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Models and methods for economic policy: 60 years of evolution at CPB*

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What is now known in English as the Netherlands Bureau for Economic Policy Analysis (CPB) has been involved in econometric model building since its foundation in 1945. During the 60 years of developing and using the models reviewed in this article, CPB's model building has evolved significantly. Over this period, a shift of emphasis can be observed from econometrics and empiricism to economic theory. New questions from policymakers and new features in the national economy have guided research, while new developments in econometrics and economic theory were taken on board wherever they helped to improve the quality and scope of the analysis. Although considerable progress has been achieved in several spheres, even the most sophisticated and up-to-date models continue to be riddled with some long-standing limitations and weaknesses.

Keywords and Phrases: econometric models, model building, economic policy preparation.

1 Introduction

While 2006 marks the 60th anniversary of *Statistica Neerlandica* and the 50th anniversary of the Econometric Institute of the Erasmus University Rotterdam, in 2005 the Netherlands Bureau for Economic Policy Analysis (CPB) celebrated its 60th anniversary. The acronym CPB stands for 'Centraal Planbureau' in Dutch, because it was originally intended to be a planning agency providing estimates and guidelines for the Dutch economy in order to support the coordination of government policy in economic, social and financial affairs. Over time, planning has come to be understood as providing solid and objective information for government policy, where possible based on scientific analysis (see CPB, RIVM, RPD and SCP, 1995). This is a fair description of what CPB started to do already in September 1945 under the inspiring leadership of its first director, Jan Tinbergen.

The last 60 years have seen quite a development in statistics, econometrics and economic theory, with relevance for the scientific base of CPB's work. This paper

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intends to trace the key steps in the evolution of econometric models and methods at CPB. A broader study of the history of econometric model building in the Netherlands is provided by Barten (1991) and Verbruggen (1992), while den Butter (2003) examines what has changed and what has remained the same in the use of econometric models in Dutch policy analysis since the late 1970s. Passenier (1994) offers a broader description of the history of CPB and den Butter (2006) describes CPB's role in the formulation of economic policy in the Netherlands.

This article focuses on the development and use of econometric macro models for the Dutch economy at CPB. Of course, this does not mean that CPB is the only organization which develops and applies models of this type in the Netherlands. The Dutch central bank (DNB) and several private banks, for instance, are very active in this field. But it must be said that the interest in model building at universities and ministerial research departments has declined appreciably since the late 1980s.

On the contrary, nor does the focus on macro models in this contribution mean that CPB has not developed other models and methods over the years. Within economic policy making, a shift of emphasis has taken place in the direction of such themes as infrastructure, market regulation, research and innovation, population ageing, and institutions, none of which is easily analyzed with a standard macro model. That is why CPB has developed and used several different types of models and methods over the years, including applied general equilibrium (AGE) models and a wide range of instruments for cost–benefit analyses.[1] As it is beyond the scope of this article to provide a complete overview of all the models and methods used, we have opted to concentrate on the type of instrument with which CPB has had the longest and the most experience, namely macro models for the Dutch economy, and we will consider other models only in passing.

In section 2, we consider the significance and limitations of models in policy formulation. In section 3, we outline the evolution in the development and use of models at CPB over the last 60 years. In section 4, we conclude by outlining the lessons from the past, some general characteristics of the evolution and the main challenge for the near future.

2 The art of model building and model use

2.1 The functions of a model

Many policy measures in the macroeconomic sphere can only be understood and discussed properly with the help of a model which sets out the key relationships between the macroeconomic variables. Such a model is an important instrument in considering relevant relationships, if only because in a model all accounting identities are observed. Usually people's mental frameworks cannot cope with all the consequences of a policy measure on a set of more than two or three interrelated variables. A small array of algebraic equations and a computer can certainly help the thinking along. When analyzing the consequences of a policy proposal at the

macroeconomic level, where, as they say, everything relates to everything else, a model is indispensable.

But what exactly is such a model used for? Broadly speaking, a macroeconomic model is applied in five ways. First, it can help to outline and analyze, in a consistent way, future developments under current policies, like in forecasts and scenarios. Secondly, a model can be used to calculate uncertainty variants. These uncertainty variants show how the projections change in response to different developments in the exogenous variables that drive the model, like the exchange rate, the oil price or world trade. Thirdly, a model can offer insights into the likely effects of policy options or policy variants. Fourthly, a model can be used to make sensitivity analyses, which indicate the sensitivity of forecasts or policy effects with respect to certain parameters or model specifications. Finally, a model can help to analyze what happened in the past and what might have happened in the past under different circumstances; this type of application, sometimes called 'cliometric analysis', is very rare, however.[2] CPB refrains from using the macroeconomic models for policy optimization, as is explained in Don (2004).

The forecasts enable policymakers and politicians to determine whether the expected future developments correspond to their political desires. The policy variants indicate the scope for realizing these political desires. The uncertainty variants and sensitivity analyses convey the uncertainties which the policymaker should take into account.[3]

2.2 Limitations and weaknesses

It is the model builder's task to develop a model that is suitable for these primarily future-oriented applications. Clear account must be taken of a model's limitations and weaknesses. As the economic reality is more complex and less constant than can be reflected in a relatively simple set of equations, these limitations and weaknesses are always and will always be present. A more complex model does not offer a solution, and quickly degenerates into a 'black box', when even the user no longer understands the why and what of the model's outcomes. 'Know your limits' should be the watchword. Depending on the problem at hand, the art of model building therefore lies in including only those equations which together give a realistic picture of the key relationships between the objectives and instruments of the economic policy in question.[4] The result is the well-known adage 'different models for different purposes'. The art of model building requires a knowledge of economics, experience, intuition and a large dose of common sense. Econometric tests and techniques should come second.

When describing what is generally regarded as the first econometric macro model ever developed, Tinbergen (1936) already refers to the model builder's art:[5]

> To get a clear view, stylisation is indispensable. The many phenomena must be grouped in such a way that the picture becomes clear, yet without losing its characteristic traits. Of course every stylisation is a hazardous venture. The art of the social economist's work

> lies in this stylisation. Some stylisations have been unwieldy, others have been unrealistic. But stylisation is essential. The alternative is barrenness.

The limitations and weaknesses of models are not only caused by the necessary stylization of reality. The often inadequate availability and poor quality of the required data also play a significant role. Another problem is that the model builder is forced to strike compromises between the desires of policymakers, theoretical economists and econometricians. Pesaran and Smith (1985, p. 132) offer an apt characterization of the model-building process:

> The clients see the models as being insufficiently relevant to their problems of forecasting and policy; the economic theorists see the models as being inconsistent with their knowledge of the economy; the theoretical econometricians see the models as being inadequately estimated and tested. ... Each of the three criticisms is made by a separate group who emphasize one of the three criteria at the expense of the others. Clients emphasize relevance, theorists consistency, econometricians adequacy, and the need for balance between the goals tends to be forgotten.

The model builder has to resolve these modelling conflicts on a case-by-case basis, and to decide them relying on his or her expertise. This always involves a trade-off, however. In his evaluation of the development and use of macro models at the Bank of England, Pagan (2003) comes to a similar conclusion:

> ... the history of economic modelling can be regarded as one attempting to solve a conflict between the distinct desires that a model should be both theoretically and empirically coherent. ... For many reasons it has proven impossible to satisfy both desires simultaneously, and therefore a trade-off is perceived to exist.

Because of this trade-off, elements of the end product will always be open to criticism. A model that fulfils the desires of all those involved has yet to be invented.

2.3 Criteria for applying models in policy formulation

The above implies that a model which is used in the practice of policy formulation will not be evaluated primarily on the characteristics of its estimation techniques or the values attached to the various test statistics. A suitable model has to meet the following six criteria:[6]

1. *Qualitative plausibility*. Each behavioural or institutional equation in the model must be comprehensible and interpretable in qualitative terms, with the relevant economic theory as the guiding principle.
2. *Quantitative plausibility*. The numerical values of the parameters in the equations must be realistic in the light of stylized facts, input–output ratios and institutional knowledge, for instance.
3. *Broad correspondence with the results of empirical studies, including time series analysis*. For hard-line econometricians, this criterion probably sounds very limp. But it cannot really be tightened any further, because in applied research we do

not know enough about the consequences of misspecification and measurement errors for the properties of various estimators. Given a lack of knowledge about the real model, we cannot rely too heavily on estimation results which strictly speaking we can only interpret under the hypothesis that we do know the real model. Broad correspondence can be assessed on the basis of confidence intervals and measures for goodness-of-fit.

4. *Good match with recent data*. Because the main applications of a model tend to relate to the future, it is important to use up-to-date information and that the model can describe the recent economic situation, i.e. the starting point of the analysis.

   In using the model to make short-term forecasts, it is worth mentioning that most recent and still provisional figures published by national statistical offices should be treated with some caution, as these are often revised subsequently, and sometimes substantially so.[7] When one has strong suspicions, on the basis of whatever information, that the provisional figures will be revised, it is better to anticipate this when making forecasts.
5. *Good simulation characteristics of the model as a whole*. This is a kind of double check on the plausibility of the equations, now assessed in particular in their interrelationships. In practice, this assessment is carried out largely on the basis of analyses of policy variants and uncertainty variants. However plausible each equation may be on its own, it is not impossible that in combination they will lead to unlikely time lags or leap-frogging effects, for instance.
6. *Suitability of the model for the analysis in question*. Have all the relations which play a role from the theoretical economic perspective been incorporated into the model, and if so, have these relations been correctly quantified? On cost–benefit grounds it is not possible to develop a dedicated model for each policy issue. It is more efficient to develop a single model or a few models to analyse a range of issues. In special cases, a special version of the model may be developed, in which some elements are elaborated in greater detail on the basis of targeted research or diverge in other ways from the standard model.

2.4 The correction of imperfections

Application of the above-mentioned criteria, in particular number 4, may mean that relationships found in the past, no matter how advanced they may be from an econometric perspective, cannot be simply applied to the analysis in question. For that reason CPB checks, prior to each forecasting round, the residuals of the behavioural equations over the previous 20 quarters. In particular, we check for systematic patterns and outliers. If these are found, it is possible that the relations specified in the equation were different in the recent past (and hence may be different in the near future as well) from the average during the sample period. In principle, the occurrence of such a situation is not surprising, because in many cases there are considerable time gaps since the final year of the sample period and because

economic behaviour may well change over time. The straight application of equations estimated for the past to analyses relating to the future implies an assumption that the described economic behaviour is stable over time. If there are indications that the modelling based on the past does not adequately reflect the relations in the future, then appropriate adjustments should be made. If this is not done, the model will be misleading or uninformative (see also Zalm, 1988; Don, 2004). Or to quote Carnot, Koen and Tissot (2005, p. 133):

> A 'push-button' approach – feed the model with the latest data and let it do the work – would be uninformative at best, and outright misleading at worst.

When correcting the model's imperfections, the model builder always faces some awkward questions and has to choose between two evils. Not correcting is by far the easier option, but this is likely to lead to misleading model outcomes, and should therefore be rejected. Correcting is to be preferred, then, but this is invariably rather messy. There are two ways of taking account of observed imperfections when using models: interfering with the model's structure, or adding autonomous terms or 'add factors'.

Ideally, a model change should be preceded by a detailed and thorough study, but usually there is neither the time nor the relevant data for that. After all, the observed misspecification usually relates to a recent phenomenon or to relations which are difficult to quantify. A telling example of this is the way in which the consumption equation in SAFE, a quarterly model used until recently for short-term forecasts, was adjusted on an *ad hoc* basis in order to take account of the changed relationship between household wealth and consumer spending. This is considered in greater detail in Box 1. Put euphemistically, the way in which the consumption equation was adjusted would not have won a beauty contest from an economic theoretical or econometric perspective. But this was still better than making no adjustment at all, because the old specification could no longer offer a reliable picture of consumer behaviour in the near future. It is important to be open and transparent about such model adjustments, however, so that others can cast a critical eye over the preferred solution, make suggestions for improvements, and assess the sensitivity of the model outcomes to the choices made.

Box 1. Adjustment of the consumption equation

Gone are the days when the volume of private consumption was relatively easy to forecast. Not least because of the higher standard of living, consumption growth is now not only determined by changes in real disposable incomes and real interest rates, but also by volatile wealth developments and rather intangible psychological factors. Between 2001 and 2003, in particular, this resulted in considerable overestimations of Dutch consumption growth by all forecasting institutes, including CPB. It seems plausible that this related to the way in which the slump

(continued)

Box 1. (continued)

in share prices after September 2000 was reflected in the consumption equation. The downward effect of share price falls was probably underestimated, for various reasons. First, share ownership among Dutch households had soared in the late 1990s, so that by 2001 it was much higher than the average during the sample period that was used to estimate the consumption equation (1972–1999).[a] Secondly, during the sample period, there were only a couple of occasions when the stock market index fell on an annual basis, so that the estimated marginal consumption coefficient related above all to share price rises. Perhaps, then, share price falls had a stronger and faster effect on consumption behaviour than share price rises.[b]

The best way to take account of this final point was to test the hypothesis of asymmetric wealth effects and to incorporate the results into the model as quickly as possible, in the hope of enhancing the accuracy of the consumption forecast. But that was where the problems started. As mentioned, there were not enough years of falling share prices to test the hypothesis. Testing the asymmetry via the error-correction term, à la Carruth and Dickerson (2003), was a possibility, but the downside of this was that the asymmetry would then apply to all explanatory variables, whereas only the asymmetrical wealth effects mattered in this case. So something had to be dreamed up for it. The estimated coefficient (0.033) had a relatively large standard deviation (0.028). This could be explained by a possible asymmetry. The preferred solution was to use a higher coefficient (0.054) in the case of a share price fall. This figure corresponded to the higher coefficient of the other two wealth terms (i.e. house ownership and residual wealth) but was still within the confidence interval. To generate a faster effect, the effective time lag was halved from around three quarters to one-and-a-half quarters.[c] This new specification was then used to analyze the residuals of the consumption equation in the past, which led to the conclusion that the adjustment seemed to be an improvement. At the same time, a study was started to test the hypothesis of asymmetric wealth effects with the help of panel data. This study has now been concluded, and it confirms the existence of this type of behavioural effects.[d]

[a]Kranendonk and Verbruggen (2002) document the estimated consumption equation.

[b]This was even more the case because the recent stock market correction occurred precisely at a time when the individual savings ratio had dropped to a post-1945 low, relatively many new investors had entered the stock market (not least because of the popularity of a number of 'people's stocks'), and share-owning households were relatively overweighted in ICT stocks, the prices of which tumbled particularly hard.

[c]CPB (2002c, p. 26) refers to this diverging specification in the case of falling share prices.

[d]See Mastrogiacomo (2006).

Sometimes there is not even enough time and data to adjust the model on an *ad hoc* basis, and the model builder has to make do with adding autonomous terms or 'add factors' to one or more behavioural equations. This happens regularly at all institutes which make short-term forecasts on the basis of models.[8] In these cases

it is also important to document all autonomous adjustments, so that the extent to which and the reason why the model was adjusted can be examined. To that end, CPB has kept a unique autonomous terms account since 1998. It is currently being investigated whether and to what extent these autonomous adjustments have made a positive contribution to the quality of the forecasts.[9]

The example of the changed relationship between household wealth and private consumption deals with a relation which was already incorporated into the model, but which, with an eye to the future, was probably not correctly quantified. Another common occurrence is that a relationship deemed relevant for a specific analysis has not been modelled at all (cf. criterion number 6 above). In that case, the straight application of the (possibly very sophisticated) standard model may also lead to incorrect conclusions. There are quite a few relations which can plausibly be assumed to exist, but which are not expressed in a standard macro model. Among those that spring to mind are what are called the 'programme effects' of more education, more public safety or more infrastructure, for instance.[10] A standard macro model models only the budgetary and expenditure effects of such policies, not their impact on productivity. This imperfection has hampered CPB's analyses of political parties' election programmes, for instance. These analyses are discussed in greater detail in Box 2.

From this it follows that expertise is essential not only in model building, but also in model use. It is certainly possible to make useful analyses with a simple and incomplete model if those who analyze the outcomes and prepare the reports are sufficiently aware of the model's weaknesses. It is also possible to make some serious blunders with a sophisticated and complex model, for instance by using it for analyses for which it is not suited. The pitfall of models is that they always yield outcomes, and it requires great experience, intuition and above all common sense not to fall into this trap.

In a broader sense, the criterion that the model should be suitable for the analysis in question, was one of the main drivers for the evolution of model building at CPB. As seen in the next section, new questions from policymakers and new features in the national economy have guided research. At the same time, new developments in econometrics and economic theory were taken on board wherever they helped to improve the quality and scope of the analysis. Not all efforts were successful, some of them appeared to be blind alleys (see section 3.6). Many would have been impossible without the continuously growing power of computing machinery and the increasing data availability over the last six decades.

3 Sixty years of model building at CPB

3.1 In the beginning

Before Jan Tinbergen became CPB's first director in 1945, he had already been a pioneer in the development of macro models for many years. In 1936, his efforts resulted in the first econometric model for the Dutch economy, which is generally

Box 2. The analysis of election programmes

In the model-based analysis of a single-policy option, the question of the model's suitability or otherwise is reasonably straightforward. Matters become more complex when complete policy packages, consisting of a large number of very diverse budgetary and institutional measures, have to be studied. This is the case, for instance, with the analysis of election programmes of political parties and the coalition agreement of a new cabinet. Since 1986, when the Netherlands's three largest political parties – Christian Democratic Appeal (CDA), Labour Party (PvdA) and People's Party for Freedom and Democracy (VVD) – first asked CPB to assess the economic effects of their election programmes, ever more parties have made such requests. Prior to the general election in May 2002, CPB analyzed no fewer than eight election programmes.[a]

This type of analysis, which on this scale and in this style is unique in the world, pushes a model to its limits, however. At many points during the process, CPB struggles with the question whether the model contains all the relevant relationships in a responsible way. To assess this, we look in particular at whether the various trade-offs are also reflected in the model outcomes in a balanced way. After all, policy measures which cost nothing and have no adverse effects – Friedman's 'free lunches'– are rare. If this is not evident in the model outcomes, eyebrows will be raised within CPB. In many cases, this is because of one or several neglected relationships in the model, which then needs to be corrected. This can be done not only by adding autonomous terms or adjusting certain specifications, but also by adding to the standard model the outcomes of other models which are more suitable for specific issues. For instance, in 'Charting Choices' (CPB 2002a,b), as part of an analysis of the labour supply effects of specific tax measures targeted on specific groups, the basic model JADE was fed with the outcomes of the general equilibrium model MIMIC. Another option is to assess, in a qualitative way, certain aspects which are relevant but have not or not yet been properly quantified. CPB frequently relies on this option to take account of a model's limitations in the analysis of election programmes and alternative budget proposals, for instance.

[a]See CPB (2002a,b), Graafland and Ros (2003), and van Opstal and Timmerhuis (2005).

considered the first econometric model in the world.[11] From the outset this model was intended to be used for policy making. Tinbergen had developed it, at the request of the board of the Netherlands Association for Political Economy and Statistics, in order to throw light on the question whether the domestic economy could revive even without an improvement in the export position, either with or without government intervention. To answer this question, Tinbergen (1936) analyzed no fewer than seven policy options, including a devaluation of the guilder, which emerged as the best option. It is unclear whether and to what extent the guilder's actual 20% devaluation in 1936 was influenced by Tinbergen's analysis.

The model contained 24 equations, including 15 behavioural equations. Most coefficients were estimated with a least squares method. In order to ensure a symmetrical treatment of variables on the left and right side, Tinbergen opted for diagonal regression – a very early, partly intuitive approach to the problem of measurement errors. The estimates were made by hand, that is, with pen and paper. In the early years of model building, many scatter plots were also drawn, but these were overtaken with the emergence of the computer. The sample period was 1923–1933, containing only 11 annual observations. Most of the data material, which Tinbergen had gathered with great difficulty from a range of sources, originated at Statistics Netherlands (CBS), where he worked at the time. The model contained various discrete time lags of 1 or 2 years, and thus already had a dynamic character.

When CPB was founded soon after the end of the Second World War, its brief in the first instance was to provide diagnoses of and projections for the economic situation. The lack of data as well as their limited quality prompted a creative and clever use of statistical information to gain a rough but quantified outline of the Dutch economy. Projections or forecasts were important in determining the government's financial scope from an early stage, as illustrated by the debate on the first Claims Memorandum in 1955. In this context, the forecast for tax revenues, and hence for economic growth, was of critical importance.

In the early 1950s CPB used a simple model, and from that time the publications also included policy variants. The turn of the decade saw the foundation of the Social and Economic Council (SER), a tripartite body bringing together representatives of employers, trade unions and independent experts, and the Central Economic Committee (CEC), a government body. These institutions created a policy-oriented platform for CPB's work. In the following years, the CPB analyses became more accepted and understood. But it took until the 1960s before economists and econometricians trained in quantitative methods gained a foothold in the policy-units of government ministries, employers' associations and trade union federations.

The Central Economic Plan of 1955 included a description of what became known as the '1955 model', although it had already been in use for several years before the publication date. This model consisted of 27 equations, including 12 definition equations. Following on from the centralized wage policy pursued in the 1950s, pay rate changes were exogenous. Another noteworthy feature is that the price elasticity of exports was set at –2.[12] In the model description it was noted that the employment equation was not used for the 1955 forecast, because the model did not take account of the labour shortage which had emerged in 1954. In other words, the analysts were already well aware of the models' limitations, and they took account of these in their applications.

3.2 Keynesian expenditure models

The quality of this first CPB model was not widely appreciated, to put it mildly. The model was not only completely linear, but it was also static. The parameters

were partly the result of guesswork and partly derived from research from the distant past. Although the model was certainly a major help in preparing forecasts and variants, its shortcomings were all too evident. These shortcomings determined the priorities for further research. It was decided to set up a wide-ranging study which took in the latest developments in the sphere of economic theory and econometrics. The strong link with policy making was reflected in the objective that the model should contain all the variables which were deemed important for political decisions (see THEIL, 1953). The project was entitled 'An econometric analysis of the Dutch economy'.

Considerable time was reserved within the project for improving, gathering and constructing the required data. As the project's name suggests, econometrics constituted a major component. Much thought was given to optimal estimation techniques. Ordinary least squares (OLS) was rejected in principle because of the model's non-recursivity and its use of less reliable data series (see KOYCK and VERDOORN, 1956). In practice, a multi-stage system was used to estimate the coefficients. In the first stage, the equations were estimated with OLS. In the second stage, more refined estimation techniques were used, such as two-stage least squares (TSLS) and limited information maximum likelihood (LIML).

A reading of the project reports from the period makes one realize how much better off today's model builders and econometricians are. The econometricians of the 1950s faced huge constraints. As KOYCK and VERDOORN (1956) wrote:

> The processing capacity of the electronic calculators available in the Netherlands sets certain limits on the size of the model. The source of possible difficulties lies both in estimating the parameters and in solving the system.

At that time the limit was about 70 variables. The annual models were not calculated at CPB's offices in The Hague, but at the Mathematical Centre of the University of Amsterdam. It is all so different these days: it takes an average personal computer around 30 s to calculate the current quarterly model, SAFFIER, which contains around 2400 equations and 2850 variables, for 400 years; and the calculation itself actually takes <2 s; most of the time is taken up with writing the outcomes to disk.

Shortly afterwards, a new model was presented at a conference of the Econometric Society (see VERDOORN and VAN EIJK, 1957). The viability of the new approach was tested by using this model to determine the specific combination of policy options which would maximize a linear welfare function. This approach was recognized in the field in the form of an article by VAN EIJK and SANDEE (1959) in the leading journal *Econometrica*, but it does not appear to have left a strong impression on policymakers.

The first major product of the 'An econometric analysis of the Dutch economy' project became known as the '1961 model'. This model included 36 equations and was highly dynamic and also nonlinear. The equations were estimated with the help of TSLS. The years to which the estimations related covered the periods 1923–1938

and 1949–1957, with the post-1945 years given a double weighting. From a theoretical perspective the model was far ahead of its time. Thus it included various spill-over terms from the monetary to the real sphere, which would only gain wide currency with the emergence of disequilibrium theory in the 1970s. What is more, the 1961 model already included the first variables indicating a recognition of the supply side of the economy. The description of the model in the Central Economic Plan 1961 once again illustrated CPB's nuanced view of the value of estimation results. Thus it argued:

> ...it may be necessary in specific instances to change the form of one or more equations or to revise the numerical values of the coefficients, in order to take account of the impact of factors which are not or not correctly reflected in the model.

The 1961 model and its successors 63-D and 69-C can be characterized as Keynesian expenditure models on an annual basis, with the emphasis on the demand side of the economy. The way in which the supply side of the economy was modelled still left much to be desired. Thus investments were not given a capacity-creating effect in any of the models, and the tension on the goods market was approached through the unemployment rate. In the CS model, which was developed around 1965 to generate a medium-term forecast for the first time, the supply side was given considerably more attention.

3.3 Attention to the supply side

The 69-C model also marked the end of an era from an econometric perspective. CPB's model building was undergoing a shift of emphasis from econometrics and empiricism to economic theory. Broadly speaking, this shift of emphasis – which did not occur overnight but was a gradual process – can be attributed to two developments.

First, in the course of the 1960s, politicians and those involved in policy preparation became increasingly interested in medium-term forecasts and analyses. In these analyses, such concepts as capital stock, production capacity and technological progress play an important role. However, there were no directly observed data for these variables. This lack of data made empirical estimation difficult and forced the model builders to rely more on economic theory. The CS model built by VAN DEN BELD (1967) was the first example of this. The study by DEN HARTOG and TJAN (1976) into vintage production functions also fitted in with this new line of research.

The second reason for the shift of emphasis from econometrics and empiricism to economic theory was the disappointing predictive and analytical power of the 69-C model, in which so much econometrics had been deployed. Estimates based on LIML, TSLS or the full-information recursive fix-point method (see HASSELMAN, POST and VAN DEN BELD, 1977). were not able to explain the surge in unemployment in the early 1970s. This led to a growing realization that a sophisticated econometric model was not necessarily an adequate model. Thus the thread running through the line of development which started with the CS model was not the refinement of econometric techniques but the broadening of the economic content.

The introduction of the clay–clay vintage production function had major consequences for economic policy making. The policy recommendation arising from the VINTAF model, the first official CPB model which included the new production function, was clear enough: wage moderation. Published in DEN HARTOG, VAN DE KLUNDERT and TJAN (1975), VINTAF was estimated with OLS, with the exception of the production function. The model and the analysis flowing from it came as a bombshell. Many articles were published on the issue, and even a petition did the rounds at the universities. This was the first time that a CPB model had attracted so much public attention. There was not only applause, but also heavy criticism. The criticisms, brought together by DRIEHUIS and VAN DER ZWAN (1978), were rooted partly in econometrics but above all in economic theory.

The main focus of the criticism by Driehuis and van der Zwan was the model's use in policy making. To what extent, Driehuis and VAN DER ZWAN (1978, p. 25) asked, can models provide a basis for formulating and implementing policy in a situation that is decidedly different from the past, the period to which these models are wholly or partly geared both in terms of their specifications and estimation of the parameters? A good question, indeed, which should have been asked of previous models as well, but had never previously sparked such a wide-ranging debate. Above we have shown that CPB was well aware of the limitations of models based on the past, and that for that reason it would adjust models if required. However, several of the criticisms put forward by Driehuis and van der Zwan and others were justified, and – although not altogether new to the CPB model builders of the time – they certainly stimulated further research.

One of the criticisms of the VINTAF model concerned the absence of a monetary sector. During the 1970s, as the government budget deficit widened steadily, this omission was considered increasingly serious. After all, the favourable expenditure effects of higher budget deficits were fully reflected in the model, while the unfavourable crowding-out of private investment on the capital market was ignored. That is why the successors to VINTAF I and II, namely the annual model FREIA and the quarterly model KOMPAS, contained extensive monetary sectors.[13] In the monetary submodel, the levels of short-term interest rates and bond yields were derived from the balance between supply and demand on the short-term government debt market and the capital market respectively. Incidentally, the high degree of simultaneity of the equations in the monetary bloc led to the application of estimation techniques for simultaneous equations.

3.4 Structure and cycle: separate or together?

In the mid-1980s the FREIA and KOMPAS models were integrated into FK'85, (see CPB, 1985; VAN DEN BERG, GELAUFF and OKKER, 1988). which in turn was succeeded by the quarterly model FKSEC (see CPB, 1992). The addition of 'SEC' in the name points to the main innovation of the latter, namely the disaggregation by six sectors on the supply side of the economy. The macro levels of production capacity,

investment and employment were determined bottom-up. This acknowledged a criticism made during the earlier VINTAF debate, namely that the clay–clay vintage production function was not well suited to describing the labour-intensive industries in the service sector. As it happens, employment in the service sector responds more quickly to changes in real labour costs, and the critics who argued that the vintage model exaggerated the favourable effects of wage moderation were not proved right. Because FKSEC models the expenditure side of the economy (with the exception of investment demand) at the macro level, the model had to be supplemented with a 'cumulated production structure' (CPS) matrix. Such a matrix links the volume and price developments of macro expenditure categories on the one hand with those of the gross added value per sector on the other.

After the monetary submodel had been part of the national macro model for a couple of years, it was already removed in the FKSEC model. Given the consistent and credible monetary policy pursued by the Dutch central bank (DNB) aimed at maintaining a stable exchange rate between the guilder and the deutschmark, Dutch bond yields had already moved virtually in line with German yields for some time. Because interest rates were essentially the only modelled transmission mechanism from the monetary to the real sphere, the extended monetary submodel was replaced by a very simple equation, in which Dutch short-term interest rates and bond yields tracked their German equivalents. The experiences gained with modelling monetary relations were then used in the study of the world economy, which requires estimates of exchange rates as well as interest rates. Incidentally, the removal of the monetary bloc from the national model did not make the monetary transmission mechanisms any less important. On the contrary, the impact of interest rates on the real economy is actually considerably greater in SAFFIER, the current short- and medium-term macro model, than it was previously in FREIA and KOMPAS.

The use of the quarterly model FKSEC for analyses over both the short and medium term had various operational disadvantages. Modelling in quarters was just awkward for medium-term analyses. Moreover, as politicians and policy researchers became more interested in structural economic developments, there was a growing need for a better economic theoretical foundation of the model. This resulted in a new annual macro model, JADE (see CPB, 1997a). This model paid close attention to the consistent derivation and estimation of behavioural equations on the basis of up-to-date theoretical insights, in the conviction that this would facilitate the analysis of policy issues related to the economic structure.

To reflect the growing split in the labour market, employment in JADE was divided into high-skilled jobs and low-skilled jobs. The supply of goods and services was modelled in JADE with a CES production function, the parameters of which were consistently translated into the equations relating to the demand for the production factors labour and capital. The specifications for private consumption and the wage rate were also based on modern economic theories. These theories were used to identify cointegrating relations between the variables, describing the structural equilibrium of the economy. Error-correction mechanisms (ECM) were

employed to describe the dynamics of the adjustment path towards that equilibrium. This approach followed the example of other model builders in answering two of the three fundamental deficiencies identified by Sims (1980) in the macro models in use at that time, namely the weak theoretical foundation of the individual equations and the econometric identification of the structural parameters in the absence of *a priori* restrictions on the lag structure of the model. For various reasons, JADE deliberately did not accommodate Sims's third deficiency, namely the absence of forward-looking expectations of economic actors.[14] The trend towards better theoretical foundations and stable structural parameters also made the model less sensitive to the Lucas critique, which states that parameters and expectations may not be invariant to policy measures (see Lucas, 1976).

The disaggregation by sectors and the related modelling of the CPS matrix in FKSEC offered relatively little added value for the short-term projections. But these extensions did make the model more complex and less transparent. The call for a simpler model, which would abstract from aspects which were not very relevant for short-term developments, led in the late 1990s to the development of SAFE, a quarterly model focused on the demand side of the economy (see CPB, 2002c).

The original versions of JADE and SAFE diverged sharply. In the development of JADE the emphasis was on economic theory and the model's sound long-term characteristics, while in the development of SAFE the empirical base and short-term dynamics received much more attention. However, over the years the later versions of the two models gradually converged. Thus, a production function was built into SAFE for the purpose of analyses relating to potential growth and the output gap, which were attracting strong interest both in the Netherlands and abroad.[15] Moreover in JADE, the distinction between low- and high-skilled jobs on the one hand and between the exposed and sheltered sectors on the other were abandoned, because of the low added value they offered. Further studies were also conducted on various model elements, the results of which were subsequently built into JADE and SAFE in virtually the same way so as to avoid unnecessary differences in analysis. An example is the disaggregation of exports into re-exports and domestically produced exports. This convergence process between JADE and SAFE was further enhanced as the users of SAFE found practical ways to implement the error correction mechanisms in their model handling routines on a quarterly base.

As it happened, over time all major reasons for JADE and SAFE to diverge, had gone. So in late 2004 JADE and SAFE were integrated into SAFFIER, the model which is currently used by CPB for short- and medium-term analyses.[16] In order to avoid the operational problems that bedevilled the earlier integration of the quarterly and annual model into FK'85, SAFFIER exists in two versions. The quarterly version is used for short-term analyses and forecasts. The accompanying quarterly projection is then converted into an annual projection, after which the annual version is used for medium-and long-term analyses and forecasts. The model's quarterly and annual versions differ only with regard to the specification of the

time lag structures. The model core, containing the behavioural equations and the accounting equations, is identical in both versions.

3.5 Stronger focus on structure: applied general equilibrium models

The above-mentioned shift of emphasis from econometrics and empiricism to economic theory not only characterizes the evolution of the econometric macroeconomic models; it is also reflected in the development of a new type of model at CPB, namely the applied general equilibrium model.

Around 1986 CPB started a long-term programme to study the macroeconomic impact of microeconomic policies. At the time there was no appropriate tool to study targeted policies such as minimum wages and unemployment benefits, whereas the interest in these 'supply side' policies was growing. In order to give a sound analysis of these targeted measures, CPB started to build the MIMIC model.

The focus of the MIMIC model is on the labour market. Hence much time was spent on the proper modelling of the labour supply, labour demand, wage formation and the process which matches vacancies and job seekers. The MIMIC model was the first 'computable general equilibrium' (CGE) model constructed at CPB. 'General equilibrium' is meant to indicate that the intentions of all agents are consistent. Furthermore, CGE models typically derive their behavioural equations from explicit utility maximization by households and profit maximization by firms. Indeed, MIMIC was the first CPB model to derive macroeconomic outcomes from explicit utility and profit maximization at the micro level. Since it derives behaviour from structural parameters, it goes further than JADE in answering the Lucas critique. However, the CGE set-up also has some limitations. For instance, the adjustment paths from one equilibrium to another cannot be studied, which may be rather important for certain policy measures, such as pension reform. Furthermore, the empirical knowledge on various structural parameters is often limited. Hence the results are usually interpreted as longterm, and a sensitivity analysis becomes an essential part of the analysis. But the gains in consistent and stable behavioural equations are believed to outweigh these limitations for the policy questions which MIMIC is intended to address.

In 1994, MIMIC was considered to be fit for policy analysis and was used extensively by CPB to analyze labour market issues.[17] In the following years much time was spent on capturing more relevant mechanisms through which taxes affect behaviour, improving the empirical base and analyzing new measures which were moving up the policy agenda, such as subsidies for childcare and to get the long-term unemployed back into work. The new model version was presented by Graafland *et al.* (2001). Since 2001 various other targeted policies, such as active labour market policies and paid leave arrangements, have been studied.

Useful as the MIMIC model is for comparative static analyses of several labour market measures, the model is unfit to analyze the issues that are raised by the ageing of the population and other intergenerational topics. For that purpose, CPB

has developed new tools. Around 1995, the generational accounting system of Auerbach, Kotlikoff and Leibfritz (1999) was applied to the Netherlands, taking into account the future tax receipts from funded pension schemes and the likely increase in female labour participation (see ter Rele, 1998). At the turn of the century, CPB started to construct an 'overlapping generations' (OLG) model, called GAMMA (see Draper *et al.* 2005, for a description). GAMMA focuses on the labour supply and on the consuming–saving decisions of individuals over the life cycle. With many agents maximizing their lifetime utility in a constantly changing world and assuming perfect foresight, this model is at the frontier of CGE modelling.[18]

3.6 Blind alleys?

Like the history of any research area, the history of macro-modelling at CPB also features disappointments and unsuccessful projects. Box 3 highlights some of these ill-fated modelling efforts. To be sure, we do not think these efforts were wasted. Only by walking them down for some time, one can find out that some alleys are blind, or for the time being appear so. Later efforts may benefit from earlier explorations and perhaps find more promising routes.

Following the lead of Malinvaud (1977) and the practical approach of Kooiman and Kloek (1985), there were some attempts to model macroeconomic disequilibrium, in particular smooth switches from general excess supply to general excess

Box 3. Not just national and macro

This paper focuses on macroeconomic models used at CPB for analyzing the Dutch economy. Yet, over the years, many other types of models have also been developed, such as world models and multi-sector models, each from a specific need to structure the analysis of a selected set of economic relationships.

For instance, the study of long-term global economic developments requires a model which focuses on international trade, technological progress and the availability of resources. WorldScan, CPB's applied general equilibrium model for the world economy, provides this focus. This model is recursively dynamic and based on standard neo-classical theory, with some extensions and adaptations. Specific versions of WorldScan include, for instance, the spill-over effects of investments in research and development or specific instruments to reduce greenhouse-gas emissions in climate change policies (Lejour and Nahuis, 2005; Kets and Verweij, 2005). The WorldScan model has been extensively used in long-term scenario building, with a focus on Europe within diverging global economic environments, in analyzing the impacts of alternative policies in reducing global warming, and in analyzing the issue of EU enlargement, both for the 10 accession countries and for the possible accession of Turkey.[a] For analyses with a strong sectoral dimension, CPB uses the Athena model, which distinguishes 18 industries.[b] In

(continued)

Box 3. (continued)

the 1980s and 1990s, sectoral models were mainly used for short- and medium-term analyses. Macroeconomic forecasts were complemented by results on the sectoral level. In recent years, the focus of the Athena model has shifted towards more structural and long-term analyses. To that end, more emphasis has been put on a sound theoretical structure, and less on the short-term dynamics. The most important changes concern the modelling of the production structure, in which all behavioural equations are now derived from profit maximization by firms. The usefulness of Athena now lies in particular in the possibility of constructing long-term scenarios and analyzing policy measures involving changes in the economic structure. In the construction of CPB's four new long-term scenarios for the Dutch economy, Athena has played an important role (Huizinga and Smid, 2004). Furthermore, the model is frequently used to analyze the long-term effects of specific policies, such as the construction of a high-speed rail link to Paris, an expansion of Schiphol Airport, and the imposition of environmental taxes on carbon dioxide emissions (CPB, 1997b, 2000; Broer, Mulder and Vromans, 2002). Finally, the various submodels and accounting models for the public finances, the social security system, the pension funds and life insurance companies, the wage formation and the purchasing power deserve a mention. In scientific terms these models are less spectacular, but they are certainly valuable instruments in making forecasts for the Dutch economy and analyzing the policy options. Because the institutional structure is modelled in much greater detail in these instruments than in the macro models, the outcomes of the macro models in the above-mentioned spheres are often 'overruled', as it were, by those of the submodels.

[a]For some recent applications of the WorldScan model, see de Mooij and Tang (2003), Lejour (2003), Bollen *et al*. (2002) Bollen, Manders and Mulder (2004), Lejour, de Mooij and Cape (2004a) and Lejour, de Mooij and Nahuis (2004b). A CPB publication that describes the current version of WorldScan is forthcoming.

[b]Athena is the successor to the multi-sector models VINSEC (Draper, Nieuwenhuis and Tjan, 1987) and BETA (Eijgenraam and Verkade, 1988), see CPB (1990, 2006).

demand on the labour market. Fitting such a model suffered from lack of data for the alternative regimes and in practice the extension of the model did not add insights that carried much relevance for forecasting or policy analysis. Over time, it was replaced by the concept of equilibrium unemployment (Broer, Draper and Huizinga, 2000), which is strongly linked to the wage equation of the model. This concept proved more fruitful for policy analysis because it helped to disentangle the cyclical and structural components of unemployment.

Moreover, CPB research was affected by the rational expectations revolution. A fully rational perfect foresight type of behaviour was considered unrealistic, but experiments were performed replacing backward-looking expectations with forward-looking expectations in some crucial behavioural equations. The practical

consequences of these model changes tended to be small and were not considered worthwhile, also because there was no sound empirical basis for the relevant coefficients (Okker, 1988). Still, the GAMMA model mentioned above features perfect foresight and it seems likely that we will see some form of forward-looking behaviour in the main CPB macro model in the future.

Perhaps the most interesting example of more and less successful modelling efforts dates from the second half of the 1980s. Around 1986, CPB identified as one of its top priorities, getting a sound grip on a major policy problem in the Dutch economy of that time, i.e. the impact of the tax and social security system on the labour market. It started three different and in a way competing modelling approaches to tackle the issue: (1) a micro-model focussing on empirical labour supply behaviour at the level of individual households; (2) a macro-model featuring a substantial disaggregation of the labour market, distinguishing between several types of labour on both the demand and the supply side; and (3) a computable general equilibrium (CGE) model providing an explicit description of labour supply decisions as the result of utility maximization in households facing a budget constraint that reflects the tax code and social security system. The third approach held the best promises for studying alternative tax and social security regimes, but at the same time it was the largest and most risky project. It took its inspiration from successful CGE models that were recently developed in the US to study the quantitative impact of the tax regime on the capital market.[19] However, applying these methods to the labour market was a new challenge.

The researchers following the first approach were quick in delivering some results relevant for the minimum wage debate (van Schaaijk and Waaijers, 1988), but they did not really master the labour supply issue. The second approach did not overcome its theoretical puzzles and lack of data. In the end, the third approach turned out to be successful, but it was long before the first tentative results became available (Gelauff *et al.*, 1991). Indeed, this marked the first version of the MIMIC model, which has seen many successors and a host of policy applications.

4 Conclusion: the lessons, the trend and the challenge

Looking back at 60 years of model building at CPB, a number of *lessons* can be drawn.

(a) There is no single, overriding model of the Dutch economy which covers all aspects for all policy-relevant issues. That is why CPB places much emphasis on the adage 'different models for different purposes'. Stylization is and remains unavoidable, as too much integration of economic aspects into a single model leads to a 'black box' which quickly suffers from the 'garbage in, garbage out' syndrome. Hence Tinbergen's contention in 1936 that 'stylization is indispensable' has lost none of its topicality.

(b) The art of model building lies in reflecting this indispensable stylization in the model, taking account of the latest economic, theoretical, econometric and empirical knowledge. Because the economic reality, the economic theory and the availability of data are constantly changing, the outcome of this stylization process – that is, the latest model – is different every time. Time and again model builders try to take account of phenomena from which abstractions were made in the first instance, but which over time proved essential for adequate analyses.
(c) No model is perfect. There is no model which can fulfil all desires in the areas of economic theory, the empirical base, econometrics and operationality. Awkward choices will always have to be made, so that elements of the model are and remain open to criticism.
(d) CPB's strength lies not so much in the development of models, but more in the responsible use of these instruments. CPB has more experience with this than any other economic research institute in the world. When using models, it is crucial to bear in mind the limitations and weaknesses of the models, in order to prevent misleading outcomes. This implies that a model may have to be adjusted as necessary for the analysis in question, with messy compromises from the economic theoretical and econometric perspectives often unavoidable.

If there is one trend in 60 years of model building at CPB, it is the shift of emphasis from econometrics and empiricism to economic theory. This shift was driven by new policy questions and new theoretical insights. At the same time it was made possible by new econometric techniques, increased computing power and improved data availability. On the theory side, in particular, the Lucas critique called for a more solid foundation of models in economic theory and structural parameters. More or less at the same time, national economic policy gradually changed emphasis from cyclical stabilization to improving the economic structure. This change came about both because of disappointments with the effects of cyclical policies (see SER 1984, pp. 36–44). and because of a growing understanding of the (in)effectiveness of such policies. Indeed, the ongoing process of European integration restricted the scope and the effectiveness of several forms of national economic policy. It shifted attention to policies aimed at improving the institutional framework and the incentive structure on various markets, first of all on the labour market. Somewhat later, longer-term issues came on the agenda, in particular those related to ageing and the sustainability of public finance. For analyzing structural and long-term issues, the required empirical evidence centres around some key elasticities. While the new policy questions sometimes called for new and different models altogether, several issues could not be ignored by the builders of traditional macro models, if only to maintain consistency in the overall economic analysis. Macroeconomic forecasting and policy analysis for the short and medium term is still an important task of CPB. Indeed, given the clients' demands of the forecasts in terms of consistency and coherence so that they can be used effectively in social and economic policy preparation, the traditional macro models are actually indispensable.

We think that the main *challenge* for macro model building at CPB in the coming years is the incorporation of what are called the 'programme effects' of policies aimed at improving labour productivity, for instance, through more competitive markets, or through more public spending on education and research or infrastructure. To address this challenge, CPB has launched a major project, for which the initial findings have recently been published in Canton *et al.* (2005). This study attempts to bring closer together the literature of modern growth theory (in which investments in education and research on the one hand and competitiveness on the other are determining factors for the growth in labour productivity) and the world of macro model building. It also makes clear that there is still a long way to go. A reliable and policy-relevant incorporation of programme effects will still require much creativity and energy from model builders and econometricians inside and outside CPB.

Even if we succeed in solving this complex problem satisfactorily, the models will continue to be riddled with many limitations and weaknesses. Nevertheless, macro models remain useful instruments in policy formulation, and they deserve our full attention and dedication. A captain will never throw overboard his compass because it does not help to avoid a foul in the dark.

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Notes

1. A list of the instruments currently used by CPB is available on its website (http://www.cpb.nl), under the heading 'Models and methods'.
2. See e.g. Gelauff (1986) for a cliometric analysis of the Dutch economy between 1973 and 1984.
3. This way of communicating uncertainty is discussed in Don (2001b).
4. Zalm (1988) and Don (2004) examine in greater detail the significance and the limitations of models in policy preparation.
5. The full text of Tinbergen's 1936 paper, originally written in Dutch, is available in English as 'An economic policy for 1936', in Klaassen, Koyck and Witteveen (1959, pp. 37–84). There the quoted phrases are found on p. 41, in a somewhat different wording.
6. These criteria are largely based on Cripps and Fetherston (1979).
7. 'Actual figure' is therefore a relative concept. Kranendonk and Verbruggen (2005, p. 16) discuss this in greater detail. Statistics Netherlands (CBS) is increasingly transparent on this matter. For instance, Nijmeijer and Hijman (2004) show that between 1991 and 2001 the CBS's initial estimate of GDP growth on average came out 0.35 percentage points lower than the final GDP growth figure, which is published two and a half years after the end of the reporting year in the national accounts.
8. See e.g. Wallis and Whitley (1991), Pagan (2003) and Carnot *et al.* (2005).
9. This study is being conducted by CPB in cooperation with the Econometric Institute of the Erasmus University Rotterdam. CPB examines the accuracy of its forecasts and the

reasons for any forecast errors on a regular basis (see, e.g. Don, 1994; Kranendonk and Verbruggen, 2005).

10. Zalm (1988) quotes some other examples of missing relationships.
11. Less well known is that in the early 1930s Tinbergen also developed the first model with 'rational expectations'. According to Keuzenkamp (1991), the fact that Tinbergen's (1932) article 'Ein Problem der Dynamik' was published in the then leading German journal *Zeitschrift für Nationalökonomie* and not in an English-language publication is one of the reasons why this interesting contribution has remained unnoticed.
12. This is often referred to as the 'Tinbergen 2', which was confirmed empirically for decades afterwards and used in various CPB models. Tinbergen (1987) modestly acknowledged that the credit for the '2' lay with Keynes. In this context he reports the following anecdote: 'I told him that at the CBS we had calculated regressions to estimate this elasticity, and that we had indeed come close to the figure of −2. I thought he would welcome that news. He responded that this was good news for us, because we had found the right figure. He said he much preferred to rely on his own intuition than econometric estimates. Perhaps rightly so'.
13. See CPB (1983a,b). More than a decade before KOMPAS was applied, Driehuis (1972) had developed the first CPB model on a quarterly basis. Driehuis's model was developed for an economy with virtually full employment. Because unemployment surged during the 1970s, the model was repeatedly amended to maintain a good match with actual economic developments.
14. A first reason is that rational expectations models typically predict a more rapid adjustment of agents' behaviour than is generally observed. As a result, these models do not always perform well in practice. A second reason is that gathering information, needed to adjust agents' expectations, is not free as the early rational expectations literature assumed. If these costs are rather high and if the costs of making inaccurate predictions is rather low, it may be rational for economic agents not to adjust their expectations. See CPB (2003, p. 8).
15. Don (2001a) estimated the growth potential of the Dutch economy over the medium term, using the production function method.
16. See the forthcoming CPB Document on SAFFIER.
17. See Gelauff and Graafland (1994) for the model and several examples of its use in policy analysis.
18. The GAMMA model has recently been used to analyse options for pension reform, see Westerhout *et al*. (2004).
19. For a review, see Henderson (1991).

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