

**Project Document**

# **Macroeconomic Modelling in Central Banks in Latin America**

**Kenneth F. Wallis**



Economic Commission for Latin America and the Caribbean

This document has been prepared by Kenneth F. Wallis, Department of Economics University of Warwick, Coventry CV4 7AL, UK, [K.F.Wallis@warwick.ac.uk](mailto:K.F.Wallis@warwick.ac.uk), <http://www.warwick.ac.uk/go/kfwallis>, within the activities of the project “Red de Diálogo Macroeconómico en América Latina REDIMA Fase II”: The helpful comments of Francisco Villarreal on a previous version of this paper, and the practical assistance of André Hofman, Francisco Villarreal and Pilar Arturo at ECLAC are gratefully acknowledged.

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## Contents

Abstract .....	5
1. Introduction .....	7
2. A suite of models for forecasting and monetary policy analysis .....	9
2.1. Nowcasting and short-term forecasting .....	9
2.2. Short-to-medium term forecasting models .....	10
2.3. Medium-to-long term models .....	13
3. Some Latin American concerns .....	15
3.1. Data considerations .....	15
3.2. Time-series econometrics .....	16
3.3. The institutional framework .....	17
4. Conclusion .....	19
References .....	21



## **Abstract**

This paper presents an overview of current developments in macroeconomic modelling for forecasting and policy analysis in Latin America, based on material presented at a REDIMA project meeting at the UN Economic Commission for Latin America and the Caribbean, Santiago de Chile, in September 2007. Some particular issues that arise in modelling emerging economies are described, in the context of recent developments in modelling developed economies.



# 1. Introduction

This paper presents an overview of different approaches to building macroeconomic models for forecasting and policy analysis that are current in Latin America. It is based on material presented at a meeting that formed part of the modelling component of the Regional Macroeconomic Dialogue Network (REDIMA) project. The project is managed by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC, in Spanish CEPAL) and financed by the European Commission. The meeting took place at ECLAC's headquarters in Santiago de Chile on 27-28 September 2007.

The model presentations by representatives of the Central American Monetary Council and the central banks of Argentina, Brazil, Chile, Colombia, Guatemala and Peru are the main input to this paper. It is convenient to refer to these as the seven country models, albeit inaccurate in respect of the first-mentioned, which relates to the collective economies of Central America and the Dominican Republic. The programme of the REDIMA meeting also included presentations by members of ECLAC, the UN Project LINK group, the IMF, the World Bank and the present author, drawing on his experience in model comparison exercises: Wallis (2004) is a recent example. The model presentations were mostly accompanied by documentation, in various stages of preparation and completeness. In view of the transitory nature of much of this material, no references to these documents are included in the list of references at the end of this paper. Instead, interested readers are referred to the website <http://www.eclac.cl/id.asp?ID=29930> where a depository of the most recent versions of the documentation of the models is being maintained.

In their review of inflation targeting, Mishkin and Schmidt-Hebbel (2007) include four of these countries – Brazil, Chile, Colombia, Peru – among “emerging economies that had full fledged inflation targeting in place in late 2004”. A fifth – Guatemala – is in the process of implementing a sequence of inflation targets that call for gradual reductions in inflation from 6% to 3% between 2006 and 2011. Inflation targeting is a forecast-based policy, and efficient outcomes require accurate forecasts of future economic activity and inflation.

An emphasis on accountability and transparency is a feature of monetary policy regimes of inflation targeting, and a desire for transparency has in many cases resulted in increased openness about the economic models and forecasting systems used in the monetary policy process. Several central banks have described their use of a “suite” of models, no single model being able to do everything that is required in economic analysis and forecasting. To capture the

same idea in statistical analysis more generally the American statistician John Tukey spoke of a “bouquet” of models. Others speak of a “stable” of models – horses for courses – which includes the “workhorse” model that provides the central framework for organising the analysis of monetary policy in the short-to-medium term. Whatever the language used, a similar use of a suite of models for macroeconomic forecasting and policy analysis emerged from the presentations at the REDIMA meeting. Sometimes this was stated explicitly by way of introduction, and although all the presentations focused on a single model, the fact that these represented various members of a typical suite implicitly conveyed the same idea. This is accordingly used to organise the discussion in this paper.

The paper proceeds as follows. Section 2 distinguishes three different target periods for forecasting and monetary policy analysis and describes the typical members of the suite of models found at each stage, both in general terms, relative to current developed-economy modelling and its antecedents, and with brief comments on the seven country models. Section 3 reflects on some specific difficulties of modelling emerging economies, relating to data considerations, their implications for econometric methods, and the institutional framework. Section 4 contains concluding comments.

## 2. A suite of models for forecasting and monetary policy analysis

Monetary policymaking is complex. Central bankers examine a vast array of data, hear from a variety of advisors, use suites of models to interpret the data, and apply judgment to adjust the predictions of the models. (Davig and Leeper, 2007, p.607).

In this section the time horizon for forecasting and monetary policy analysis is divided into three: the present and immediate future; the short-to-medium term, up to two or three years ahead; and the medium-to-long term. This is a convenient but possibly arbitrary division, because although the main focus of attention is different at each stage, there is some overlap in the tools that are used.

### 2.1. Nowcasting and short-term forecasting

A forecasting exercise usually begins with the present. It is important to know where the economy is now, to provide the initial condition for forecasts for the future, and to provide an assessment of the current conjuncture relative to earlier forecasts of it and the policy decisions based on them. Estimating where the economy is now in the face of delays in the production of data has become known as “nowcasting”: if  $t$  denotes the present period, and the information set available to forecasters refers to outcomes in period  $t-1$ , then an estimate of where we are now is a one-step-ahead forecast. When the first-released data are subject to subsequent revision, “backcasting” may also be undertaken to estimate the final revised data that will be released at some future time, which are presumed to be closer to the “truth”.

The techniques used for backcasting, nowcasting, conjunctural assessment and forecasting one or two quarters ahead are primarily statistical in nature, supplemented by expert judgment and internal consistency checks. Forecasts of key aggregates such as inflation and GDP growth are often constructed “bottom-up” from forecasts of their components, contributed by sector analysts using a mixture of statistical analysis and expert judgment. Statistical time series models have been developed that accommodate the almost continual but irregular arrival of data and the resulting “ragged edge” problem, datasets with mixed frequency data, and the extraction

of signals from large datasets. Eklund and Kapetanios (2008) provide an overview of state-of-the-art forecasting with large datasets. These include indicator models, of which leading examples are, in Europe, the work of the EuroCOIN group (Altissimo et al., 2001, 2007) and, in the United States, the work of Stock and Watson (2002, for example). The statistical methods mostly focus on forecasting one variable at a time, and the illustrations and applications in these papers relate to aggregate outcomes. Nevertheless the same statistical procedures are available to the sector analysts, and comparison of the aggregate statistical forecast to the sum of the component forecasts provides a simple consistency check, which may be supplemented by various bookkeeping and accounting checks.

No matter how successful statistical time series models might be in short-term forecasting, however, they provide no economic story. To check the consistency of the forecast with established economic relationships and to interpret and communicate the forecast in economic terms, other models with economic structure are required. In particular, statistical models typically project forward assuming unchanged policy, whereas the analysis and discussion of policy proposals or anticipated changes requires a model of their economic impact. Many economic variables display considerable inertia, so that statistical projections based on unchanged conditions perform well for one or two quarters even when policy changes. Other variables are forward-looking, however, and expectations of the future affect current outcomes. In practice the balance begins to tilt from statistical models towards models that embody more economic understanding when forecasting more than six months ahead, to which we now turn.

## 2.2. Short-to-medium term forecasting models

Macroeconometric models considered under this heading have a long history, during which different styles of model have emerged. The oldest is the simultaneous equation macroeconometric model (SEM) sometimes associated with the names of Tinbergen and Klein, who inaugurated this style of analysis in the 1930s and 1940s. Sometimes this model is referred to as a structural econometric model, using the first adjective in the traditional Cowles Commission sense. This style of modelling has itself seen substantial development over time (as described, for example, by Wallis, 1995, 2000), often as a constructive reaction to critics, of whom the most notable were Lucas (1976) and Sims (1980), from different points of view.

Responses to many of the criticisms are embodied in the contemporary SEMs maintained by monetary and fiscal policy agencies, research institutes, and a few academic economists.

Sims (1980) argued that the structural identification of the then-existing SEMs was incredible. He proposed the alternative strategy of estimating unrestricted reduced forms, treating all variables as endogenous, namely vector autoregressive (VAR) models. The subsequent recognition that, for policy analysis, VAR models still require identifying assumptions (Cooley and LeRoy, 1985, for example) resulted in a variety of ways of formulating such “structural VAR” (SVAR) models, starting from Bernanke (1986), Blanchard and Watson (1986), and Sims (1986) himself. In the meantime the cointegration literature inaugurated by Granger (1981) saw the VAR transformed into the vector error correction model (VECM), and a further proposal is to place identifying restrictions drawn from economic theory on the cointegrating relationships, leaving the short-run dynamic and stochastic specification unrestricted. This approach is called “long-run structural modelling” by Pesaran and Shin (2002), and it is applied in the construction of a small quarterly model of the UK economy by Garratt, Lee, Pesaran, and Shin (2003) and of a global VAR model by Pesaran, Schuermann and Weiner (2004); see Garratt et al. (2006) for discussions and applications of both models.

The preceding two paragraphs are mostly taken from the opening of Jacobs and Wallis (2005), who go on to compare the SVAR of Garratt et al. with a representative, modern SEMstyle model of the UK economy (Darby et al., 1999). This model can be described as New Keynesian, combining traditional Keynesian nominal rigidities with forward-looking behaviour in wage and price setting. In the short run output depends on effective demand, the main components of which are separately modelled. In particular, the consumption function is consistent with a forward-looking Blanchard-Yaari life cycle model, except that some consumers are liquidity constrained. In the long run the model's properties are close to those of an open economy version of the standard neoclassical growth model: it is neutral but not super-neutral – the level of real activity is independent of the price level but not of the steady-state inflation rate – because nominal interest payments are taxed. The model is estimated using modern time series econometric techniques at the single-equation or small subsystem level, with error correction specifications where relevant; its size precludes full-system estimation and testing. Forward expectations variables are treated as rational or model-consistent expectations.

The original VAR style of modelling abandoned the classification of variables as endogenous or exogenous, as noted above. In the closed-economy context of much of the early empirical VAR analysis – the US economy, that is – this meant treating policy variables as endogenous, and SEMs have followed suit, now containing fiscal and monetary policy reaction functions in place of their previous treatment of policy instruments as exogenous variables. In an open-economy context, however, the distinction remains, with typical SEMs of small open economies neglecting feedback effects on the rest of the world and treating “world” variables as exogenous, and often unmodelled. In forecasting exercises such variables may be projected forward using deterministic trends or ARIMA models, perhaps in a subsystem that ensures the internal consistency of the world scenario while remaining causally prior to the domestic model.

Much recent monetary policy research has been conducted in a highly aggregated, stripped-down version of the New Keynesian (NK) model (Clarida, Gali and Gertler, 1999). In this context “new” means that the techniques of dynamic general equilibrium theory pioneered in real business cycle analysis are employed, and “Keynesian” means that nominal price rigidities are also incorporated, as in the model of Darby et al. (1999) above. The result for a closed economy is a model that comprises just three equations: an aggregate demand equation or IS curve; an inflation equation or Phillips curve; and an interest rate equation or Taylor rule. All three equations may include both forward-looking and backward-looking dynamics. In open economies the exchange rate has an important role in the transmission mechanism of monetary policy, and is typically modelled via an interest parity condition (Svensson, 2000, for example), which takes the number of equations to four. The equation count may be increased by including definitions of real and nominal interest rates and exchange rates, all of which may appear.

These small NK models typically work with variables expressed as deviations from steady-state or equilibrium values (“gaps”), and they are estimated from detrended or filtered data. Practical forecasting applications focus on observable outcomes and so the trends need to be put back in, that is, the model forecasts of filtered data need to be “recoloured”, adopting the prewhitening-recolouring terminology also due to John Tukey, initially in respect of the spectral density estimation problem. If the trend has been estimated by regression on linear or polynomial terms in the time index, then projecting the estimated trend into the forecast period is straightforward. If the data have been prefiltered by Hodrick-Prescott or Whittaker-Henderson filters then projections can be based on a time series model for which the chosen filter delivers optimal signal extraction. There is usually some ambiguity surrounding the choice of such a model, and this is not often attempted in practice.

The models of Argentina, Guatemala and Peru presented at the REDIMA meeting share the aggregate NK framework, in each case extended to accommodate specific national

circumstances. All three are placed in the context of a forecasting and analysis system or suite of models, in which the presented model plays “a main role” or is “the core model”.

**Argentina** The first version of the Small Economic Model (SEM) of Argentina is of the basic open economy NK form described above. The second version is an extended version that includes a model of central bank intervention in the foreign exchange market, to provide a more realistic representation of the situation of developing countries. This is achieved by adding equations for money market equilibrium (“LM curve”) and the sterilisation of the effects of foreign exchange market intervention by the issuance of bonds, together with a second policy rule. The result is that four different monetary policy regimes can be modelled: a fixed exchange rate regime against the US dollar; a fixed rate against a basket of currencies; a pure float inflation targeting regime, as in the first version; and managed floating. The model is estimated (by GMM) over a period that includes two major economic crises and different economic policy regimes, which requires the use of several dummy variables.

**Guatemala** The Modelo Macroeconomico Semiestructural (MMS) of Guatemala contains two extensions to the aggregate demand equation of the basic NK model. The first arises from open economy considerations of direct relevance to many emerging economies, namely the importance of trade and the associated susceptibility to external shocks. Thus total demand is disaggregated into its domestic and external components, and each component is separately modelled. Second, domestic aggregate demand is a function of the long-term real interest rate, so a term structure equation is also included. In addition, the Phillips curve includes the influence of the price of oil. The “foreign” variables of the model essentially reflect conditions in the United States.

**Peru** The Modelo de Proyeccion Trimestral (MPT) of Peru extends the basic NK model to accommodate the additional monetary policy transmission channels that exist in a partially dollarised economy with incomplete, segmented financial markets. Also, as in Argentina, the central bank intervenes in the foreign exchange market, but the MPT simply models the outcome for the exchange rate, namely its reduced volatility and increased persistence. As usual in these models, there is no conventional disaggregation into the components of aggregate demand (that starts with  $Y=C+I+G+X-M$ , say), but an external component is acknowledged, as in MMS above, in this case through the inclusion of the foreign output gap in the aggregate demand equation. This equation also includes an explicit fiscal impulse variable. Gap variables are measured as deviations from trend levels, in turn described by reduced form autoregressions, and parameter restrictions ensure long-run nominal neutrality.

The models of Brazil and the collective economies of Central America and the Dominican Republic presented at the REDIMA meeting are also designed as short-to-medium term forecasting models. However they share more of the features of the SVAR and SEM-style models of the UK economy discussed above than those of the models of Argentina, Guatemala and Peru.

**Brazil** The Medium-Size Model of Brazil separately models the main components of aggregate demand, the supply side comprises a Cobb-Douglas production function and a forward-looking Phillips curve, and monetary policy follows a Taylor rule. The estimated equations are in (log) first differences, with no levels terms that would help to tie down the steady state in an economic sense. Cointegrating relationships are one way of doing this, but they cannot be statistically established from the available data series, which are relatively short and subject to structural breaks. We return to this topic in Section 3.2 below.

**Central America and the Dominican Republic** The Central American Monetary Council’s MECA model similarly focuses on the main components of final demand, but with no constraints on supply. This reflects the realities of the economies of Central America and the

Dominican Republic, which are very small and open, with high rates of unemployment and underemployment, and relative underutilisation of capital. As with the European Central Bank's Area-Wide Model of the euro area (Fagan, Henry and Mestre, 2001), the first task is to construct aggregate time series data for the region as a whole, in the face of changes due to structural reforms and the adoption of new statistical methods to accord with international standards. The resulting annual series, 1970-2006, are used to estimate error-correction equations for inflation and the main components of final demand, together with ARIMA models for several exogenous variables, to provide projections for use in model-based forecasting of endogenous variables.

All five models discussed in this section are used in this way, for short-to-medium term forecasting, also for simulations over similar horizons of the economy's response to various kinds of shocks. These include perturbations to exogenous variables such as oil prices or US economic growth, to unmodelled policy variables such as public expenditure or administered prices, and to endogenous variables via intercept/residual adjustments. In these last cases there is usually no story told about the source of the perturbation, whereas in the case of variables such as the exchange rate or the policy interest rate the different channels on the right-hand side of the equation represent different sources of potential shocks, which would be expected to have different second-round effects.

Notwithstanding this difficulty, these exercises all involve relatively small perturbations that can be realistically analysed in existing models without respecification. They are examples of what Sims (1982) called "normal policymaking" as opposed to "permanent shifts in policy regime" in his response to the rational expectations school's criticisms of policy analysis with econometric models. He concluded that the "ambitious, probably unattainable goal of the rational expectations school – to identify parameters of behavior that would be invariant to unprecedented permanent changes in rule – should not condition an entire research plan. We should be improving our methods for estimating and using statistical models that do not require identifying such parameters. Most policy analysis does not require that kind of identification" (1982, p.151). Nevertheless the search for that kind of identification – of "deep" parameters that describe preferences, tastes and technology – continued, eventually resulting in today's dynamic stochastic general equilibrium (DSGE) models, to which we now turn.

### 2.3. Medium-to-long term models

Macroeconomic models describe how aggregate economic outcomes result from the objectives and constraints of the key agents – domestic and foreign households, firms, and fiscal and monetary authorities – and their interactions in markets for goods, capital and labour. They embody assumptions about those objectives and constraints and the characteristics of those markets. In practice the assumptions balance simplicity, to achieve tractability, against the complexity that is needed to achieve an accurate description. In the simplest textbook model all necessary markets exist, in which optimising agents with full information interact perfectly competitively. In practical developed-economy models immediate departures are goods markets in which firms have monopoly power, labour markets in which firms and unions bargain over wages and employment, and missing financial markets. The representative agent remains an attractive simplification for many macro modellers, despite objections (see Kirman, 1992, for example). Indeed, how to provide macro models with better micro foundations is by no means settled (see the review by Janssen, 2008, for example).

The models of Chile and Colombia presented at the REDIMA meeting are DSGE models in different stages of development. Their theoretical structure follows contemporary standards as represented by Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003), who

consider applications to the US and euro area economies respectively, both treated as closed economies. An extension to open economies is then an obvious requirement in modelling Chile and Colombia, where foreign trade has an important role. For price and wage setting, however, both models adopt the standard Calvo (1983) mechanism, despite its empirical inconsistencies, at least with US data (Dennis, 2007).

The Model for Analysis and Simulations (MAS) of Chile extends the standard treatment of production, which distinguishes final and intermediate goods production, to further distinguish domestic and foreign intermediate goods, and hence domestic and foreign final goods. In addition, a commodity-exporting production sector which is a price-taker in foreign markets is included. This captures the role of the copper sector in the Chilean economy, which accounts for some 10% of GDP and 40% of exports. With respect to household behaviour, a departure from the standard treatment is the assumption that a proportion of households have no access to asset markets and hence no facility for intertemporal optimisation; instead, they consume all their disposable income each period. The existence of such “non-Ricardian” households implies that there is a role for fiscal policy, which is represented by the structural surplus fiscal rule used by the Chilean government since 2001.

Parameter values in MAS are determined by a mixture of calibration and estimation, with Bayesian estimation based on the likelihood function of a log-linear version of the model, for detrended variables, expressed in state-space/VAR form. Orthogonalised residuals are identified as named “shocks” – to preferences, labour supply, productivity ... – which are all first-order autoregressions. To a time-series econometrician such residual autocorrelation would indicate dynamic misspecification, but matching such properties of the data is not a priority in DSGE modelling. Instead attention focuses on impulse response functions, variance decompositions and historical decompositions. Again, when the unobserved shocks or residuals assume important roles in the decomposition analysis, a time-series econometrician’s interpretation would be that the modelled parts of the various relationships, in terms of included observable variables, have low explanatory power. Finally, as in Smets and Wouters (2003), the in-sample fit of MAS is compared to that of several VAR and Bayesian VAR models fitted to the same data. For most variables and horizons, the forecast RMSE of MAS is the smallest, but no plots of forecasts and actuals are presented, so the absolute quality of the forecasts cannot be assessed.

The PATACON model (Policy Analysis Tool Applied to Colombian Needs) also incorporates extensions of the standard closed-economy DSGE model to accommodate foreign trade and finance, via a similar disaggregation of production to that introduced into the Chilean model. There are specialised firms that differentiate final goods for export, and raw material and consumption/investment importers, together with import transforming firms. The specification of the theoretical structure of the model is complete, and its calibration, estimation, and use in policy analysis are in progress.

### 3. Some Latin American concerns

This section discusses two main areas of concern for macroeconomic modelling in Latin America, when attempting to emulate macroeconomic modelling in developed economies. The first is data, their availability, quality and changing statistical characteristics, the last feature leading to a discussion of time-series econometric methods. The second is institutional development, both on the ground and in the models, where there are more questions than answers. The discussion is mostly driven by examples that arose during the REDIMA meeting.

#### 3.1. Data considerations

The non-availability of series that a developed-economy econometrician might take for granted is notable in two areas. The first is the labour market – employment, unemployment and wages. Whereas an explicit treatment of the labour market has been noticeably absent from IMF and IMF-led modelling ever since the first days of MULTIMOD, nor is it found in modern DSGE models, it is an important part of the workhorse models of many developed economies. In some cases high employment is a policy objective. But even if not, in inflation-first or inflation-only policy regimes it is important to be alert to all possible sources of inflationary pressure, of which a leading example is the labour market. Some Latin American modellers listed this as a desired development of their models. This might be pursued in an equilibrium framework along lines suggested by Hall (2005), or in an empirical econometric framework following the approach used in the multicountry model NiGEM (Barrell *et al.*, 2004). But such a development, by whatever means, is hindered by the lack of reliable data series.

The second general area is stock variables, wherever stock-flow interactions and the specification of a steady state with stock-flow consistency are important. Early examples which brought stock effects to the attention of developed-economy modellers were: the increase in the personal savings ratio in the 1970s, attributed to inflation reducing the real value of the stock of financial assets; the evolution of the capital stock following the first oil shock; the stock implications of the US budget deficit; and portfolio shifts underlying the currency instability of the late 1970s and early 1980s. A leading example in contemporary models is personal wealth. While it should not be pretended that the desired data are everywhere available, its importance is reflected in the finding that, in many countries, personal income, consumption and wealth are

cointegrated, but personal income and consumption are not. A second example is the debt stock. In early macroeconomic models it was possible to carry out a simulation of a government expenditure shock, blithely unaware of the resulting debt explosion, because the debt position was neither monitored nor modelled. This is no longer the case, and current models include fiscal policy rules that ensure that the government's intertemporal budget constraint is satisfied.

Improvements in data provision and quality are the objective of a separate strand of the REDIMA project. Here we focus on an important issue in short-term forecasting, namely the uncertainty that is present whenever real-time data on the current conjuncture are subject to subsequent revision. Many national statistical offices undertake regular studies of the revision process of national accounts data, and many macroeconomic forecasters are alert to the possibility that future revisions might be forecastable. Studies of the revision process typically yield summary statistics such as the mean square revision over given time intervals in the past, which can be used to indicate the likely size of future revisions, in the absence of known changes in data gathering and processing methods. Some Latin American modellers mentioned the desirability of reporting measures of forecast uncertainty, such as forecast intervals or fan charts, which should be encouraged, and the uncertainty of forecast initial conditions is an important component of the uncertainty of forecasts of future outcomes. A recent addition to the Bank of England's collection of fan charts relates to the nowcasts and backcasts of GDP growth, and incorporates uncertainty about possible future revisions to recent data. The new backward looking fan chart first appeared in the August 2007 *Inflation Report*; it was then incorporated into the GDP growth forecast fan chart, which thus looks to the past as well as the future, in the November 2007 *Inflation Report* (see also Cunningham and Jeffery, 2007).

### 3.2. Time-series econometrics

Changes in the statistical characteristics of macroeconomic time series occur for a variety of reasons, some internal to the data gathering and processing methods, others relating to changes in the economic behaviour that is being measured, usually referred to as structural breaks or regime changes. Several Latin American modellers described the difficulties such changes present for the practical application of standard time-series econometric methods.

In testing for unit roots in a single macroeconomic time series it is well known that an otherwise stationary series that is subject to level shifts or breaks in mean can deliver test statistics that do not reject the hypothesis of a unit root. To avoid such incorrect inferences the breaks, at either known or estimated dates, should be included in the statistical analysis. This is relevant in many countries that have recently adopted inflation targeting, where it is important to accommodate regime changes when analysing the inflation series, so that inflation can be appropriately treated as a stationary variable in the current regime.

In regression analysis a popular specification is the error correction model, describing the process of adjustment to a long-run position represented by a cointegrating relationship. These relations, together with the static and dynamic homogeneity properties of the ECMs, have important roles in characterising the steady-state properties of the system. As above, in testing for a cointegrating relation, level shifts or breaks in mean can result in rejection of stationarity of the residual, that is, rejection of cointegration. Again, the solution is to include the breaks in the statistical analysis, as discussed by Johansen, Mosconi and Nielsen (2000). This approach is employed by Attfield and Temple (2006) in establishing stationarity of the "great ratios" in the United States and the United Kingdom. Note also that they work with ratios expressed in current prices, which are stationary under more general conditions than ratios of real quantities.

In forecasting it is the current regime that is relevant to the analysis, unless future changes have already been announced, and if the corresponding data series are relatively short and appear uninformative on important questions, and methods discussed in the previous two paragraphs are of no assistance, then various mixed estimation procedures that give weight to the prior requirements of the model specification might be considered. Ultimately time-series econometric methods might be replaced, for this purpose, by the calibration methods familiar in CGE modelling. In this connection it is interesting to note that in the DSGE-VAR framework used by Del Negro, Schorfheide, Smets and Wouters (2007), the VAR is written in VECM form, which can be seen as a move towards endogenisation of the steady state of DSGE models. However the authors report that comparisons of forecast summary statistics (no forecast tracking results are shown) are hampered by the fact that the stylised cointegrating relations “are at odds with the data” (2007, p.138). No information is provided on the nature of this discrepancy, nor information about the statistical analysis on which it rests, nevertheless one might look forward to the eventual establishment of data-admissible long-run relations, akin to those that feature in the long-run structural modelling approach of Pesaran and Shin (2002) and Garratt et al. (2006).

### 3.3. The institutional framework

Several examples of the adaptation of developed-economy modelling practice to local Latin American conditions are described above. Some of these relate to distortions in financial markets, in turn related to the low level of development of financial institutions, which are of more general concern. A further specific example in discussion at the REDIMA meeting is how to model the impact and recycling of overseas remittances. That adaptation of “standard” modelling practice to local conditions is needed not only across emerging economies but also across developed economies is apparent from multicountry macroeconomic models. In modelling and forecasting business investment, for example, it is important to distinguish between the relative roles of the capital market and the banking system as external sources of finance, which differ between the United States and the United Kingdom. (Which is not to say that the recent evidence of malfunctioning credit markets in the United States is not of concern to UK policy makers.) Returning to the Latin American context, a specific distortion recently evidenced in Brazil by Claessens *et al.* (2008) is the influence of political connections in gaining preferential access to bank finance.

For macroeconomic forecasting an important byproduct of well developed financial systems is reliable market signalling. For example, data presented to the Bank of England Monetary Policy Committee and published in the Inflation Report regularly include implied expectations of future interest rates and inflation, and their uncertainty, extracted from the prices of a variety of financial instruments, including futures contracts, index-linked government bonds, and options traded on the London International Financial Futures and Options Exchange (LIFFE). Particularly notable is Chart 4.3 in the November 2005 Inflation Report, showing changes in the uncertainty of future oil prices as revealed by density forecasts derived from options markets. This may be of interest to Latin American modellers whose inflation equations contain oil prices, which implies that the inflation forecast error variance, a measure of future inflation uncertainty, is a function of the changing uncertainty of future oil prices.



## 4. Conclusion

This paper takes a snapshot of elements of a suite of models that central bank staff presented at the REDIMA meeting. Different styles of model are represented, and are placed in the context of general model development trends. The principal responsibility of the model proprietors is monetary policy, nevertheless in economy-wide modelling other policy frameworks are relevant. In this context the Deputy Governor of the Bank of England responsible for monetary stability recently identified two key issues. “First, is an individual country’s set of monetary, fiscal, financial, and exchange rate frameworks internally consistent? ... Second, are different countries’ policy frameworks consistent with one another?” (Lomax, 2006, p.438). Although she was outlining proposals for redesigning the surveillance activities of the IMF, the first question is also relevant for macroeconomic modellers. The policy framework in a typical contemporary liberal-market, developed economy, and in models thereof, comprises an independent central bank targeting inflation, tight rules on discretionary fiscal policy with some automatic stabilisers, the free movement of capital, and floating exchange rates. The presentations and discussions at the REDIMA meeting made clear that such a framework, and models thereof, cannot be generalised to emerging economies without taking careful account of country-specific and institutional factors. Emerging economies are highly heterogeneous, and more susceptible to external shocks than developed economies, thanks to their greater reliance on trade, hence direct comparisons of model properties need to be approached with caution.

The Deputy Governor’s second question is then relevant to two final issues discussed at the REDIMA meeting, namely what form might future model comparisons take, and is there a role for formal model-based policy coordination exercises. In the technical literature model based coordination exercises seem to have diminished in interest in recent years, perhaps since little formal coordination seems to occur in practice. But comparative analysis of national economies is a regular, ongoing activity of international organisations, although in the case of the IMF the desirability of its continuance is under discussion, as indicated above. Supplementing this activity with regular comparative analysis of extant models of national economies would help answer her second question, and in turn help to achieve greater stability. To do this on a regional basis seems a good place to start.



## References

- Altissimo, F., Bassanetti, A., Cristadoro, R., Forni, M., Hallin, M., Lippi, M., Reichlin, L. And Veronese, G. (2001). EuroCOIN: a real time coincident indicator of the euro area business cycle. Discussion Paper 3108, Centre for Economic Policy Research, London.
- Altissimo, F., Cristadoro, R., Forni, M., Lippi, M. and Veronese, G. (2007). New EuroCOIN: tracking economic growth in real time. Discussion Paper 5633 (revised), Centre for Economic Policy Research, London.
- Attfield, C.L.F. and Temple, J.R.W. (2006). Balanced growth and the great ratios: new evidence for the US and UK. Discussion Paper No.074, Centre for Growth and Business Cycle Research, University of Manchester.
- Barrell, R., Becker, B., Byrne, J., Gottschalk, S., Hurst, I. and van Welsum, D. (2004). Macroeconomic policy in Europe: experiments with monetary responses and fiscal impulses. *Economic Modelling*, 21, 877-931.
- Bernanke, B.S. (1986). Alternative explanations of the money-income correlation. *Carnegie-Rochester Conference Series on Public Policy*, 25, 49-99.
- Blanchard, O.J. and Watson, M.W. (1986). Are business cycles all alike? (with discussion). In *The American Business Cycle* (R.J. Gordon, ed.), pp.123-179. Chicago: University of Chicago Press for NBER.
- Calvo, G. (1983). Staggered contracts in a utility-maximizing framework. *Journal of Monetary Economics*, 12, 383-398.
- Christiano, L.J., Eichenbaum, M. and Evans, C.L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113, 1-45.
- Claessens, S., Feijen, E. and Leaven, L. (2008). Political connections and preferential access to finance: the role of campaign contributions. *Journal of Financial Economics*, in press.
- Clarida, R., Gali, J. and Gertler, M. (1999). The science of monetary policy: a New Keynesian perspective. *Journal of Economic Literature*, 37, 1661-1707.
- Cooley, T.F. and LeRoy, S.F. (1985). Atheoretical macroeconometrics: a critique. *Journal of Monetary Economics*, 16, 283-308.
- Cunningham, A. and Jeffery, C. (2007). Extracting a better signal from uncertain data. *Bank of England Quarterly Bulletin*, 47(3), 364-375.
- Darby, J., Ireland, J., Leith, C. and Wren-Lewis, S. (1999). COMPACT: a rational expectations, intertemporal model of the United Kingdom economy. *Economic Modelling*, 16, 1-52.

- Davig, T. and Leeper, E.M. (2007). Generalizing the Taylor principle. *American Economic Review*, 97, 607-635.
- Del Negro, M., Schorfheide, F., Smets, F. and Wouters, R. (2007). On the fit of New Keynesian models (with discussion). *Journal of Business and Economic Statistics*, 25, 123-162.
- Dennis, R. (2007). The frequency of price adjustment and New Keynesian business cycle dynamics. Working Paper 2006-22, Federal Reserve Bank of San Francisco.
- Eklund, J. and Kapetanios, G. (2008). A review of forecasting techniques for large data sets. *National Institute Economic Review*, No.203, 109-115.
- Fagan, G., Henry, J. and Mestre, R. (2001). An area-wide model (AWM) for the euro area. Working Paper No.42, European Central Bank, Frankfurt.
- Garratt, A., Lee, K., Pesaran, M.H. and Shin, Y. (2006). *Global and National Macroeconometric Modelling: A Long-Run Structural Approach*. Oxford: Oxford University Press.
- \_\_\_\_\_ (2003). A long run structural macroeconomic model of the UK. *Economic Journal*, 113, 412-455.
- Granger, C.W.J. (1981). Some properties of time series data and their use in econometric model specification. *Journal of Econometrics*, 16, 121-130.
- Hall, R.E. (2005). The labor market and macro volatility: a nonstationary general-equilibrium analysis. Working Paper No.11684, National Bureau of Economic Research.
- Jacobs, J.P.A.M. and Wallis, K.F. (2005). Comparing SVARs and SEMs: two models of the UK economy. *Journal of Applied Econometrics*, 20, 209-228.
- Janssen, M.C.W. (2008). Microfoundations. In *The New Palgrave Dictionary of Economics* 2nd edn. (S. Durlauf and L.E. Blume, eds). Palgrave Macmillan, in press.
- Johansen, S., Mosconi, R. and Nielsen, B. (2000). Cointegration analysis in the presence of structural breaks in the deterministic trend. *Econometrics Journal*, 3, 216-249.
- Kirman, A.P. (1992). Whom or what does the representative individual represent? *Journal of Economic Perspectives*, 6, 117-136.
- Lomax, R. (2006). International monetary stability – can the IMF make a difference? *Bank of England Quarterly Bulletin*, 46, 434-441.
- Lucas, R.E. (1976). Econometric policy evaluation: a critique. *Carnegie-Rochester Conference Series on Public Policy*, 1, 19-46.
- Mishkin, F.S. and Schmidt-Hebbel, K. (2007). Does inflation targeting make a difference? Working Paper No.12876, National Bureau of Economic Research.
- Pesaran, M.H. and Shin, Y. (2002). Long-run structural modelling. *Econometric Reviews*, 21, 49-87.
- Pesaran, M.H., Schuermann, T. and Weiner, S.M. (2004). Modeling regional interdependencies using a global error-correcting macroeconomic model (with discussion). *Journal of Business and Economic Statistics*, 22, 129-181.
- Sims, C.A. (1986). Are forecasting models usable for policy analysis? *Federal Reserve Bank of Minneapolis Quarterly Review*, Winter 1986, 2-16.
- \_\_\_\_\_ (1982). Policy analysis with macroeconomic models (with discussion). *Brookings Papers on Economic Activity*, 1982 No.1, 107-164.
- \_\_\_\_\_ (1980). Macroeconomics and reality. *Econometrica*, 48, 1-48.
- Smets, F. and Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European Economic Association*, 1, 1123-1175.
- Stock, J.H. and Watson, M.W. (2002). Macroeconomic forecasting using diffusion indexes. *Journal of Business and Economic Statistics*, 20, 147-162.
- Svensson, L.E.O. (2000). Open-economy inflation targeting. *Journal of International Economics*, 50, 155-183.
- Wallis, K.F., (2004). Comparing empirical models of the euro economy. *Economic Modelling*, 21, 735-758

- \_\_\_\_\_ (2000). Macroeconometric modelling. In *Macroeconomic Policy: Iceland in an Era of Global Integration* (M. Gudmundsson, T.T. Herbertsson and G. Zoega, eds), pp.399-414. Reykjavik: University of Iceland Press.
- \_\_\_\_\_ (1995). Large-scale macroeconometric modeling. In *Handbook of Applied Econometrics* (M.H. Pesaran and M.R. Wickens, eds), pp.312-355. Oxford: Blackwell.