as well as its inhomogeneous nature, estimates are often unavoidable when compiling data. An additional problem is that the individual economies developed quite differently up to around 1993. This results in an unusually high degree of uncertainty regarding the initial specification of the model. This uncertainty will, however, become less significant from year to year.

HWWA Index of World Market Prices of Raw Materials[1]

(1990 = 100)



Raw Materials and Groups of Materials[1]	1998	Jan. 99	Feb. 99	Mar. 99	Apr. 99	May 99	June 99	July 99[2]
Total Index	72.0 (–22.4)	64.6 (–18.2)	62.8 (–18.3)	68.4 (–8.1)	74.6 (–1.6)	75.6 (0.7)	76.2 (6.3)	81.2 (14.9)
Total, excl. energy	88.2 (–13.7)	82.7 (–11.7)	81.1 (–13.5)	80.0 (–14.3)	79.9 (–14.2)	80.5 (–11.6)	80.0 (–9.7)	79.7 (–8.0)
Food, tropical beverages	115.8 (–12.2)	105.5 (–18.3)	100.5 (–22.7)	97.4 (–22.3)	95.2 (–22.2)	95.2 (–20.8)	94.6 (–17.3)	87.6 (–20.8)
Industrial raw materials	78.9 (–14.5)	75.0 (–8.2)	74.6 (–8.6)	74.1 (–10.2)	74.8 (–10.2)	75.5 (–7.0)	75.1 (–6.1)	77.0 (–2.0)
Agricultural raw materials	79.3 (–14.4)	77.7 (–4.0)	78.3 (–3.9)	77.7 (–6.3)	77.1 (–8.1)	77.5 (–5.2)	77.8 (–4.3)	78.0 (–1.3)
Non-ferrous metals	71.1 (–20.8)	63.5 (–17.0)	63.3 (–15.5)	63.4 (–15.8)	67.2 (–11.6)	69.0 (–5.6)	67.4 (–3.4)	73.3 (5.2)
Energy	61.4 (–29.0)	52.7 (–23.9)	50.8 (–22.8)	60.8 (–1.9)	71.1 (10.2)	72.4 (12.1)	73.7 (21.7)	82.2 (36.4)

[1] On a US dollar basis, averages for the period; figures in brackets: percentage year-on-year change.
[2] Up to and incl. 23rd July.