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Challenges for Europe in the world, 2030

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AUGUR

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Introduction to the CAM databank and model

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Introduction to the CAM databank and model

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Abstract

The CAM model of the world economy derives from applied macro-economic research to support economic policy analysis at Cambridge, UK in the 1970s. The current version includes a databank with time series for 130 countries and country groups from 1970 to 2008 from which series are extracted using a flexible aggregation method to generate results for the world divided into between 10 and 20 geographical groupings or blocs that form the object of specific policy studies.

The first section of this paper explains how the CAM model will be used in the AUGUR programme. The proposed bloc classification includes a division of Europe into five regions (North, Central, West, South and East) together with four large countries (US, Japan, China and India) and nine other country groups in the rest of the world. This section also lists topics for which the CAM databank and model should provide relevant historical data and projections and describes the main development items that must be implemented to achieve the objectives of the AUGUR project.

The second section describes the databank and model in some detail. The databank holds series in US dollar values and other units disseminated by UN organisations. Problems that have to be solved in constructing the databank from different sources include standardisation of geographical codes through time and across sources, estimation of missing values, inconsistency of estimates of exports and imports in national accounts, balance of payments statistics and trade statistics and differences between totals that should match for the world as a whole. Series for countries and country groups in the CAM model are aggregated from US dollar values in the databank and converted into domestic and international purchasing power equivalents to facilitate comparisons through time and across blocs. Another major taks is the preparation of estimates of assets, liabilities and wealth that are consistent with domestic and external financial flows.

The third section reviews the structure of the model and the way in which different assumptions about policy may be specified in simulations. A brief account is given of the operation of programs that implement the model (fully described in the CAM User Guide).

The last section gives a preview of historical data and projected trends that are of particular interest for the AUGUR programme.

Appendices provide additional technical information about notation and measurement conventions and the derivation of real values, volumes and price deflators from series in the databank as well as a listing of all important variables modelled in the current version of the CAM.

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Background

The role of the CAM model in the AUGUR project is to provide a quantitative time-series framework for historical analysis and projections for Europe and the world economy to 2020 and 2030. The CAM model originates from work at the Cambridge University Department of Applied Economics in the 1980s and has been developed progressively over the past two decades for use in global macro-economic analysis. Since 2005 the model has been extensively revised and updated for use in the State of the World Economy (SOWE) project supported by participants in Brazil, China and India and as a tool for global policy analysis in the UN Department of Economic and Social Affairs (UN DESA/DPAD).

The historical databank for the CAM model is implemented on MS SQL Server with an Excel front end for extraction and aggregation of annual time series covering the world divided into 130 countries and country groups for the period 1970 - 2008. Data analysis and modelling are implemented using the EViews econometric package.

Concepts and coverage

The model is designed to examine historical developments as a basis for construction of alternative scenarios for the future in which different assumptions may be made about trends, shocks, policy objectives and responses. The world economy is divided into a number of blocs using a flexible system of geographical aggregation that allows researchers to specify the number of blocs and the grouping of countries in each bloc. The model has a relatively detailed coverage of trade and the balance of payments with separate subsystems for primary products, energy, manufactures, services, income and transfers and capital movements that make it possible to investigate the influence of changes in terms of trade, market shares and financial flows on each bloc. The impact of exchange rate movements on each component of the current account is represented explicitly and the model is closed by assumptions about adjustment of domestic spending, inflation and exchange rates in each bloc to GDP growth, the current account and the accumulation of assets and liabilities including government debt and net external positions.

Local policies and global policy coordination

One of the main interests of a global model lies in the potential for estimating transmission effects that escalate the interplay of policies and outcomes to the world level. On the basis of historical evidence it is not possible to be confident that endogenous mechanisms in the economic and financial system will ensure that the outcome for each bloc is optimal or even satisfactory in the long run. At the same time globalisation has created a situation in which no bloc can be sure of having sufficient power to determine the outcome for its own economy by unilateral policy action as has been demonstrated by the experience of the U.S. in recent years.

Different types of policy coordination can be represented in the CAM by specifying rules or reaction functions involving more than one country or region. In a rule-driven approach, participating blocs agree to institute active policies with respect to variables such as the exchange rate and domestic demand in response to undesired movement of target variables such as the level of activity or the balance of payments. Such rules are modelled by building additional reaction functions into the model. In a burden-sharing scheme, member blocs commit themselves to work

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together towards a common end such as, for example, a reduction in global carbon emissions. Such schemes can be modelled by specifying explicit targets and adjusting policies in participating blocs in a synchronised fashion to secure the desired result.

In reality forward-looking scenarios for the world economy will almost always require policy coordination to achieve a result that benefits most or all countries and regions. Thus when problems are specified and studied from a global viewpoint, coordination of policy responses is a critical consideration. The CAM provides an instrument for investigating alternative patterns or methods of coordination in this context.

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1. How the model will be used in the AUGUR project

Bloc structure

For the purposes of the AUGUR project it is proposed to distinguish five groups of European countries (North, Central, West, South and East Europe) and thirteen groupings in other world regions (USA, Japan, East Asia High Income, Other Developed, CIS, North Africa and West Asia, Central America, South America, China, Other East Asia, India, Other South Asia and Other Africa). Table 1 below indicates the composition, size and average income level of each bloc.

Most of Europe has been near the top of the world income distribution in recent decades. Eastern European countries, although starting from a much lower level, have nearly doubled their average per capita income level over the past 20 years, with an expectation of continued convergence towards the European average in future. Other high-income countries – the US and Canada, Japan and other high income countries in East Asia – have broadly similar income levels to those in Europe. The total population of high-income countries exceeds 1 billion people and on average these countries have seen per capita income rise by 40% in the past two decades.

The middle-income group, comprising CIS countries, North Africa, West Asia and Latin America, has around 1.3 billion people with average income about 40% of the level in high income blocs.

The remaining population of the world, around 4.3 billion people, have average incomes less than half the level in the middle-income group and between 5% and 15% of the level in high income blocs. Although China, India and other countries in East and South Asia have increased their per capita incomes quite rapidly, low-income countries in Africa have fallen further behind and now have average incomes that are scarcely higher than in 1970.

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Table 1 Bloc definitions

Bloc	Countries	2008 Population (millions)	2008 GDP (billion ppp)	GDP per capita (thousand ppp)		
				1988	2008	% increase
North Europe	Norway, Sweden, Finland, Denmark	25	844	22,263	34,132	53.3
Central Europe	Austria, Belgium-Luxembourg, Switzerland, Germany, France, Netherlands	190	5,512	21,262	29,010	36.4
West Europe	United Kingdom, Ireland	66	2,007	19,332	30,559	58.1
South Europe	Spain, Greece, Italy, Portugal, Other Europe	128	3,072	17,822	24,085	35.1
East Europe	Albania, Bulgaria, Former Czechoslovakia, Hungary, Poland, Romania, Former Yugoslavia	116	1,551	7,353	13,348	81.5
USA	United States	316	11,637	27,054	36,846	36.2
Japan	Japan	127	3,490	21,486	27,418	27.6
Other Developed	Australia, Canada, New Zealand, Israel	66	2,102	21,472	32,029	49.2
East Asia High Income	Republic of Korea, Taiwan, Hong Kong, Singapore	83	1,875	11,512	22,679	97.0
CIS	Former Soviet Union	284	2,927	9,564	10,315	7.9
North Africa and West Asia	West Asia and Morocco, Algeria, Tunisia, Libya, Egypt, Sudan	479	4,075	4,838	8,512	76.0
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Paraguay, Uruguay, Venezuela	383	3,430	6,291	8,946	42.2
Central America	Mexico and other America and Caribbean countries	187	1,837	6,773	9,804	44.8
China	Mainland China and Macau	1,315	6,457	977	4,911	402.7
Other East Asia	Other Asia and Pacific	607	2,047	1,723	3,373	95.8
India	India	1,181	2,902	989	2,456	148.5
Other South Asia	Afghanistan, Bangladesh, Sri Lanka, Nepal, Pakistan, Other South Asia	414	760	1,122	1,835	63.5
Other Africa	All other African countries	780	1,381	1,361	1,770	30.0

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Principal topics

Historical analysis and scenarios generated by the CAM for use in the AUGUR programme will focus on longer-run topics that are of particular interest from a European and global perspective including

Trade

- competition in global markets
- technology dominance
- energy supply and use

Finance

- unbalanced external positions
- government finance
- credit trends and cycles
- inflation

Social and environmental outcomes

- environmental impacts
- unemployment and under-employment
- implications of demographic ageing
- trends in social protection

Cohesion and equality

- income distribution within countries and regions
- global inequality.

Whilst in-depth analysis will be provided by other AUGUR work programmes the role of the CAM model is to provide quantitative indicators in the form of historical time series and projections within a defined, formal framework that provides an account of inter-relationships between the topics and at the same time allows variant assumptions to be made about trends, shocks and policy responses, coordinated or otherwise, in each part of the world.

The governance framework

The most important and difficult innovation required to support the objectives of the AUGUR project is the need to investigate the plausibility and implications of different governance assumptions. Scenarios generated by the model must reflect the changing influence of different countries and world regions on normative standards and policy patterns.

Although in many ways it seems realistic to suppose that policies of each bloc in the contemporary globalized world are largely reactive, the bargaining power of countries and country groups is both unequal and subject to shifting economic and political trends. Therefore the context in which policies are determined is an

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important aspect of the story that is be influenced, but not wholly determined, by financial, economic and environmental variables identified in the model.

Alternative sets of expectations about the direction in which the governance framework is likely to change will be termed "governance assumptions". The following headings have been proposed for consideration at prior AUGUR workshops:

- bipolar world (domination of US and China)
- regionalisation (local integration, reduced global influence)
- new directions in Europe (to be considered further)
- global citizenship (more equal and cooperative global relationships)
- weak governance (short-term, opportunistic alliances)

To make these or other governance assumptions meaningful and effective in CAM model projections it will be necessary to define specific behavioural changes that may be expected to follow with more or less force from each set of assumptions. For example, depending on the governance framework, there may be different trends in global, regional and bilateral patterns of trade, different emphasis on energy policies, greater or less flexibility in external financing and development assistance for low-income regions, etc.

An iterative process will be necessary in order for AUGUR teams to reach some degree of consensus on the potential impact of different governance assumptions on policies and outcomes for Europe and other world regions. Therefore after a preliminary discussion scheduled for the June 2010 AUGUR workshop, the CAM modeling group will prepare an initial set of scenarios, differentiated by governance assumptions, for circulation and review by all teams at the end of the year.

Extensions of the model

A number of variables will be added to the CAM databank and model to provide additional information relevant to topics listed above. Historical coverage will be maximized by the use of UN sources wherever possible but it must be accepted that in some cases such as environmental impact, migration and activity rates it will not be possible to provide meaningful estimates for all territories going back to 1970. Therefore CAM model procedures for specification and estimation of behavioural equations will have to be adjusted to take account of such gaps in availability of historical data.

Areas in which extensions of the databank and model are required include

- energy supply and demand by type of fuel together with environmental impacts (with assistance from CIRED)
- demographic structure and migration flows (with assistance from SOAS), and
- participation rates (with assistance from SOAS and ISMERI).

Such extensions will be implemented in a preliminary manner before the end of 2010 so that results can be included in historical analysis and scenarios to be circulated at the end of the year.

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2. The databank and derivation of data for use in the model

The databank

The CAM databank relies mainly on UN sources that are designed to provide global coverage. Although there are problems of availability, reliability and accounting consistency, experience to date indicates that such data give a reasonably consistent picture of economic developments confirmed by regularity of cross-section and time-series relationships (Cripps and Khurasee, 2006). An iterative adjustment method developed by R. Byron (1978) is used to resolve inconsistencies and enforce accounting identities at the level of individual countries and the world as a whole.

Observations that depart significantly from the historical pattern can usually be explained by wars, political upheavals or other major disruptions or data errors that are more-or-less self-evident when traced back to original sources. At the same time there is a wide variation in reliability of data and all observations in the CAM databank are tagged to indicate whether they have been estimated or substantially adjusted and to record the original source from which they derive (Cripps and Khurasee, 2010a).

The most important reservations about data for the world economy over the past 40 years concern discontinuities resulting from the breakup of the former USSR, gaps in data for many territories in the 1970s and 1980s and the absence of regional data for India and China that each account for nearly 20% of the world's population.

The main adjustments that have to be made to data from UN and other sources are as follows.

GEO mapping to obtain continuous series with common coverage

The population of reporting countries (territories) has changed over the period since 1970 and shows some differences between sources. These problems are resolved by mapping and aggregating source data to a common geographical classification that is less detailed than the classifications available for individual topics and reduced time periods but satisfies the need for consistency through time and across topics.

Inconsistencies between sources

Data values provided by different UN sources for a given territory and year that in principle refer to the same concept or variable often differ substantially. Such differences can arise when data are reported by different agencies and at different times, particularly when values are subject to currency conversion (e.g. to US dollars) or where reported data are known to be incomplete. Therefore, for example, substantial differences are found for many countries and time periods in estimates of exports and imports reported in national accounts statistics, balance of payments statistics and trade statistics.

The CAM databank gives primacy to national accounts aggregates since these provide a framework for aggregating trade, expenditures, income and production. Balance of payments and trade series are in general adjusted to make totals consistent with national accounts aggregates.

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Errors and gaps

All source data is screened to identify outlying data values that imply dramatic and implausible discontinuities (peaks and troughs). Outlying values that appear on inspection to be seriously misleading are rejected and treated as missing values.

Since one of the objectives of the CAM databank is to provide the best possible estimates of global series with breakdown for regions and larger countries, an attempt is made to fill gaps for individual reporting territories. A range of estimation methods, reported in detail in the WD User Guide (Cripps and Khurasee, 2010a), is used for this purpose, following a hierarchy that begins with simple interpolation (e.g. if values are missing for one or two intermediate years) and ends with attribution of a zero value in cases where no other estimate appears more plausible.

Inconsistencies between world totals

In principle international transactions (flows) should be the same, whether reported by the paying or receiving country and positions (stocks) should be the same whether reported by the issuer/debtor country or the asset holder. In most cases it is not possible to make bilateral comparisons of individual components, this principle does imply that world totals reported by each side (imports and exports, receipts and payments or assets and liabilities) should be equal in value. In most cases differences between world totals for a given concept and year are small, of the order of 1-2%, but sometimes larger differences arise, especially when missing values for some reporting units have to be estimated.

The CAM databank enforces consistency of world totals for all relevant variables in each year by making minimum necessary changes, taking account of other required adjustments such as consistency with national accounts aggregates mentioned above. as part of the iterative adjustment process mentioned above.

Databank series and measurement conventions in the model

The CAM model employs an accounting framework in which variables are presented in real terms to maintain comparability through time and across countries. International transactions of all blocs are measured in dollars adjusted for global inflation while domestic series are measured on a base-year purchasing-power basis.

On the other hand series recorded in the databank are generally denominated in current dollars. Reporting institutions or UN statisticians convert original values denominated in different currencies to US dollars using period-average market exchange rates for flow variables and end-year market exchange rates for asset positions and other stocks.[1]

This section explains how variables used in the model are derived from series recorded in the databank.

Values in constant purchasing power units

Two purchasing power concepts are used in the CAM model:

[1] In cases where there have been very erratic movements of market exchange rates, the rates used to derive dollar values are adjusted. The conversion rate used can be deduced by comparing series denominated in national currency units with series for the same variables denominated in US dollars.

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i) domestic purchasing power, or valuation of money flows in terms of goods and services entering domestic final expenditure in each bloc (consumers expenditure, government expenditure on goods and services, gross spending on fixed capital and inventories).

ii) global purchasing power, or valuation of money flows in terms of goods and services entering final expenditure in the world as a whole.[2]

Real values in domestic or global purchasing power units are calculated by dividing current dollar figures by the relevant deflator. There is a different domestic deflator for each bloc reflecting differences in the price of goods and services purchased in each country and in each year.

Table 2 Year 2000 purchasing power parity adjustments

Bloc	*Ratio*	*Bloc*	*Ratio*
North Europe	1.010	CIS	0.241
Central Europe	0.873	North Africa and West Asia	0.453
West Europe	0.969	South America	0.549
South Europe	0.715	Central America	0.556
East Europe	0.377	China	0.396
USA	0.980	Other East Asia	0.375
Japan	1.453	India	0.307
Other Developed	0.809	Other South Asia	0.339
East Asia High Income	0.728	Other Africa	0.394

The deflator for each bloc (country or country group) is calculated by comparing the aggregate current dollar figure for domestic expenditure with the constant dollar figure for the same series, rebasing to 2000 and scaling to reflect purchasing power differences in the base year.[3] By implication the ppp figure for domestic expenditure in each bloc has the same pattern of year-on-year proportionate changes as the constant dollar figure from which the deflator was derived. Also ppp figures for income and individual components of domestic expenditure maintain the same ratios to total domestic expenditure as current dollar figures from which they are derived.[4]

[2] This includes traded goods and services together with goods and services that are domestically produced and consumed in each country.

[3] The base year adjustment is made by dividing the total of UN Statistical Office base year estimates of GDP at purchasing power parity for all countries in a given bloc with the corresponding total for GDP converted at market exchange rates.

[4] For a discussion of comparisons through time and across countries see Schreyer and Koechlin (2002) and World Bank (2008). In the CAM source series are aggregated to bloc level using current and constant price dollar values converted at market rates. A base-year purchasing power adjustment is then applied to data for each bloc as a whole. Thus percentage changes of stocks and flows through time are the same are the same whether measured at base-year market rates or base-year purchasing power parities. In many cases the choice of measure makes little difference to model equations and results. In some cases model relationships seems to approximate historical behaviour and imply greater uniformity of behaviour when purchasing power parities are used. This is particularly the case for relationships between physical energy use and GDP and between changes in the volume of net exports of primary commodities and GDP.

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Similar propositions hold for the world expenditure deflator that is calculated as the ratio of current dollar expenditure in the world as a whole to constant dollar expenditure converted at base-year purchasing power parities.

Core equations of the CAM model use series for income, expenditure and domestic asset positions measured in domestic purchasing power terms. Series for external transactions and assets are measured in world purchasing power terms to maintain equivalence between blocs and ensure that external transactions and asset positions balance for the world as a whole. Series measured according to either convention can be converted to the other by the real exchange rate.

The real exchange rate

In the CAM the real exchange rate for each bloc is defined as the ratio of international to domestic purchasing power of money converted at market exchange rates. The real exchange rate adjusts through time in response to differences between inflation of the price of domestic expenditure, changes in the nominal exchange rate against the dollar and inflation of the dollar price of domestic expenditure in the world as a whole. The real exchange rate is often relatively high in high-income blocs where many locally-produced products and services are expensive and low in low-income blocs where locally-produced products and services are often relatively cheap.

It should be noted that when real exchange rates enter into the determination of market shares the CAM evaluates real exchange rates on a relative basis. Therefore the choice of world deflator is neutral so far as the determination of market shares is concerned.

Volume measures

In the CAM as in other macro-models, series for expenditure, trade and output measured at constant prices are used as indicators of volume. For domestic expenditure as a whole, volume and ppp value are equal by definition. But although the CAM does not track volume measures for components of domestic expenditure such as consumers expenditure, government expenditure on goods and services and non-government expenditure on fixed assets and inventories, volume measures are required for exports and imports of goods and services in order to determine demand for GDP considered as a volume measure. Therefore the CAM records and forecasts volume and ppp value measures for each category of exports and imports.

National income measured in purchasing power terms is defined as the sum of domestic expenditure and the external current account converted to domestic purchasing power. GDP is defined as the sum of domestic expenditure and the trade balance in 'volume' terms, i.e. measured at constant prices. The difference between national income in purchasing power terms and GDP in volume terms arises from two factors - net external receipts or payments of income and transfers, and changes in relative prices of exports and imports (terms of trade effect). When components of the external current account and trade volumes are measured consistently, the relationship between GDP (output) and income (purchasing power) is given by an identity.

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Terms of trade and prices in world markets

Average prices of exported manufactures and services in the world as a whole tend to follow the world expenditure deflator while prices of oil and commodities are subject to large relative price fluctuations and exhibit non-stationary long-run behaviour.[5]

Such movements in relative prices have had marked effects on income and capacity to purchase imports in countries with a relatively high degree of specialisation as exporters or importers of primary commodities and energy.

These effects are captured in the CAM by the use of volume and real value measures for exports and imports in each category making it possible to distinguish the effects of trade on output and income and trace the impact of terms of trade changes on prices and price inflation relative to costs of domestic output.

Inflation and current dollar measures

The CAM includes equations for inflation and exchange rate movements that are used to derive predicted values for domestic expenditure deflators and the world expenditure deflator. Current dollar series are then generated by multiplying purchasing power measures by the relevant deflator.[6] [7]

Domestic currency inflation rates in each bloc are defined as weighted averages of percentage changes in domestic currency expenditure deflators (price inflation) for member countries and domestic currency GDP deflators (cost inflation) respectively. Given US inflation and predictions of real exchange rate movements it is straightforward to derive the world expenditure deflator and use this to calculate current dollar series for all blocs. Weighted average domestic currency inflation rates in blocs other than the USA are then used to predict weighted average nominal exchange rate changes against the dollar.

Constant dollar measures

Constant dollar series measured at base-year market exchange rates rather than purchasing parity rates are calculated by dividing each "volume" series by the base-year purchasing power parity adjustment for the bloc.

The above definitions and conversions maintain adding-up properties for series measured on different bases and to that extent provide consistent measures of current value, purchasing power and volume. The main disadvantage is that deflators representing weighted averages of prices in different countries or blocs do not necessarily give an unbiassed impression of the impact of inflation. Thus, for example, when expenditure weights change rapidly in favour of emerging low-income economies it is possible for the real exchange rate to decline simultaneously

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[5] As is well known, prices of primary commodities have tended to fall while the price of oil and other traded fuels have tended to rise.

[6] See Appendix A for a formal presentation of the relationship between CAM definitions and national accounts source data. This appendix also provides proofs of identities that relate model variables defined in constant price and constant purchasing power terms.

[7] In cases where there have been very erratic movements of market exchange rates, the rates used to derive dollar values are adjusted. The conversion rate used can be deduced by comparing series denominated in national currency units with series for the same variables denominated in US dollars.

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in all blocs as the average price of world expenditure is pulled down relative to prices in high-income regions. To put this another way, it is possible for the average price of goods and services to fall at a time when prices in each bloc are static or increasing if the share of low-cost blocs in total expenditure on goods and services increases.

Another caveat is that expenditure-weighted inflation rates in each bloc may not provide a good indication of the impact of inflation on asset values if asset positions in different countries within the bloc are not proportional to expenditure (e.g. if asset positions in countries with high inflation are much smaller than those in countries with lower inflation). The same caveat applies to nominal and real interest rates in each bloc.

Estimation of assets, liabilities and wealth

Financial flows such as savings and investment, government deficits and the external current account and capital transactions are reflected in accumulating asset and liability positions that eventually feed back into current period spending and saving decisions. Therefore in principle it is important for medium and long-term models to track the accumulation of stocks of assets and liabilities as well as year-to-year flows. This section briefly explains how time series of assets, liabilities and wealth for each bloc are constructed for use in the CAM using information from the databank together with assumptions about depreciation and holding gains and losses.

It is important to note that the core model measures financial flows and stocks of asset, liabilities and wealth in real terms (purchasing power of each year). For consistency, holding gains and losses must also be measured in real terms. In particular financial assets with fixed money values usually show a holding loss as their real value is eroded by inflation. An offsetting cash flow (asset purchase) is required to maintain real asset value.

Holding gains and losses

The difference between the change in end-year values of each asset holding and cash flows in the year is generally assumed to represent holding gains or losses.[8] Since International Financial Statistics (IFS) and other sources used to construct the CAM database do not provide data on holding gains, one or the other of the following methods is used to estimate holding gains for use in the model:

i) if corresponding cash flow series are available: holding gains = the change in end-year asset values less net acquisition (cash flow) in the year.

ii) otherwise: holding gains = prior-year asset value x valuation change where the valuation change is estimated on the basis of inflation (for assets whose values tend to be eroded by inflation) or real GDP growth (for non-replaceable capital assets - i.e. land).

[8] The exception is government investments in state enterprises and loans to the private sector and, in principle, bank loans which may be subject to large-scale write-offs. In such cases the change in end-year asset values should be equal to cash flows (net purchases or sales) plus holding gains less write-offs.

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Balance of payments capital account

The IMF's International Financial Statistics database (IFS) provides series on flows across the balance of payments capital account and on the net external position of each country, all reported in current dollars. Missing values are supplied in the CAM databank by backwards extrapolation using flows and assumptions about holding gains. Holding gains for each asset group (exchange reserves, other external assets and external liabilities) are calculated by comparing annual flows with changes in end-year positions.[9]

Asset values and holding gains are calculated relative to the global purchasing power standard to permit reconciliation of cross-border values and holding gains for the world as a whole. Asset values in terms of domestic purchasing power are obtained by dividing by the real exchange rate. Holding gains and losses relative to the domestic purchasing power standard can be calculated by making an allowance for the effect of changes in the real exchange rate on asset values brought forward.

The banking system

IFS aggregates relating to the balance sheet of the banking system in domestic currency terms are converted to current dollars in the CAM databank and missing values are interpolated or extrapolated with reference to current dollar GDP.

Real-terms balance sheets, holding gains and cash flows of the banking system are estimated for use in the model by deflating current dollar values of assets and liabilities and estimating holding gains or losses due to inflation and exchange rate changes.

In the CAM the banking system is defined to include the central bank. Assets of the banking system include exchange reserves and domestic lending. Government investment in banks (deposits and capital) is identified explicitly. The residual item, termed "deposits" in the model, includes net external liabilities of banks other than the central bank.

Government

Series for government debt are derived from GFS and other sources. Non-bank holdings of government debt are calculated by subtracting bank lending to government.

Holding gains and losses are estimated making an assumption about inflation.

Government debt is affected not only by the budget balance (net lending or borrowing) but also by asset transactions with state enterprises, banks, households and non-residents (e.g. lending to foreign governments or international institutions). Although published data are very weak in this area, the CAM makes rough estimates of the annual cash flow arising from government asset transactions and the changing net asset position.

The cash flow is calculated as a residual (equal to revenue plus borrowing less other expenditure and investment in banks). The end-year value of government

[9] In cases where imputed holding losses are implausibly large, the end-year value of assets has been revised upwards on the admittedly arbitrary assumption that the loss in any one year would not have exceeded 50% of prior-year asset value.

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investments and lending is estimated by cumulating flows with an allowance for holding losses and a conservative assumption about the minimum end-year value relative to GDP.[10] To maintain plausible results for government's net asset position it is necessary to assume substantial asset write-offs over the historical period in at least half of the blocs identified in the model.

Table 3 Estimated write-off rates for government loans and investments 1970-2008 (% p.a.)

Bloc	*Rate*	*Bloc*	*Rate*
North Europe	20.8	CIS	1.0
Central Europe	0.0	North Africa and West Asia	2.6
West Europe	0.0	South America	6.0
South Europe	2.6	Central America	8.5
East Europe	10.7	China	0.0
USA	0.0	Other East Asia	8.6
Japan	6.1	India	8.9
Other Developed	14.4	Other South Asia	8.6
East Asia High Income	29.1	Other Africa	0.0

The private sector

Remaining balance sheet items that must be estimated for the private sector are capital consumption and tangible assets as a component of wealth. Capital consumption is estimated as a fixed percentage of prior-year capital. Tangible assets are estimated by cumulating flows of investment less capital consumption with holding gains sensitive to real GDP growth.[11]

[10] In many cases it is necessary to assume high asset values in 1970 to avoid negative figures in the 1980s or 1990s when privatisation yielded substantial positive cash flows to the government account.

[11] The current version of the model assumes capital consumption equal to 3% of prior-year capital value and a 0.5% elasticity of capital value relative to real GDP. These parameter values yield plausible series for capital and wealth in all blocs but may require adjustment in the light of estimates from other sources.

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Implied ratios of capital to income in each bloc are summarised in the following table.

Table 4 Estimated ratios of capital stock to income, 1970-2008

Bloc	*Minimum*	*Mean*	*Maximum*
North Europe	4.2	4.6	4.9
Central Europe	4.4	4.7	5.0
West Europe	3.8	4.3	5.0
South Europe	4.4	4.6	5.0
East Europe	4.4	4.7	5.1
USA	3.8	4.2	4.9
Japan	4.9	5.5	5.9
Other Developed	4.2	4.6	5.0
East Asia High Income	4.1	4.6	5.1
CIS	4.7	5.8	7.7
North Africa and West Asia	3.9	4.6	6.0
South America	3.8	4.4	5.0
Central America	4.3	4.6	5.0
China	4.4	4.8	5.4
Other East Asia	3.8	4.1	5.0
India	4.0	4.3	5.0
Other South Asia	3.3	3.7	4.3
Other Africa	3.0	4.1	4.9

Wealth is estimated as the value of the capital stock plus net lending to government and net external assets.

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3. Methodology and structure of the model

Models such as the CAM are not designed to represent theory or to provide a complete account of historical data. Their primary purpose is for use in investigation of policy issues. The structure of the model and its methods of construction and operation reflect this purpose and timescales of interest as well as data availability (see Morgan and Morrison, 1999 and van den Bogaard, 1999).

The model provides a tool for investigation and learning about behaviour of the world economy and interrelationships between events in different regions through exploration of historical data, construction and modification of core variables and equations of the model and study of projections or simulations of future policies and outcomes. To the extent that the model is in some sense realistic, such activities give model users a clearer sense of magnitudes and rates of change of different phenomena and provide indications of the likely outcome of different policy interventions and norms.

Identities, behaviour and global consistency

The CAM model is regular in the sense that it uses the same basic structure of variables and equations for each bloc.[12] Differences in outcomes reflect differences in initial conditions and intercepts as well as behavioural variations incorporated in functional relationships by the use of indicator variables such as the level of income per capita.

Accounting identities provide a logical framework that constrains relationships between variables in several important ways at the bloc level including equality of expenditures and incomes, consistency of sector financial flows, accumulation of assets and liabilities and holding gains, and at the world level equality of export and import volumes and values and cross-border financial flows and assets and liabilities (see Appendix C). Recognition of the relevant identities implies many important constraints on behaviour of model variables and in so doing circumscribes possible outcomes of policies.

Remaining degrees of freedom in the model must be resolved by behavioural equations that provide approximate representations of a huge range of short and long-term real-world processes that combine to determine outcomes measured by model variables. In general the CAM uses auto-regressive equations with a structural component representing behaviour that is regarded as typical or common across countries and through time, together with constants and add factors that represent bloc-specific trends, shocks and reactive behaviour.

The main purpose of structural elements in behavioural equations is to represent interactions between model variables in the same bloc (local effects) and across blocs (spillovers). [13]

[12] The CAM is not the only world model to have this property although it goes further than most in asserting uniform values for structural coefficients.

[13] A small number of exogenous variables are included to allow specification of assumptions regarding phenomena for which time series evidence is not available (e.g. cumulation of government assets and abnormal bank write-offs).

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Values of coefficients in structural components of the equations are in most cases derived from panel estimations and are intended to allow the structure to contribute as much as possible to the explanation of differences between blocs as well as changes through time. Intercepts and residual autocorrelations may be re-estimated on recent observations for each bloc and implied residuals for the latest year may be carried forward into projections for future years.

Global consistency

In the national accounts framework flows of expenditure and output (GDP) and the trade balance or current account are jointly determined in order to maintain accounting identities.

An additional requirement in global models is that cross-border transactions and positions should balance for the world as a whole. This is achieved in the CAM by imposing proportionate adjustments on predicted values for each bloc. This scaled adjustment method may be justified on two grounds:

i) as an unbiassed method for correction of inconsistencies resulting from errors of aggregation or approximation - for example, in the reconciliation of holding gains and losses on external assets and liabilities of each bloc and the reconciliation of export and import values and volumes for most categories of trade.

ii) as a representation of the effects of competition between blocs in which shares of given totals (markets) are determined by relative advantage - for example, in the Armington model of competition in international trade which is used in the CAM to predict bilateral exports of manufactures.

Another global consistency issue is the consistency of real exchange rates predicted for each bloc. The definition of real exchange rates used in the CAM implies that the expenditure-weighted average real exchange rate for the world as a whole must be a constant.[14] This identity sets a constraint on the independent movement of real exchange rates. There is evidently a choice between specifying the real exchange rate for one bloc, e.g. the US, as a residual item, determined by changes in all other blocs, or a more symmetrical approach in which factors that might be expected to influence the real exchange rate of each bloc including the US provide an initial set of predictions, the initial predictions being subject to a uniform proportionate adjustment that enforces the identity. The latter method is preferred in the CAM on the grounds that it provides a more plausible representation of decision-making in global foreign exchange markets where position-takers must assess positive and negative factors affecting the exchange rate for each currency on a relative basis. The distributed adjustment method seems to be a better specification than one that defines outcomes for one bloc as the residual of behaviour defined explicitly for the others.

Global linkages

As shown in the diagram below, the CAM includes four types of linkage between economies of individual countries or blocs.

[14] The constant is the world average base-year purchasing power adjustment.

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World markets for primary commodities and energy

Resource endowments and long-term changes in the exploitation and use of resources imply that individual blocs tend to experience a surplus or shortfall in supply relative to domestic demand stimulating exports in the case of a surplus area or imports in the case of a deficit area. Fluctuations in the actual or expected balance between supply and demand often provoke major swings in world prices. Although it may be assumed that in the long run such price movements are eventually capable of restoring approximate balance as patterns of production and use adjust, there is little certainty about the level at which prices will stabilise. In the CAM price volatility of primary products is modelled by a demand equation and exports are assumed to be limited by availability of import markets. The world price of oil on the other hand is solved endogenously in each year so as to bring supply and demand for exports of primary energy into equilibrium.

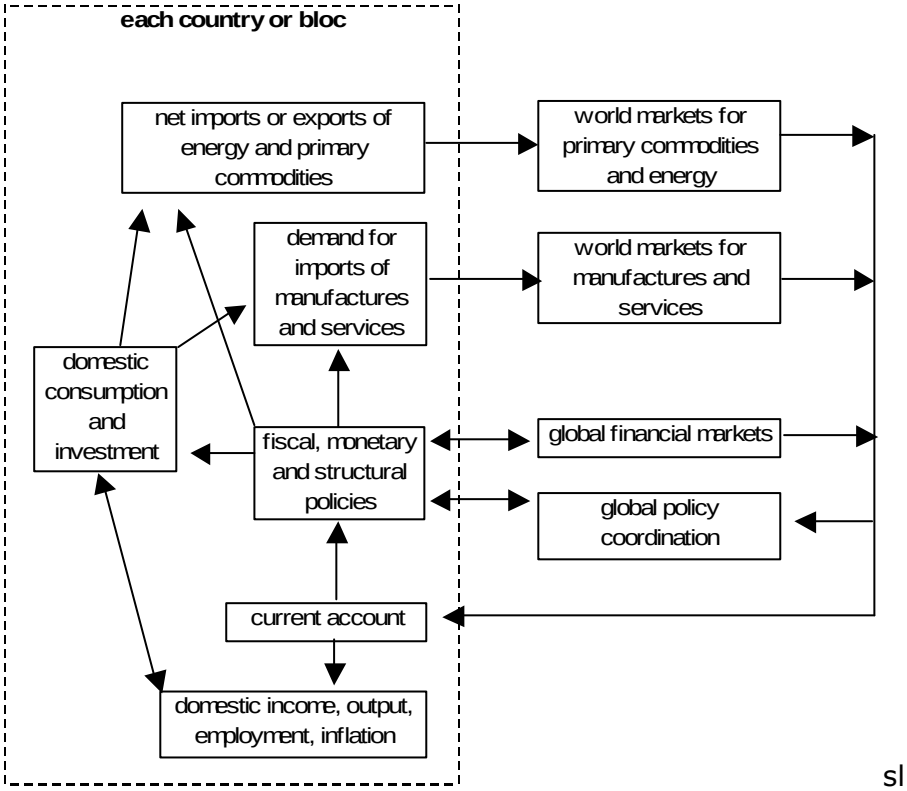

Figure 1 Global linkages

World markets for manufactures and services

World markets for manufactures and services are assumed to be demand-driven with supply-determined prices. Changes in bilateral market shares for manufactured exports represent the outcome of competition between international firms and their strategies for locating or sourcing supply. Market shares are responsive to movement of relative costs of production in different blocs.

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Global financial markets

Exchange rates in blocs with open financial systems are determined in global markets where prices respond to current and anticipated demands for each currency. In other blocs exchange rates are fixed more or less directly by the monetary authority. But despite institutional differences, longer-term considerations about the viability of exchange rates are likely to be similar in both cases. A particularly important consideration is the real or inflation-adjusted level of the exchange rate since this has a direct impact on profitability of exports and imports and therefore on trade performance and costs in each bloc.

In blocs with open financial systems the influence of global financial markets extends to interest rates, bond yields and stock prices. The monetary authority has some degree of independent influence but may not be able to move inflation-adjusted rates and returns very far from levels considered reasonable by market participants. As in the case of exchange rates, the monetary authority may be in a stronger position to fix interest rates in a less open system but is ultimately faced with similar issues to those that have to be considered by market participants in more open systems.

One important aspect of global markets is the phenomenon of 'contagion' affecting stock price indexes, bond yields and interest rates in different blocs simultaneously. When confidence factors are correlated across blocs, there is evidently a larger risk that changes in confidence will impact world trade and income on a significant scale.

International policy coordination

Many areas of public policy including, in particular, economic and financial policy are the subject of review and negotiation in a variety of global and regional forums. In addition policy-makers react to changes in the international environment with some degree of regularity. Thus there may be implicit as well as explicit coordination of policy responses, reflected in rules or norms for the conduct of policy or agreements on common action to deal with immediate problems. The CAM does not embody fixed assumptions about forms of policy coordination that have been or may in future be followed at the global level. Assumptions about policy coordination in any scenario are built onto the model by defining linked response functions where several blocs cooperate to achieve a common objective or parallel response functions where several blocs introduce similar innovations in the expectation that the combined outcome will be mutually beneficial.

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The model for each bloc

This section outlines the way in which, given the global context, bloc-level variables interact to determine the level of output, income, inflation etc. in each bloc.

Real demand, fiscal policy and the balance of payments

i) real demand is largely determined by the income of each bloc that in turn reflects domestic expenditure and critical supply factors (notably sources of primary energy) as well as external demand and prices. The level of interest rates, monetary policy interventions and financial market confidence may impact real demand but the longer-term effects of these influences are weak as compared with the effects of fiscal policy and external trade.

ii) inflation has little impact on real demand and income except in relatively extreme circumstances. In normal conditions (i.e. except in case of bottlenecks arising from critical shortage of essential inputs[15]) aggregate production tracks real demand with flexibility provided by inventories, imports and domestic margins of production capacity.

iii) fiscal policy impacts public and private spending and therefore aggregate demand, operating as a stabiliser by default. The share of disposable income taken by government does not change rapidly and tends to be somewhat higher in countries with relatively high per capita income. Government expenditure on goods and services is not closely constrained by income and the level of government debt relative to GDP varies widely.

iv) fluctuations in export earnings and the cost of imports, in particular oil and raw materials, have a direct impact on the balance of payments current account and national income. In the longer run as public and private expenditure adjust to changes in income, the current account impact diminishes and the income effect increases. Thus over a period of years it becomes evident that the distribution of income between blocs and countries is closely governed by their relative advantage or disadvantage in international trade.

Monetary policy, inflation and exchange rates

i) since the CAM lacks variables describing internal income distribution and production structure that might contribute to the explanation of inflationary episodes, inflationary pressure is related to capacity utilisation and terms of trade shifts.

ii) interest rates are typically adjusted in relation to inflation such that the real interest rate is positive but not very high.

iii) exchange rate movements have a significant impact on costs that in turn impact price-fixing and market shares of different suppliers of traded goods and services. Real exchange rate movements may change the dynamics of exports and imports, feeding into the balance of payments current account and growth of real income and demand.

[15] In such cases, high rates of inflation or hyper-inflation may occur unless demand is stringently and effectively controlled by rationing.

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iv) monetary authorities in many countries have accumulated large exchange reserves. This behaviour can be explained in part by market intervention intended to limit upward appreciation of the exchange rate in order to maintain a competitive edge in trade and in part by the desire to maintain market confidence and minimise the risk of a future currency crisis. There is little evidence that accumulation of large exchange reserves has much impact on the real exchange rate in the long run.

v) the determination of exchange rates in open exchange regimes is essentially a market process. The level of nominal and real exchange rates prevailing at any time reflects anticipations by a wide range of market participants who generate massive turnover of exchange transactions in the global market. Although exchange rates are certainly influenced by central bank intervention and by policy statements and commitments made by governments in each country, there is no simple way to model such interactions.

Matrix of stocks and flows

Financial stocks and flows for an individual bloc are summarised in the following accounting matrix. Opening stocks of assets at the top of the table are modified by flows related to income, expenditure, asset transactions, holding gains and write-offs to determine closing stocks at the bottom of the table.

External transactions and assets or liabilities suffixed with $ are converted to domestic purchasing power by dividing by the real exchange rate, rx.

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Stocks and flows for an individual bloc

Liabilities	*Expenditures and transfers*				*Assets held by*				*Total*
of	*Supply*	*Private*	*Govt*	*Foreign*	*Private*	*Govt*	*Banks*	*Foreign*	
Opening positions									
Capital					KP_{-1}				
Private						AGO_{-1}	LN_{-1}	$LX\$_{-1}/rx_{-1}$	LP_{-1}
Govt					LGO_{-1}		LGF_{-1}		LG_{-1}
Banks					DP_{-1}	AGF_{-1}			AF_{-1}
Foreign					$AXO\$_{-1}$ / rx_{-1}		$R\$_{-1}/rx_{-1}$		$AX\$_{-1}/rx_{-1}$
Total					AP_{-1}	AG_{-1}	AF_{-1}		
Final demand		C+IP+IV	G	X$/rx					F
Income									
Private	V.tt			BIT$/rx					Y
Govt		YG							YG
Foreign	M$/rx								M$/rx
Flow of funds									
Private		NLP			IP + IV	IAGO	ILN	ILX$/rx	IAP
Govt			NLG		ILGO		ILGF		IAG
Banks					IDP	IAGF			IAF
Foreign				-CA$/rx	IAXO$/rx		IR$/rx		ILX$/rx
Total	F	Y	YG	M$/rx	IAP	IAG	IAF	ILX$/rx	
Revaluations and write-offs									
Capital					KP_{-1}*(rpkp-1)-WKP				
Private						AGO_{-1} *(rpkp-1) -WAGO	LN_{-1}*(rpfa-1)-WLN	($LX\$_{-1}$ / rx_{-1}) * (rplx$-1)	HAP
Govt					LGO_{-1} *(rpfa-1)		LGF_{-1} *(rpfa-1)		HLG
Banks					DP_{-1} *(rpfa-1) -WLN	HAGF			HAF
Foreign					($AXO\$_{-1}$ /rx_{-1}) *(rpaxo$-1)		($R\$_{-1}$ /rx_{-1}) *(rpr$-1)		AX$/rx
Total					HAP	HAG	HAF	HAX	
Closing positions									
Capital					KP				
Private						AGO	LN	LX$/rx	AP
Govt					LGO		LGF		LG
Banks					DP	AGF			AF
Foreign					AXO$/rx		R$/rx		AX$/rx
Total					AP	AG	AF	LX$/rx	

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The role of policy

Variables determined by behavioural equations can be categorised in terms of their sensitivity to different types of decision-making including the potential influence of policy. CAM variables that are typically classified as policy instruments include

- monetary policy
  - interest rates
  - accumulation of exchange reserves
  - the exchange rate
  - non-bank holdings of government debt
  - government investment in the banking system
- fiscal policy
  - government expenditure on goods and services
  - government revenue (less grants, subsidies and interest payments)
  - government investment in other sectors

Other CAM variables that are mainly determined by corporate and household decisions but remain subject to a significant degree of policy influence include

- domestic expenditure
  - consumers expenditure
  - fixed investment
  - inventory changes
- energy supply and use
  - primary energy production and use
- external trade and payments
  - exports and imports of primary commodities, energy, manufactures and services
  - receipts and payments of income and transfers
  - capital flows
- inflation
  - domestic costs and prices
  - world market prices of primary commodities and oil.

The degree of government influence in these areas has ranged historically from very substantial to moderate and some cases minimal, depending on the extent of state ownership and regulation of the financial system and the economy at large.

How the influence of policy is represented in the model

Formally, all variables in the CAM are endogenous in the sense that predictions of their future values are influenced by past and current values of other variables linked

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by behavioural relationships and accounting identities. No variables are treated as entirely exogenous.[16]

Each behavioural equation embodies a structural relationship that describes the typical pattern of adjustment of the dependent variable in response to changes in other variables. Structural relationships in equations determining monetary and fiscal policy variables may be regarded as describing normal patterns of policy adjustment observed in data for the period since 1970. In the case of other variables where government policy has usually not been the primary influence, structural relationships describe normal patterns of adjustment by households and corporations.

Each behavioural equation also incorporates an exogenous component in the form of a residual which in relation to past history captures two kinds of effects: (i) the influence of "missing variables" not identified explicitly in the model, and (ii) irregular behaviour including bloc-specific trends, shocks and deviations from normal patterns of adjustment.

In the case of variables strongly determined by policy such as fiscal and monetary variables, equation residuals may be considered to represent departures from normal policy rules. The size and pattern of historical residuals in each bloc provides evidence about the degree to which deviations from normal patterns have influenced past outcomes and conditions assessments of the plausibility of future behavioural deviations.

In the case of variables less strongly determined by policy, historical residuals may indicate the influence of "confidence" or expectations as well as changes in regulatory and structural policies and indeed differences in institutions that condition reactive behaviour.

Policy assumptions and outcomes in a baseline scenario

For the purposes of policy analysis a baseline is typically a projection that assumes continuation of historical policies and behaviour into the future. Add factors are included on an ad hoc basis to capture the impact of recent or current events, anticipated near-term policy shifts and any foreseeable longer-term changes in trend.[17]

Apart from the influence of anticipated shocks or changes in trend introduced by add factors, baseline outcomes over the short and long term are driven by initial conditions (the present and recent past) and values of elasticities, propensities and intercepts (constant terms) estimated on historical data.

[16] One exception to this rule is population, currently treated as exogenous with its own auto-regressive future path.

[17] The current-year baseline incorporates add factors that align the world price of oil, GDP for each bloc in constant and current dollars as well as current accounts and exchange rates with external estimates based on the most recent data and short-term forecasts. The baseline for the first future year may include add factors to represent the effect of reported or widely-anticipated changes in investment intentions or policy innovations already in progress such as fiscal responses to the current recession. Longer-lasting add factors are introduced to represent more permanent changes in trend such as reduced growth of energy supply in the U.S. and Europe due to progressive exhaustion of accessible reserves of oil and gas.

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The main baseline typically shows the world economy going through one or two near-term cycles and converging on a steady growth path since no new shocks are introduced after current imbalances have worked through.

Alternative baselines may be constructed with different assumptions about future trends and shocks. Such alternatives may provide useful contexts for testing assumptions about governance and specific policies.

Systematic patterns of disturbance to residuals in one or more behavioural equations and blocs - usually taking the form of a cycle in which an initial wave is followed by full or partial restitution of pre-existing conditions - can be used to generate fluctuating expectations. Contagious changes in confidence may be represented by specifying linked patterns of disturbance in a number of blocs.

Longer-term baseline growth paths exhibit continuing structural changes as the balance of advantage in international trade shifts between blocs (high-income countries, emerging markets and low-income countries) and commodity groups (raw materials, energy, manufactures and services). The rate of growth of output, income and trade in the world as a whole is demand-driven in the sense that it reflects the combined outcome of decisions about consumers expenditure, investment and government spending in all blocs. In baseline projections financial institutions and production sectors are generally be expected to accommodate growth of demand in the world as a whole although specific bottlenecks may affect the growth path – for example long-term scarcity of oil and gas pushing up the cost of primary energy, or bloc-specific capacity limits or financial constraints affecting other blocs' investment and trade flows.

Baseline model closure, in the sense of adjustments to resolve imbalances within and between blocs, is distributed widely. No single variable or bloc completely determines the outcome although some variables and blocs have more influence than others.

How policy rules are specified in CAM simulations

Since the CAM has been developed as a tool for policy analysis, a range of methods are provided for specification of alternative policy scenarios.

Baseline add factors are retained in each variant scenario unless overridden by new policy assumptions specified for the scenario. Policy norms and reaction functions may be modified in each scenario in a number of ways illustrated below. In general the user can introduce policy rules that exogenize selected instruments or targets by systematic modification of add factors in behavioural equations.

In principle there are as many potential areas for policy innovation as there are behavioural equations in the model although experience indicates that the chances of successful policy innovation are not so high in all of them.

Shocks or disturbances

The simplest form of innovation that may be introduced in policy scenarios is the imposition of shocks affecting specified instruments - for example, reductions in government spending or increases in interest rates. Such shocks are imposed on an "ex ante" basis. The "ex post" result depends not only on the shocks but also on normal adjustments to the policy variable.

Linked sets of modifications may be imposed on groups of variables in the same bloc or related blocs to simulate the effects of simultaneous changes.

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Lagged adjustment rules

More complex policy behaviour may be specified by lagged adjustment rules. In this case the add factor in each year is calculated with respect to the deviation of the prior-year value of a policy objective from a target value or trajectory. The degree of adjustment in each year is specified by a multiplier.[18] The objective may be defined to be the value of another variable or it may be given as a formula such as the percentage growth rate or ratio of other variables. The target must be a pre-defined value or sequence of values, allowing the CAM program to calculate instrument adjustments on the basis of prior-year values before iterating the solution for each future year.

A group of variables may be linked to a given objective, forming a policy package. The package can combine policy variables in the same bloc or in different blocs. A multi-bloc package implies the existence of an effective coordination mechanism to define the common objective and the relative strength of policy adjustments to be made in different blocs.

Lagged adjustment rules may or may not be effective in bringing the objective near to its target value. The main risk is that if a rule has perverse effects, the gap between target and actual values may increase over time, provoking increasingly large adjustments to the policy variable. In the extreme case this may cause the model to break down before the scenario horizon is reached.

The main disadvantage of lagged adjustment in an annual model is that it implies a relatively slow response of policy to outcomes. However the policy variable remains subject to contemporaneous influences, if any such are specified by the normal policy rule.

Target-instrument rules

A target-instrument rule adjusts an instrument in such a way that the current-period value of the objective moves a specified percentage of the distance from its prior-year value to a target value. The effect is different from lagged adjustment because the policy variable is adjusted repeatedly until the objective moves the specified distance towards the target.

If the objective does not move far enough, or moves in the wrong direction the model simulation will crash. Some protection against this may be provided by setting limits on the extent to which the instrument may be adjusted (see below).

As always, adjustments to the policy variable are computed as add factors, meaning that the policy rule is imposed on top of normal behaviour of the instrument. Once again additional policy variables may be linked together to improve the prospects of moving the objective in the right direction and sufficiently close to the target.

The specified percentage movement of the objective, which we may call the "percentage achievement", may be anywhere between 0 and 100. The higher the figure, the closer the objective must come to the target. If it is 100, instruments are adjusted to whatever degree is necessary in order for the target to be reached. If the

[18] If the instrument is to be adjusted in the opposite direction to the objective the multiplier will be negative.

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percentage is zero, instrument variables are not adjusted at all and the rule has no effect.

If a high percentage achievement is specified and the simulation crashes, a lower percentage achievement may turn out to be feasible. If not, it may be better to use a lagged adjustment rule to reduce the difficulty of finding a valid solution for the current period.

In a scenario with multiple, possibly conflicting objectives, moderate percentage achievement levels may be specified for each target-instrument rule to improve feasibility of the policy mix. Such adjustments must be made on a trial-and-error basis by the person specifying the scenario.

Constraints

It is usually implausible that the value of an instrument should depart too far from values implied by normal policy rules. Therefore when policy variables are manipulated by adjusting add factors it will often make sense to impose bounds on the size of the add factors used.

The CAM provides an option to restrict add factors for policy instruments to values within a given range of probability, e.g 5% to 95%, or 1% to 99%.. The restrictions are calculated with reference to the historical distribution of residuals for the policy instrument in the relevant bloc.[19]

International spillovers

Policy rules involving fiscal and monetary policy or structural policies can be specified independently for one or two blocs without greatly changing the dynamics of the world economy as a whole. But global linkages may constrain the simultaneous achievement of targets defined independently in a large number of blocs. At this point consistency of policy rules becomes a critical issue for the world as a whole.

Spillover effects can rarely be judged unambiguously since the outcome of policies and judgement of benefits thereof depends on the global context and priority of different targets. Thus on the whole fiscal and monetary policies targetted on GDP growth may be expected to generate positive spillovers for trade partners but this would not necessarily be the case in a highly inflationary situation or one in which some countries use fiscal policy to bring down the rate of GDP growth while others need a stimulus to achieve higher growth rates. Similarly, policies targetted on reduction of inflation or trade deficits are often expected to yield negative spillovers, but there are circumstances in which the effects might not be considered negative by trading partners - e.g. partners who are themselves concerned about inflation or over-valuation of their exchange rate.

Spillover effects may be examined in the CAM by specifying independent targets and policy rules for any number of blocs. In the worst case, the targets may not be feasible and the model will not converge. Alternatively, if the targets are feasible, negative spillovers may require heavy intervention in each bloc to offset negative effects from other blocs - or in the best case with positive spillovers, required levels of intervention will come down below those that would have been required if each bloc had acted in isolation.

[19] This feature may not be implemented in the pending first delivery of CAM.

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Assuming the targets are feasible, the outcome for each bloc and scale of intervention required will be calculated by the model. Cross-border spillovers may be traced explicitly using dynamic multiplier analysis to see how variables targetted in each bloc are affected by policy adjustments in others.

International cooperation to achieve common targets

A group of blocs may agree to adjust policies in pursuit of one or more common targets. For example, the partners may seek to intervene in global exchange markets in order to keep key exchange rates near to agreed levels. In this case add factors in each bloc will be adjusted in relation to agreed target values. The relative strength of intervention in each bloc will be specified as an assumption and the intervention rule must ensure that add factors in all associated blocs move in consistent directions. The CAM will automatically calculate intervention levels required to achieve the desired result.

Other scenarios predicated on common objectives might include global cooperation to reduce emissions and mitigate climate change, improvement of living standards in low-income countries and stabilisation of financial markets and credit institutions.

The main problem with such scenarios is the assumed feasibility and efficiency of policy intervention. It is usually possible to postulate intervention rules that will adjust residuals in behavioural equations of the model to achieve the specified target but the realism of such adjustments will be open to question, especially when liberal institutional regimes restrict opportunities for policy intervention. The CAM can always be used to simulate macro-economic impacts of different patterns of burden sharing but cannot answer questions about how the required intervention could be made effective in each country or group of countries.

Conditional adjustments

CAM provides additional methods to simulate conditional changes in policy behaviour in case a target variable or function hits a specified limit. Instrument adjustments may be specified to keep the target within the limit. If and when more normal conditions return (default behaviour generates outcomes within the limit), instrument adjustments are suspended.

Examples of ceilings and floors that may trigger policy intervention include upper limits on output, capacity utilisation, government debt or external borrowing and lower bounds on variables such as the exchange-rate or exchange reserves.

Model specification, validation and simulation

The CAM model is implemented by a library of EViews programs that may readily be modified by researchers. The programs support user-defined aggregation of countries into blocs and provide graphical and tabular displays of data and results. The software includes facilities for estimating structural and stochastic parameters from the historical cross-section time-series data, displaying historical discrepancies and analysing the sensitivity of results to policy innovations and shocks (Cripps and Khurasee, 2010b). The standard sequence of operation of the programs is as follows.

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Table 5 Overview of CAM processing steps

Program	*Purpose*	*Outputs*
dat.prg	Construct historical series and compare outcomes across blocs	Analytic tables and charts of historical outcomes
est.prg	Estimate parameters of behavioural equations and check robustness and goodness of fit with historical data	Tables of estimated parameters and charts of predicted and actual values for each bloc
sola.prg	Align the model with data and estimates for the current year	Tables of residuals imposed to achieve the alignment and tables and charts of historical outcomes up to and including the current year
sol0p.prg	Check results generated by a plain projection of the model	Historical and projected outcomes
sol0.prg	Main baseline projection	Historical and projected outcomes
sol0<a>.prg	Alternative baseline projections with variant trends and shocks (stress tests)	Historical and projected outcomes, comparisons with the main baseline
solm.prg	Dynamic multiplier analysis	Multipliers and elasticities
sol<ka>.prg	Alternative policy scenarios	Historical and projected outcomes, comparisons with the relevant baseline

Estimation of behavioural equations

Estimation of behavioural equations proceeds in three stages. The first step is a review of historical data using statistical and graphical methods to check features that may determine the relevance of different assumptions about the behaviour of model variables. Functional forms resulting from this preliminary analysis are then used to define a number of econometric specifications for estimation using historical panel data.[20] Finally, implied trends and feedbacks are reviewed by generating a baseline scenario and computing dynamic multipliers to check how the model as a whole responds to shocks in the main behavioural relationships.

Panel estimation

There is a large and expanding literature on use of panel data for hypothesis testing and estimation of cointegrating relationships and dynamics in macro-economic models. Although it is widely agreed that panel data can significantly increase the power of hypothesis tests, many different estimation and testing methods have been proposed, depending on assumptions made about properties of the data sample and the underlying data generation process. Relevant methods supported directly by EViews include GLS specifications with cross-section weights or cross-section SUR (Parks estimator) and White cross-section or PCSE covariances. With additional manipulation EViews will estimate panel GMM systems. Other approaches less often used are the so-called fully modified OLS method (FMOLS) and the dynamic OLS method (DOLS).

[20] Intercepts and residual autocorrelation for some of the equations are re-estimated using a shorter data sample to ensure continuity between the recent past and the simulation period. Values of structural coefficients estimated over the full sample are retained unchanged when intercepts and autocorrelations are re-estimated.

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The most robust framework for estimation of a structural macro-model applied to multiple countries or blocs is GLS specification with appropriately dimensioned error-correction processes. One problem with this approach is that the high degree of multicollinearity of macro-economic series means that we can have little confidence in the statistical independence of global variables that might have been considered appropriate for use as instruments in a 2SLS model.[21] Other problems include the existence of "missing variables" known to have a significant influence on behaviour of model variables but for which data are not available, and the uneven quality of data for different time periods and reporting areas.

Estimation methods currently used for the CAM make the following assumptions:

1) The variance of residuals may be different for each bloc.

2) Residuals follow a common first-order autocorrelation scheme[22] and may or may not be correlated across blocs.

3) Equations may have a common intercept or bloc-specific intercepts.

4) Structural coefficients are the same for all blocs.

Each bloc-level equation is estimated using GLS estimation allowing for cross-section heteroskedasticity (cross-section weights) or additionally allowing for contemporaneous cross-section correlation of residuals (cross-section SUR).[23]

Four sets of estimates are reported for each equation (cross-section weights or SUR, common intercept or bloc-specific intercept). In most cases the specification used in the CAM is the one with bloc-specific intercepts[24] and cross-section weights. Further investigation is required to determine whether and how it is possible to benefit from the more general specification (SUR) without increasing the risk of mis-estimation due to insufficient degrees of freedom in the historical data.

The estimation program (est.prg) tabulates results of alternative schemes and generates graphs of actual vs. predicted historical values to facilitate review of the historical evidence, showing in particular which variables have shown relatively systematic or more erratic patterns and how closely model equations track actual behaviour.[25]

In a few cases coefficients estimated using historical panel data yield unsatisfactory theoretical explanations or have unacceptable implications for dynamic behaviour of

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[21] For this reason, the 2SLS option is not used in the current CAM implementation.

[22] Exploratory analysis carried out to present with several functional forms shows that bloc-specific autocorrelation may often give rise to erratic, high autocorrelation coefficients with large initial residual values for certain blocs.

[23] Standard errors of coefficients are calculated using the White cross-section method (for estimation using cross-section weights) or a cross-section method relying on the panel-corrected standard error methodology (for estimation using cross-section SUR). See chapter 37 of the EViews Users Guide II for a more detailed explanation of each method.

[24] In a few cases it has been found that specification of a common intercept is necessary to avoid projection of cumulative divergence between blocs which could not be justified on theoretical or empirical grounds.

[25] Predicted values are computed by dynamic single-equation simulation with actual values of explanatory variables other than the variable being predicted and zero residuals.

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the dependent variable or the model as a whole. In such cases the value of one or more structural coefficients is imposed to ensure behavioural responses more consistent with economic theory and historical dynamics. Cases in which coefficients are imposed are clearly indicated in the estimation program.[26]

Behaviour of the model as a whole

The purpose of the CAM is to provide a modelling capability for assessing the implications of alternative patterns of policy and their impact on different blocs within the world economy.

This requirement is somewhat different from that for a pure forecasting model. In the case of the latter, the behavioural interpretation of equations is less important than the predictive power of the system of equations taken together. The user of forecasts wants to know the likely outcome and risks attached thereto but does not expect to intervene in such a way as to change forecast outcomes.

In the case of a policy model, the behavioural interpretation of equations is crucial. When considering each equation specification it must be possible to envisage institutional descriptions of the underlying causal processes including mechanisms by which exogenous elements such as confidence and policy innovations make themselves felt.

It is also important to check that when behavioural equations estimated on historical data are used to simulate the future, the predicted responses to policy change and other important shocks or disturbances are plausible in terms of the direction, magnitude and timescale of effects. The standard checking method is to examine dynamic multiplier responses to initial shocks both in the bloc where they occur and in other blocs that may be significantly affected (see below).

Alignment with current-year estimates

Before simulations of future developments are generated the model is aligned with available data and estimates for the current year. This alignment is performed by a program (sola.prg) which sets residual terms in specified behavioural equations to align key variables such as growth of constant and current price GDP, the current account, inflation and nominal exchange rate changes with values reported or estimated in the most recent World Economic Outlook (IMF 2010).

Plausibility of the alignment procedure for each bloc is checked by generating a p-value (probability) for the size of residual adjustments based on their historical volatility.

Plain baseline projection

Before attempting to generate baseline projections that provide a useful context for policy analysis, it is important to get a clear idea of behaviour implied by a plain projection of the model with no special adjustments other than progressive phasing out of current-year residuals. If outcomes generated by the plain baseline program (sol0p.prg) are implausible, it may be necessary to modify the model itself or to impose new add factors in projections that will be used for policy analysis.

[26] The prototype version of the CAM has imposed coefficients in equations for private savings and government expenditure.

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The main baseline and variants

The main baseline incorporates user-defined add factors that represent short or long-term breaks with past behaviour including most importantly anticipated changes in trends of demography and energy supply that are not captured by the model. Variant baselines are used to examine the consequences of alternative assumptions about trends or to introduce new shocks or confidence cycles.

Dynamic multipliers

Dynamic multiplier analysis is provided by a program (solm.prg) that generates a shock to each significant behavioural equation for a user-defined list of blocs and tabulates local and global impacts up to 5 years from the initial shock.

Policy scenarios

Each combination of baseline assumptions about the world economy in general and alternative assumptions about policy intervention or regulation is specified by a separate program (sol<k>.prg or sol<k><a>.prg) where the number k designates the policy hypothesis and the letter a designates a baseline variant that provides the context for calculation of policy outcomes.

Template solution programs provided in the standard CAM software release are copied and modified as necessary to generate the scenarios. The main section of each solution program consists of a number of statements specifying policy rules that characterise the scenario. The definition of each rule includes the target (a variable or objective function), the value or sequence of values to be achieved, the instruments to be used and the strength of commitment to reach the specified target values. The syntax of policy rules and operation of solution programs are fully described in the CAM User Guide.

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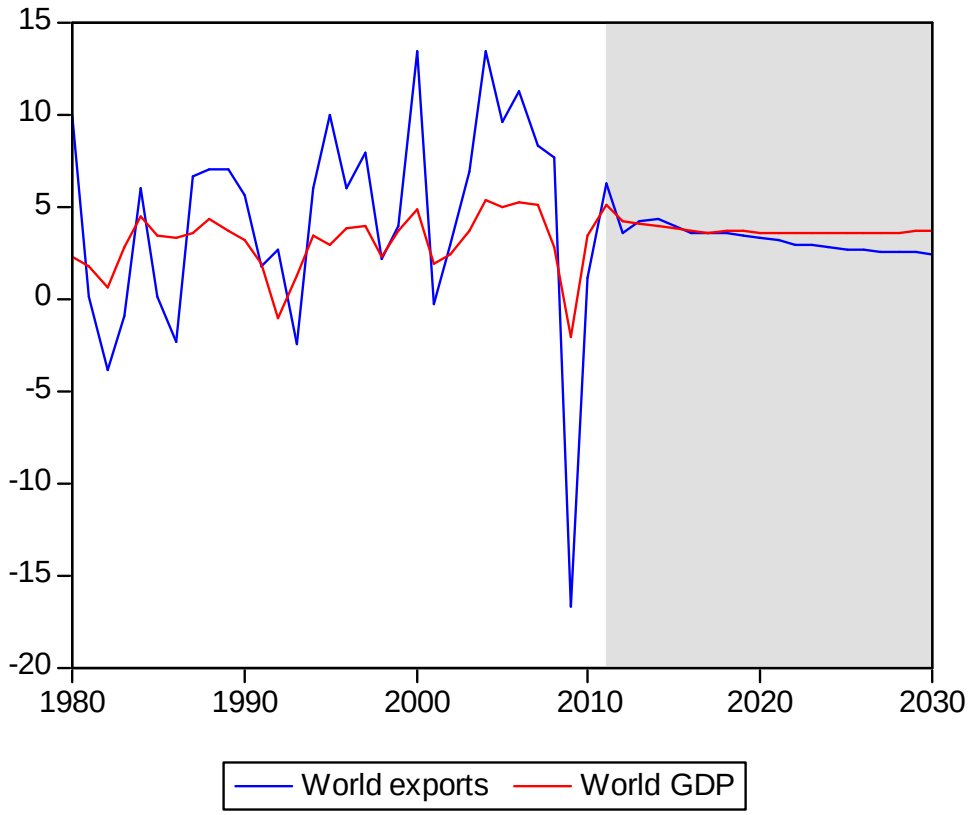
4. Historical data and baseline projections relevant to topics that are of particular interest for the AUGUR research programme

This section is intended to help readers get an impression of kinds of information that can be provided by the CAM databank and model to illuminate topics that are of particular interest for the AUGUR research programme. It must be emphasized that the historical data are subject to further checking and revision and that baseline projections may be revised substantially in response to comments and additional information provided by AUGUR teams over the next 18 months.

Trends in world trade

Growth of world exports and world GDP



World markets have grown faster than world GDP in recent decades but growth of trade may be expected to decelerate in the next decade as the effects of further liberalization are likely to be weaker than in the past and prices of internationally traded goods and services may rise relative to domestic goods and services due to higher energy and raw material prices and increased regulation in the interests of environmental and social protection.

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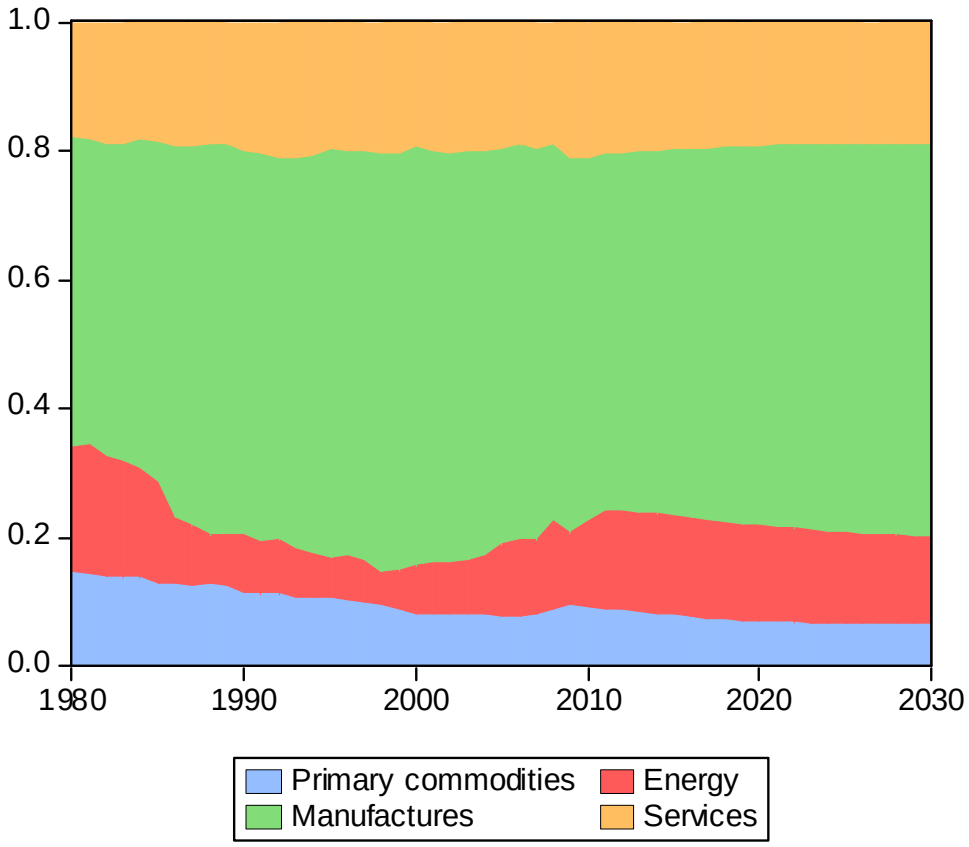
Composition of world trade



Although energy trade may account for a larger share of world exports by value than in the 1990s and current decade, the commodity composition of world trade may not change much over the next two decades. Exports of manufactures will continue to account for more than half of total trade with services accounting for less than 20% and trade in primary commodities less than 10%.

International purchasing power comparisons in recent decades confirm that low income regions of the world have much lower domestic cost levels than high income regions. This situation has been particularly evident in the current decade and is believed to be one of the factors behind the rapid growth of exports of manufactures from China and other East Asian economies.

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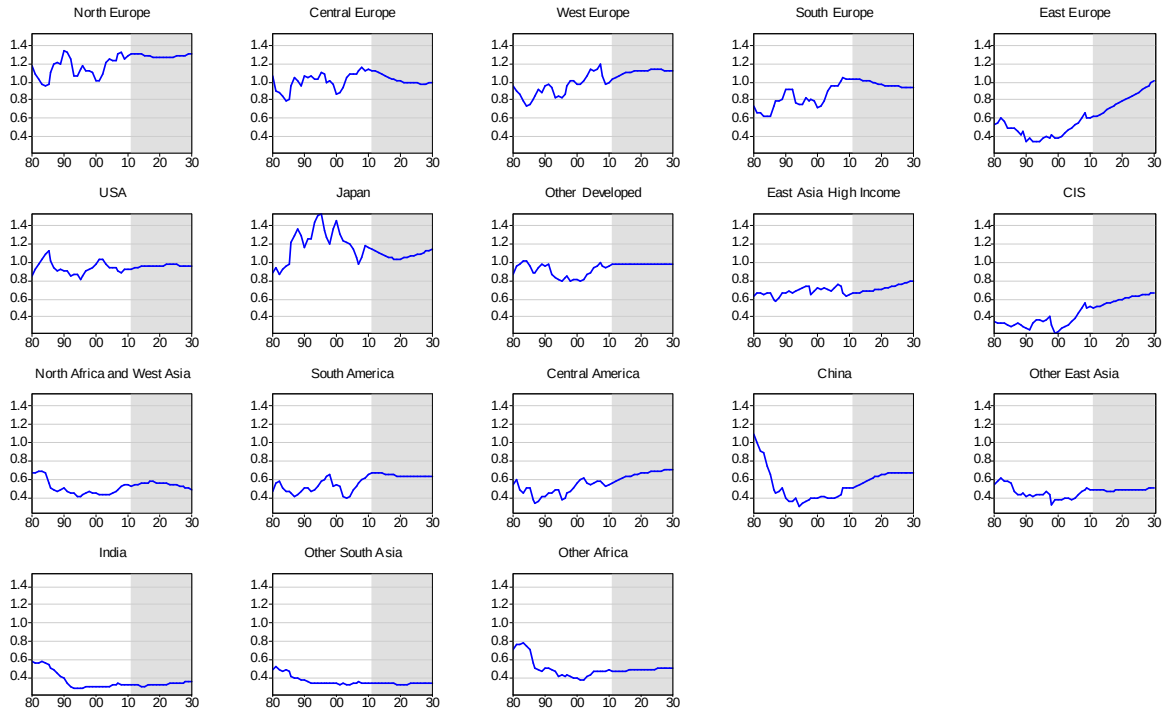
Real exchange rates



Other low and middle income regions such as countries in Africa, the Middle East, CIS and Latin America also have relatively low market exchange rates as compared with high income countries, these regions have not achieved the same degree of success in industrial exports hitherto. Competition in global markets has been very difficult for such countries to manage and their relatively weak export performance has been one of the most important factors contributing to ongoing income disparities at the global level. The CAM baseline projection portrays a situation in which real exchange rate differences persist with only minor changes through the next two decades except in the case of Eastern Europe and CIS countries whose cost levels may eventually catch up with the European average.

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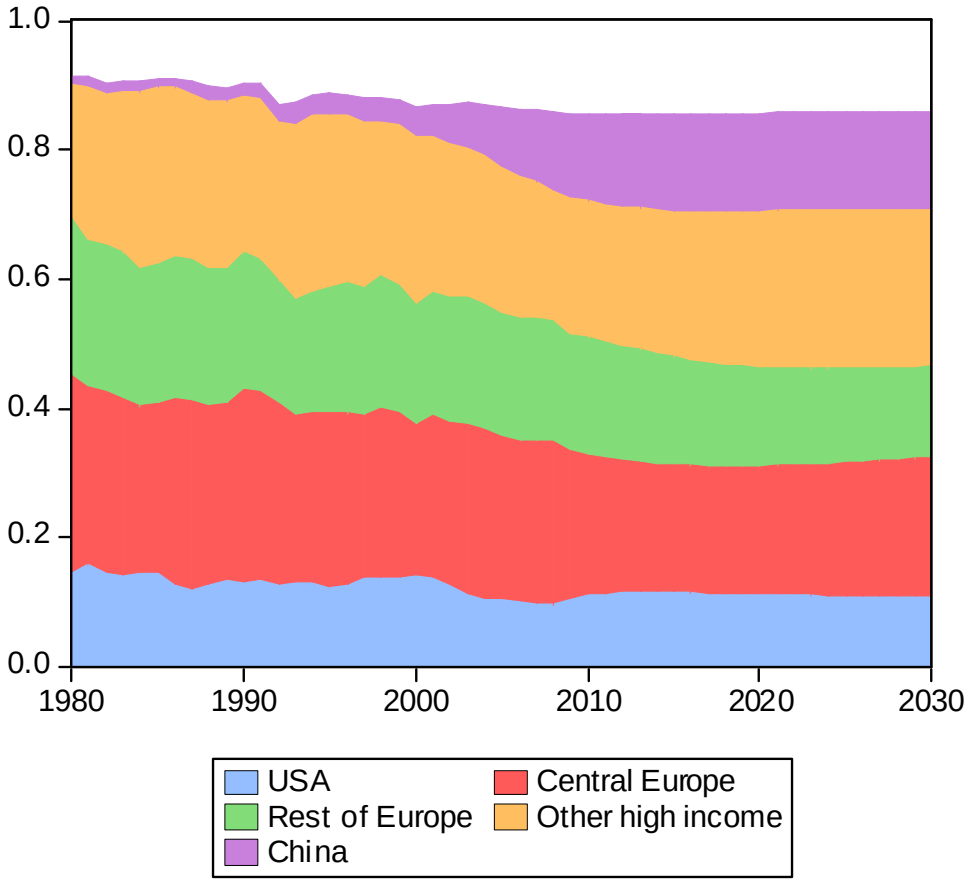
The share of high income regions and China in world exports of manufactures



The dominant position of high income countries in world trade in manufactures is confirmed by chart above. In the past two decades China has made some inroads into this position, reducing the share of high income countries from almost 90% to around 75% but the door has scarcely opened for other low and middle income regions whose combined share of world trade in manufactures may be expected to remain at around 15%. The CAM baseline implies stabilization of China's share from 2015 onwards providing some relief for Europe, the USA and other high income countries in East Asia. The share of the European periphery (North, East, South and West) is projected to decline gradually while the share of Central Europe increases.

One very crucial issue for future development of the world economy and cooperation between regions and countries with very different income levels is the question of how low and middle income countries in regions other than East Asia can acquire a larger participation in world exports of manufactures as well as imports in order to support broadly-based domestic development affording some prospect of long-term reduction in income disparities shown in table 1 at the beginning of this paper.

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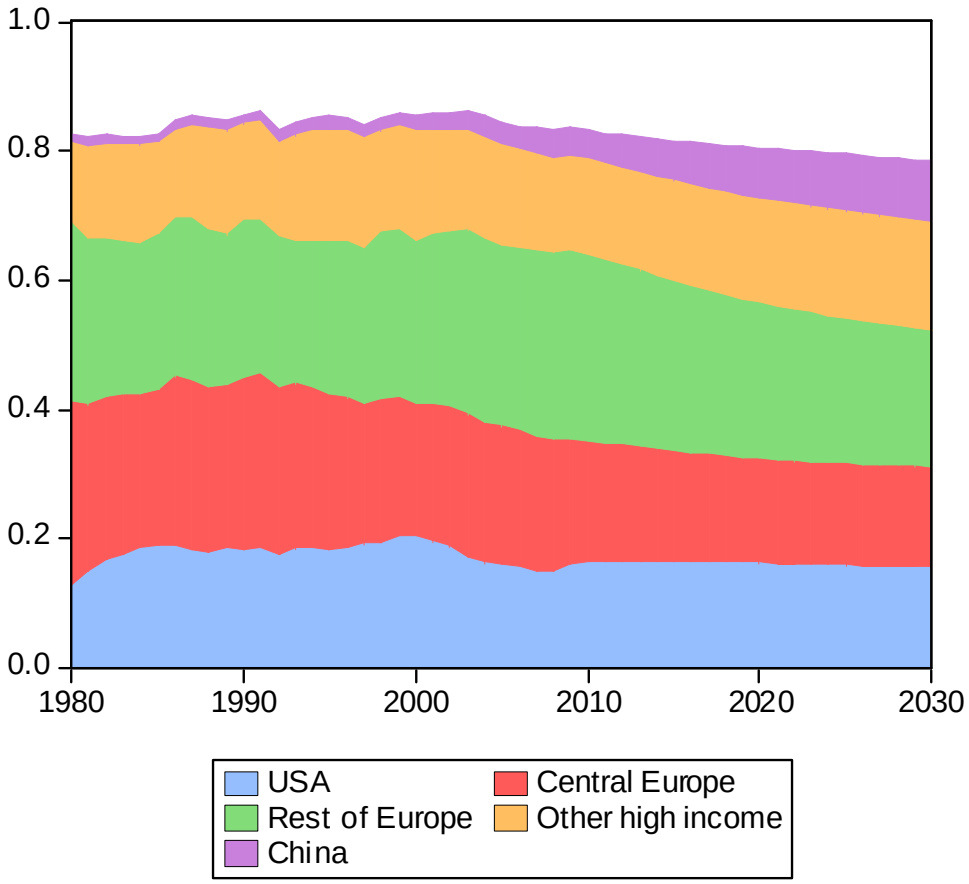
Any general evaluation of policies in this respect will depend significantly on an understanding of non-price factors in global competition. For example, if technology dominance is a key element, it may follow that partnership in technology development needs to be spread much more widely across the world in order to give low and middle income regions more opportunity to participate in global trade and improve domestic income standards.

The share of high income regions and China in world exports of services



A similar diagram for exports of services tells much the same story with the US holding a slightly stronger position (nearly 20% of the world total). The share of Europe is similar to that for manufactures. Other high income countries and China have a smaller share and the rest of the world (other low and middle income countries) has a share approaching 20% that may increase slowly in coming decades.

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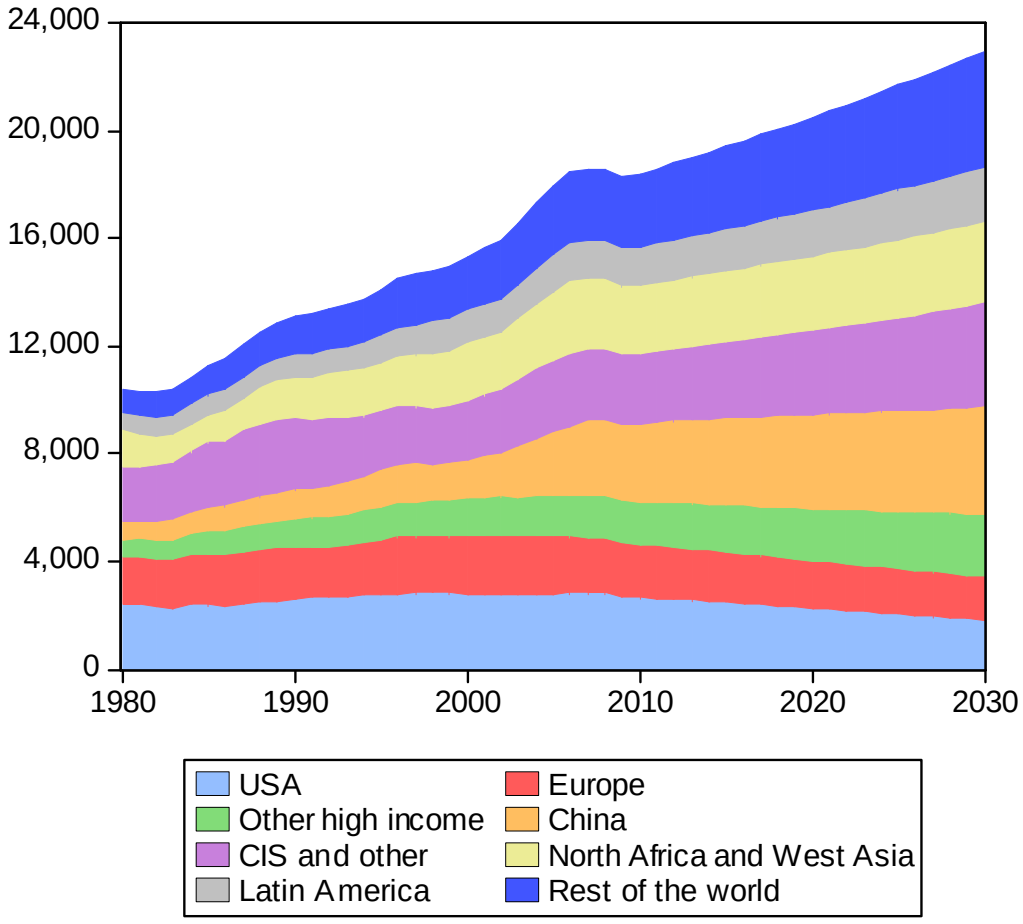
Energy supply and use

Energy resources are becoming an equalizing factor in world trade and income distribution as fuel prices rise in the long term while production in the US and Europe declines because of environmental concerns, improved efficiency and exhaustion of low-cost sources of supply. The chart below shows global production of primary energy, currently around 18.5 billion tons of oil equivalent per year, increasing to 23 billion tons by 2030. The biggest producers are China and the US, followed by the CIS and West Asia. Production in other low and middle income blocs may be expected to increase substantially over the next two decades to meet domestic demand and supply export markets.

The world's energy producers

(million tons of oil equivalent per year)



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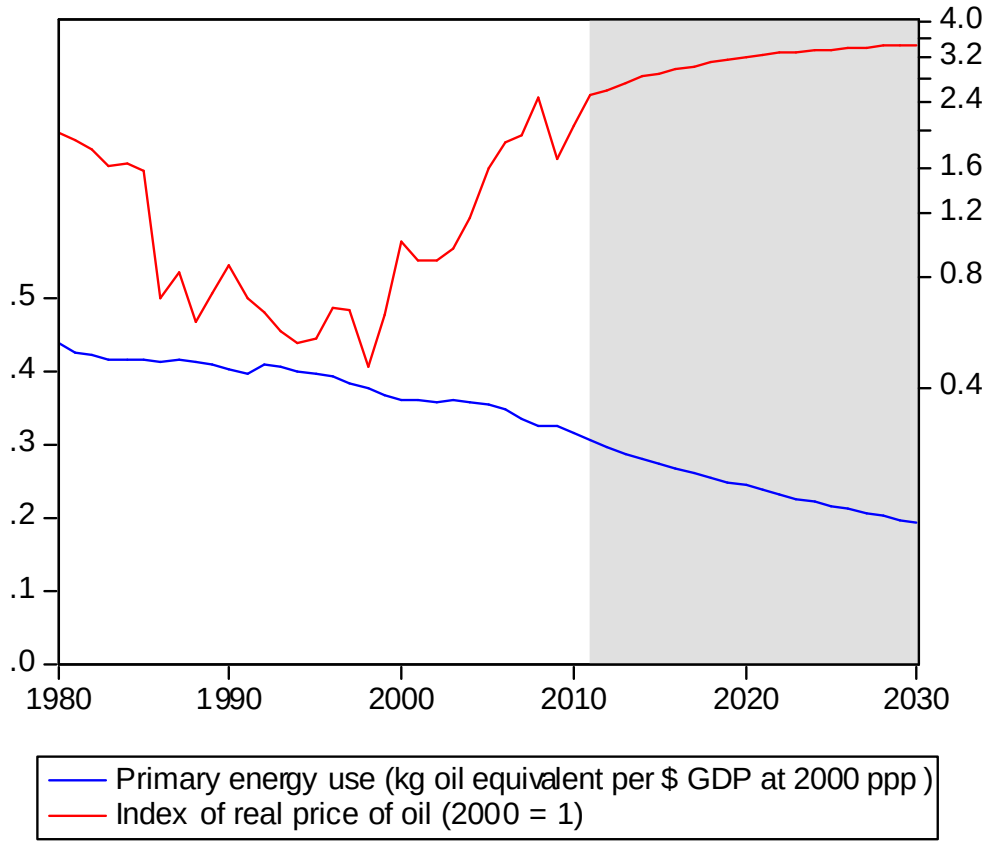
Energy efficiency and the price of oil



Primary energy production and use may grow slower than in the past due to improved efficiency so long as the price of oil remains high in real terms. Such market pressure depends in part on reduced growth of supply. The trend of increased energy efficiency may be expected in most or all blocs, especially those without extensive domestic energy resources.

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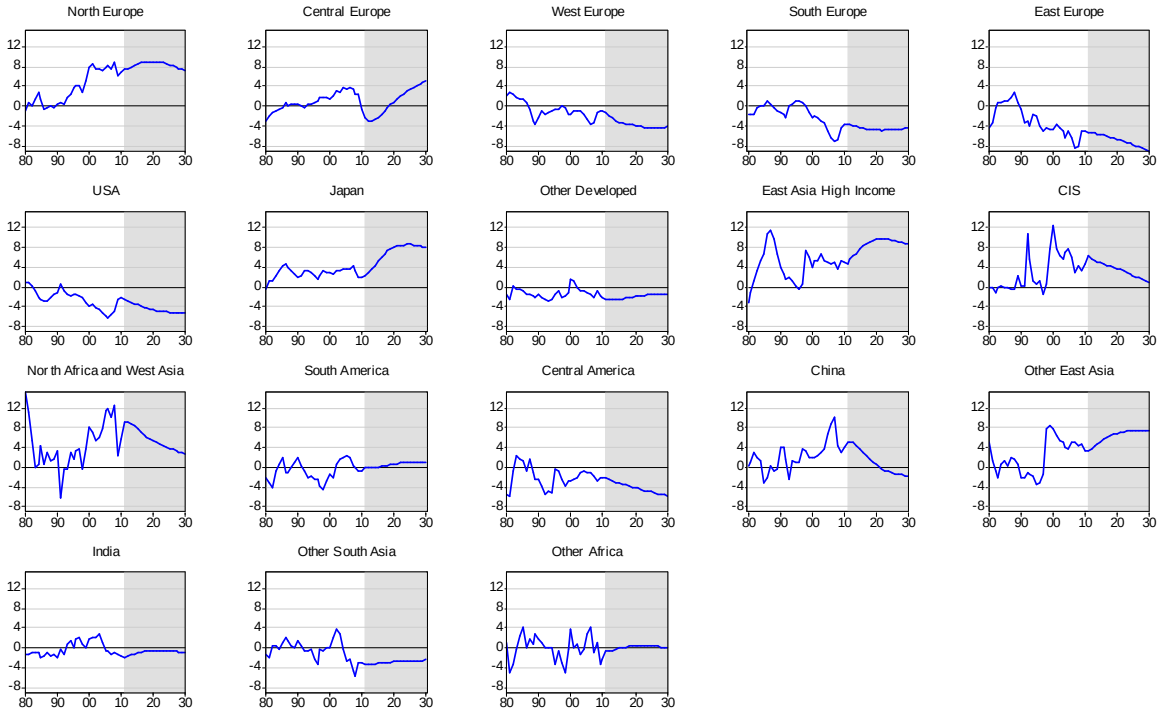
Finance

The following chart suggests that current account imbalances may continue over the next two decades on a substantial scale with Japan, other East Asian countries and energy exporters maintaining surpluses while the US and Central America as well as West, East and South Europe incur ongoing deficits. Such continuing imbalances are feasible if they can be financed by sustained capital flows without giving rise to currency crises or major issues of credit-worthiness of government and national corporations. If another wave of currency crises or credit crises comes around it is probable that deficits will be curtailed as investment falls and restrictive fiscal and monetary policies are introduced in vulnerable countries and blocs.

Current account imbalances as % of GDP



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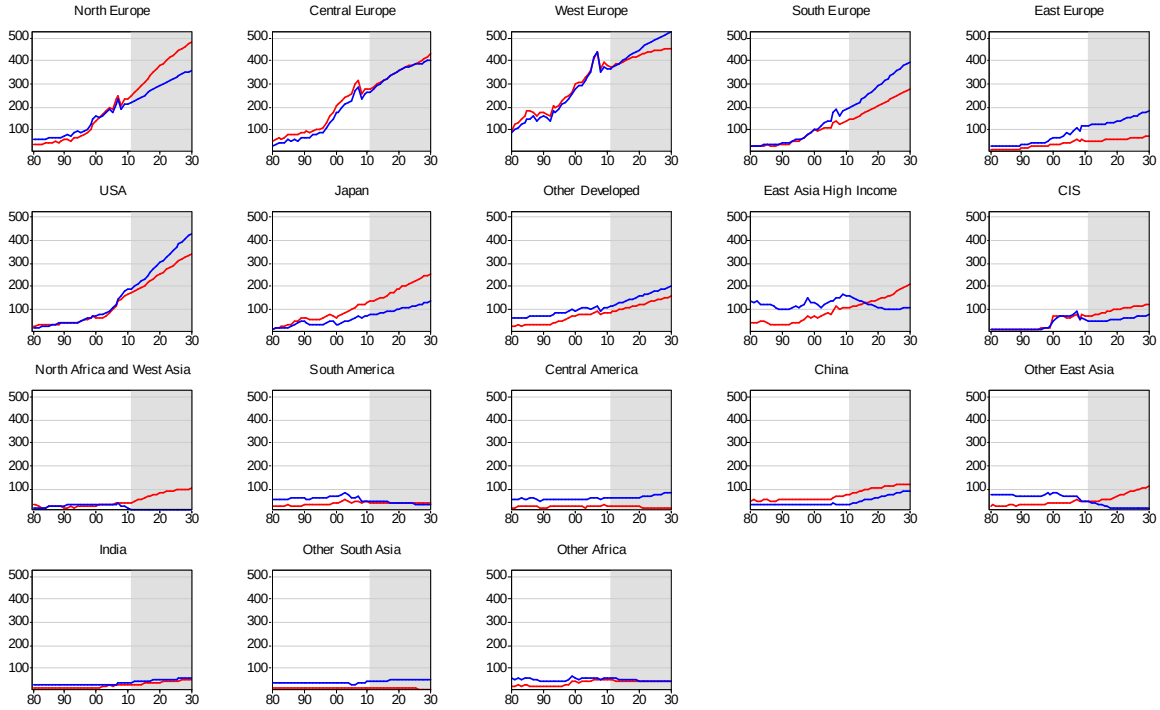
External assets and liabilities as % of GDP



External asset and liability positions in the above chart show surplus blocs accumulating net positions equal to 100% or more of annual GDP by 2030 while deficit blocs may have net liabilities of a similar magnitude. This could result in substantial net flows of income from deficit blocs to surplus blocs as shown in the next chart.

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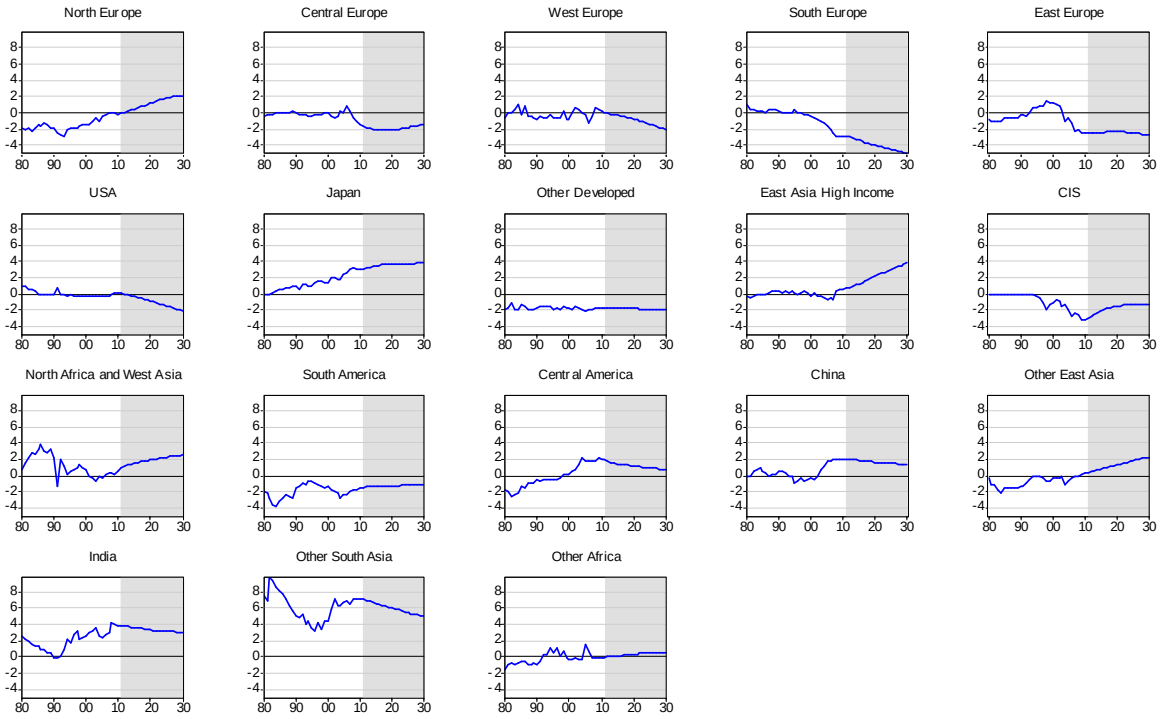
Net flow of external income and transfers as % of GDP



Japan and some other surplus blocs may receive net inflows of external income and transfers equal to 5% or more of GDP, tending to perpetuate their current account surplus and net asset position, while debtor blocs, in particular the US and East and South Europe may have net outflows of a similar order of magnitude. If this pattern is believed to imply substantial risks of financial instability policy-makers in debtor blocs may be obliged to institute measures to reduce vulnerability including exchange rate devaluation, promotion of exports and import substitutes and restrictive fiscal and monetary policies – all of which could modify the baseline significantly.

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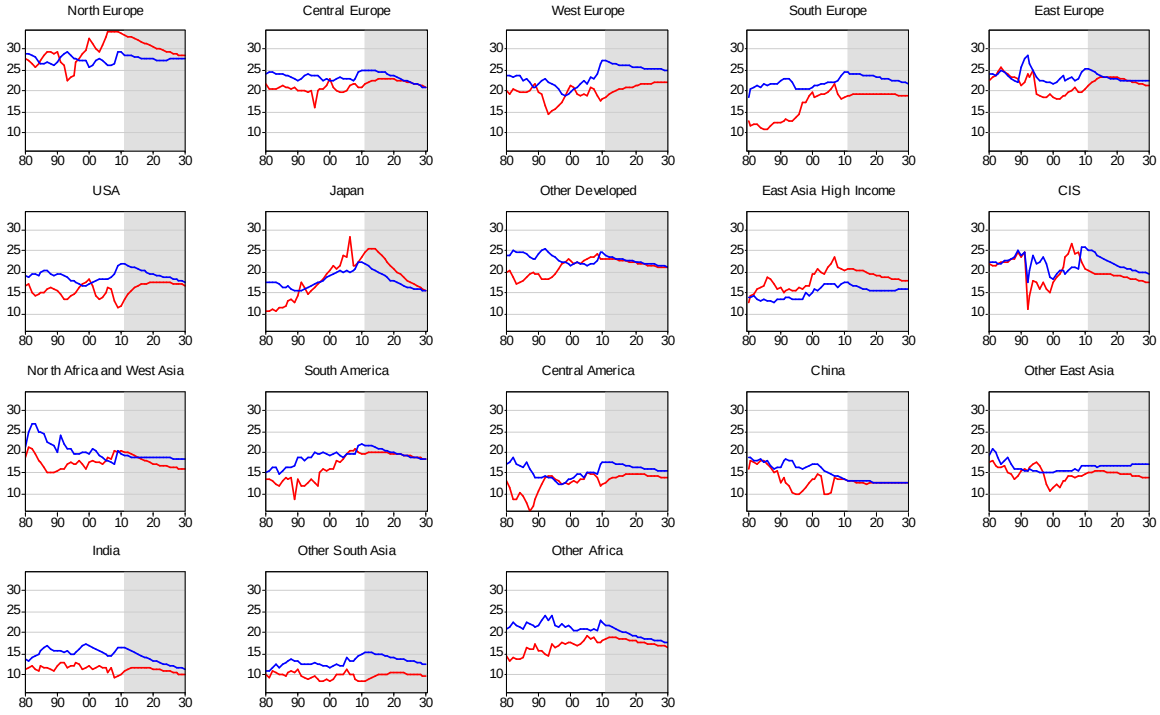
Government net revenue and expenditure on goods and services as % of GDP



The recent global financial crisis and ensuing recession has sharply increased government deficits in most blocs. As the world economy recovers from recession deficits may gradually return to more normal levels relative to GDP. Although government deficits need not be a long-term concern so long as world trade and GDP continue to expand at a reasonable pace, the accumulation of debt during and after the recent crisis needs to be examined.

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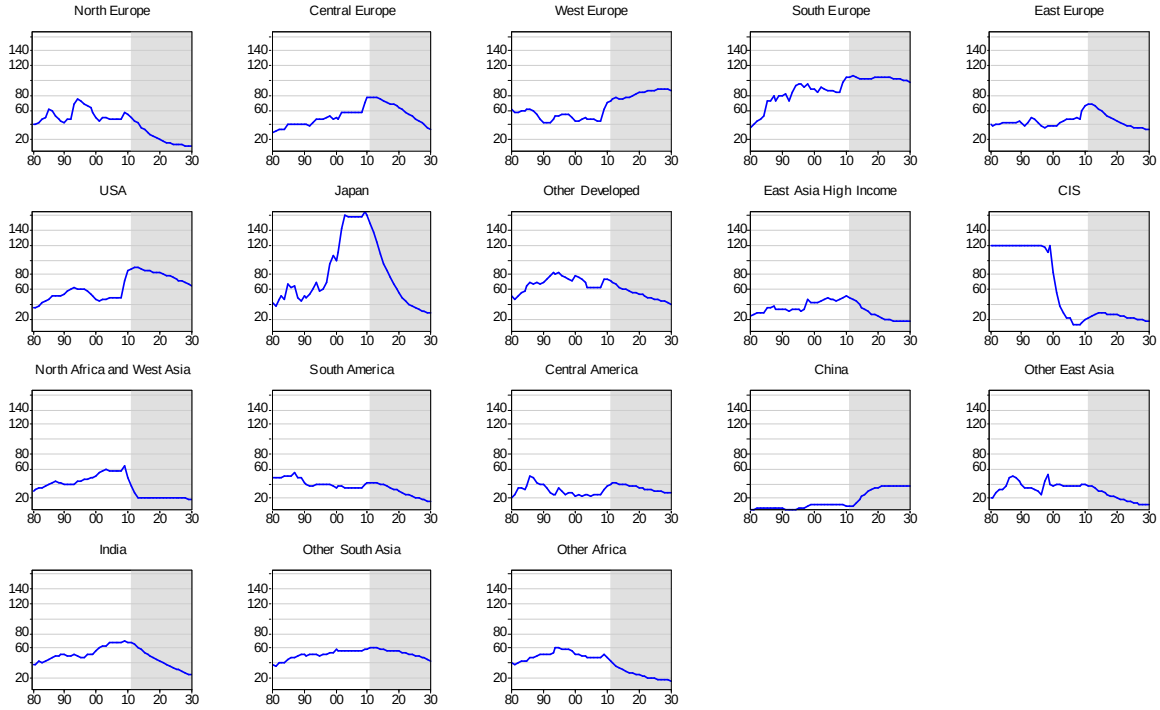
Government debt as % of GDP



The chart above suggests that the ratio of government debt to GDP will decline quite rapidly in most blocs following increases in the recession. But the ratio may remain high, between 80% and 100%, in the US and West and South Europe owing to relatively slow GDP growth in these blocs. The critical question for governments with high debt relative to GDP is the real interest rate that they pay on the debt. Although inflation could in principle bring down the debt/GDP ratio over a period of years, this remedy is unlikely to be available to local, state and national governments in the US and West and South Europe. Therefore it may be assumed that these governments will have a strong interest in the maintenance of low nominal interest rates.

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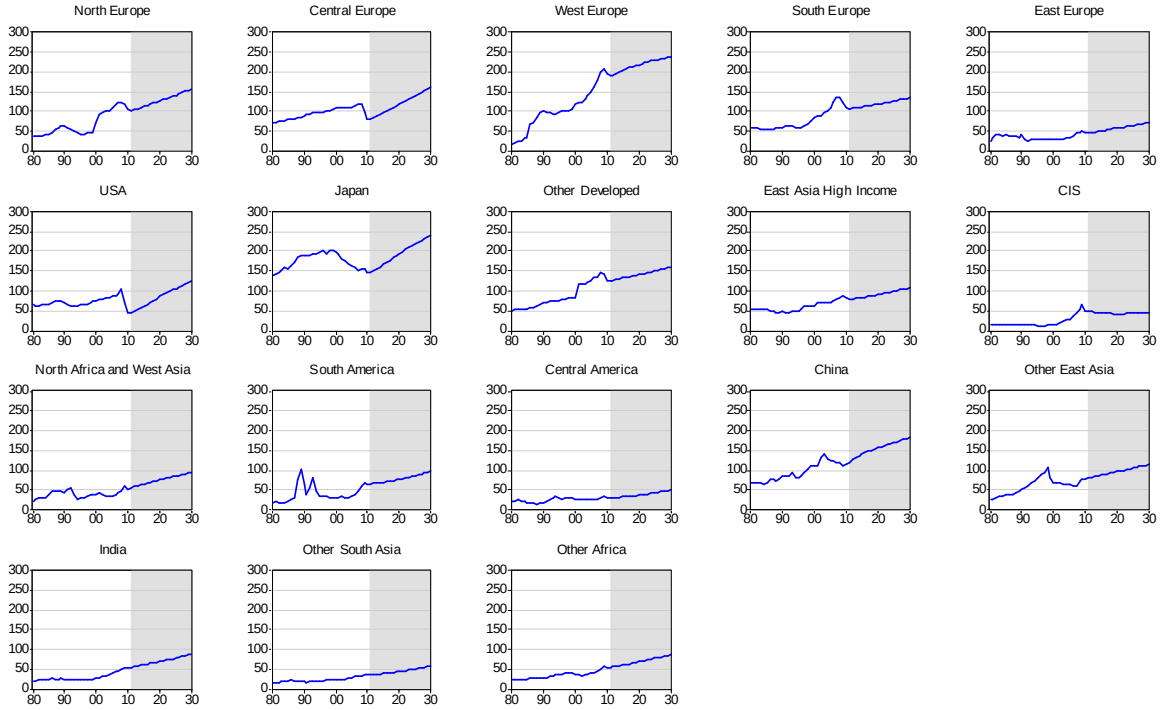
Bank lending as % of GDP



Another important issue is the role of the banking system in credit expansion which is generally considered necessary and beneficial for GDP growth but may also be a source of credit cycles that generate recessions. The baseline chart above implies continued growth of bank lending in coming decades as a percentage of annual GDP, following a reduction in many blocs during the recent crisis. Hitherto the ratio of bank lending to GDP has been less than 100% in most blocs apart from West Europe and Japan. The chart implies that the ratio may rise beyond this level in China and other parts of the developed world. It is unclear whether pressure for reform of the global financial system will reduce the trend increase in bank lending.

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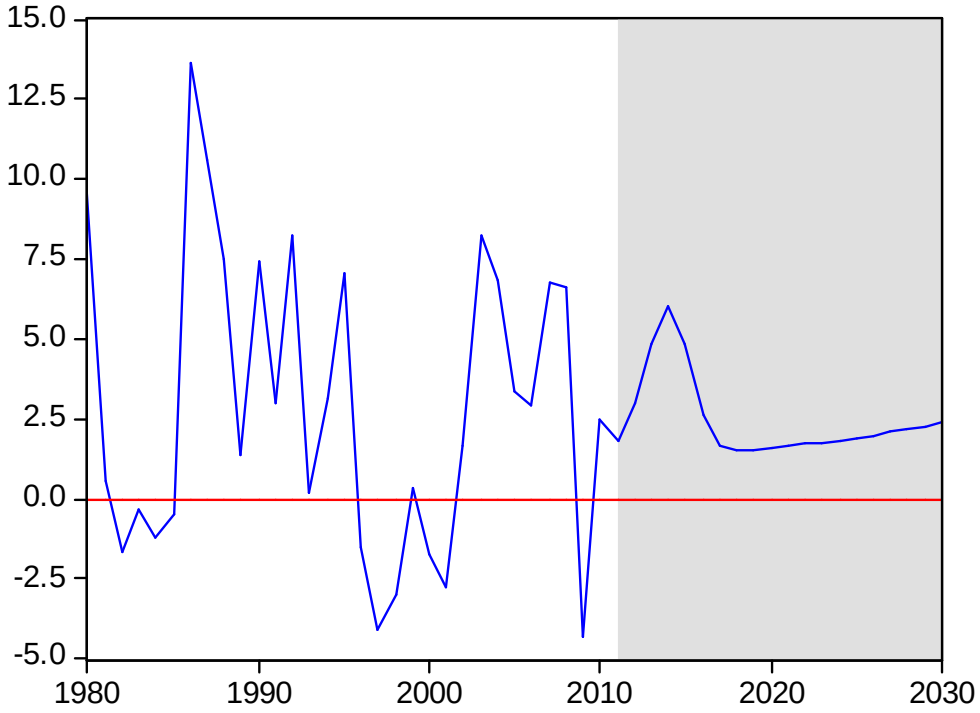
Dollar inflation (% p.a.)



Although the rate of inflation may vary widely between countries, some impression of global inflationary pressure may be given by a movements of the dollar value of world expenditure. The chart above shows significant inflation in years leading up to the current recession and suggests another wave of dollar inflation when capacity utilization peaks again as the world economy recovers from the recession. The baseline implies that there need not be much sustained inflationary pressure in the longer run even though terms of trade for oil and primary commodities may prove more robust than in the past.

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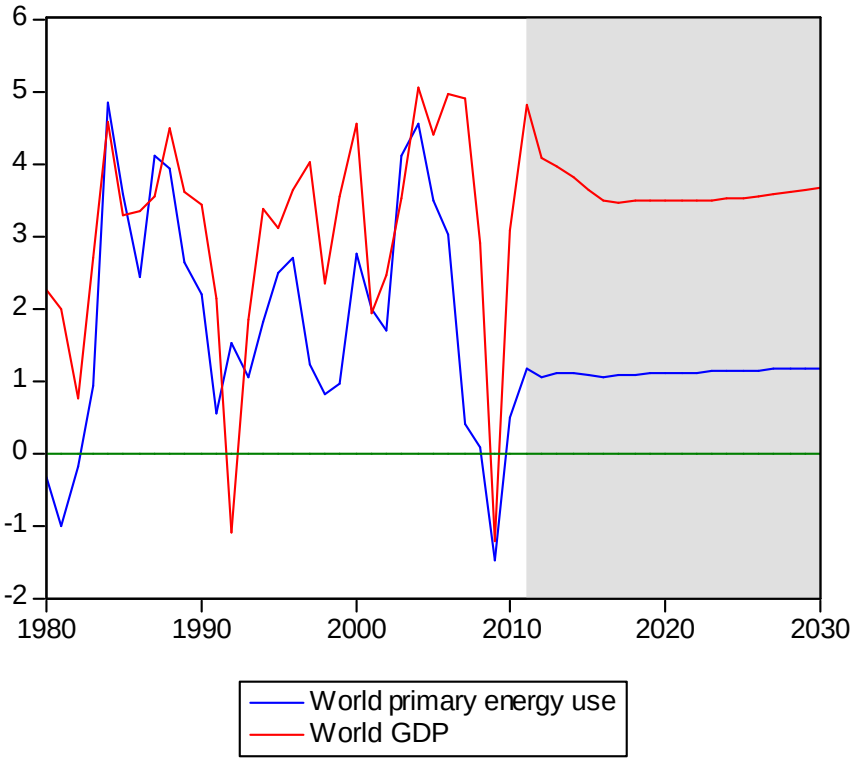
Social and environmental issues

Growth of world GDP and primary energy use (% p.a.)



Two indicators of potential environmental damage are the rate of growth of GDP and more specifically, the rate of growth of energy use. The baseline projection shows world GDP increasing quite rapidly, at around 4% per year, faster than the average growth rate in recent decades. This must imply increased pressure on local environments unless protection measures are strengthened substantially.

So far as energy supply and use is concerned, there are global, regional and local environmental risks. The average growth rate of energy use projected for the next two decades is around 1% per year. This is a lower growth rate than in the past. The main reasons for anticipating the slowdown are the high prices of oil and gas, anxiety about increased reliance on coal and nuclear energy, the potential impact of limits on greenhouse gas emissions and the high cost of adjustment to substitute energy sources, all of which may combine to make energy relatively expensive for consumers.[27]

[27] The databank and model will be expanded with assistance from CIRED to provide more information regarding the changing importance of different energy sources and associated environmental impacts.

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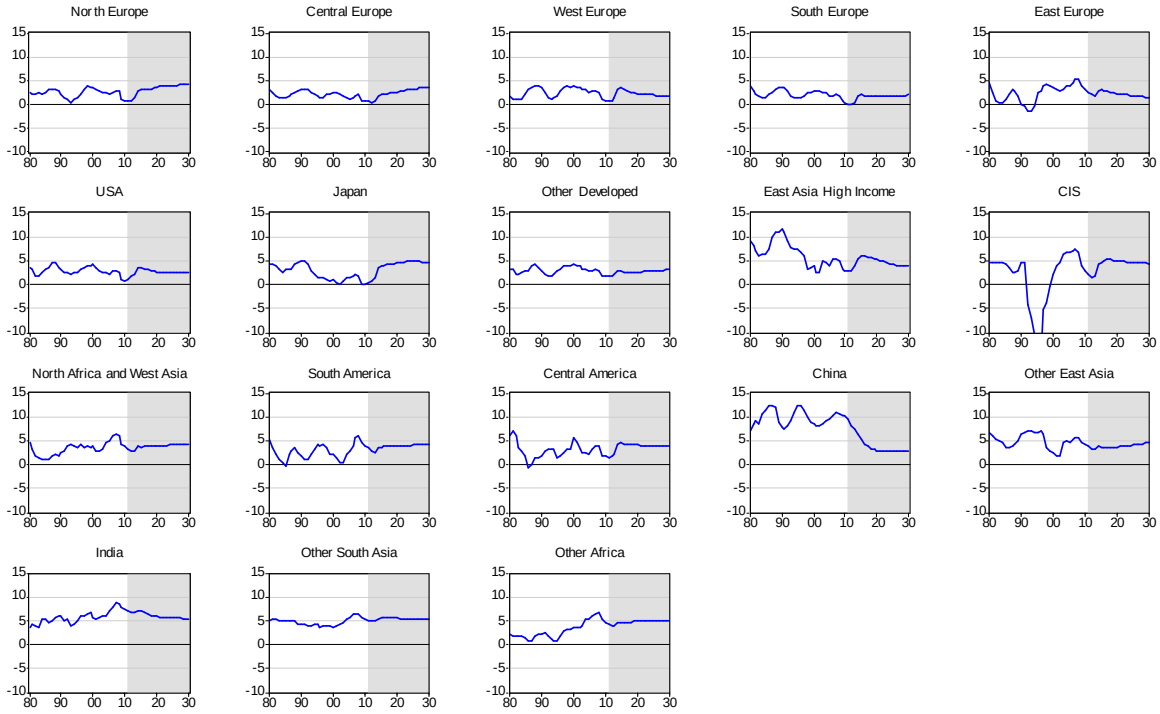
GDP growth rates by bloc, 5-year averages, % p.a.



Although GDP growth may give rise to environmental problems, it remains very important as a source of job creation, especially in service industries where employment is increasingly concentrated as automation reduces labour demand in other sectors. In most regions of the world GDP growth at a rate of 4-5% per annum or more is sufficient to stabilize or improve job opportunities and make it possible to reduce unemployment or under-employment which are among the most important causes of inequality.

The baseline projection in the chart above suggests that most regions of the world will achieve GDP growth of 4% or more in the period up to 2030 with the exception of the US and West, East and South Europe. A more detailed analysis of changes in demographic structure and activity rates is required to confirm this impression.[28]

Government expenditure on goods and services as % of GDP

[28] Additional series on demographic structure, participation and employment rates required for investigation of these topics including the impact of ageing will be added to the databank as a basis for extension of the model in this area.

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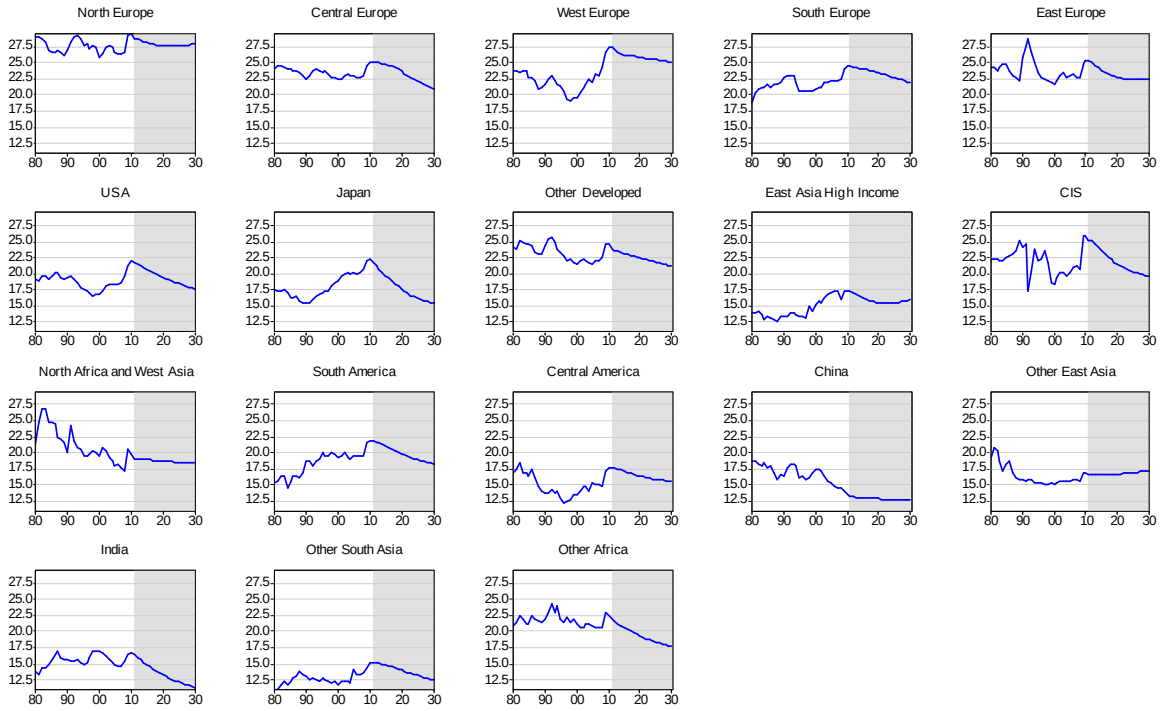

If GDP growth in high income regions is insufficient in itself to generate or maintain high participation rates, possible recourses include migration from low-growth to high-growth regions, labour market policies that favour job creation in services and redistributive measures that reduce the adverse impact of unemployment and underemployment on low-income persons and households.

There is widespread concern that intense competition for shares of world trade tends to undermine policies of environmental and social protection. Although the CAM databank and model cannot provide direct evidence on this issue, it seems likely at least that relatively high government expenditure on goods and services will be required in all parts of the world to improve environmental and social standards.

From this perspective the baseline projection showing a falling share of government expenditure in blocs with faster growth of GDP is not encouraging.

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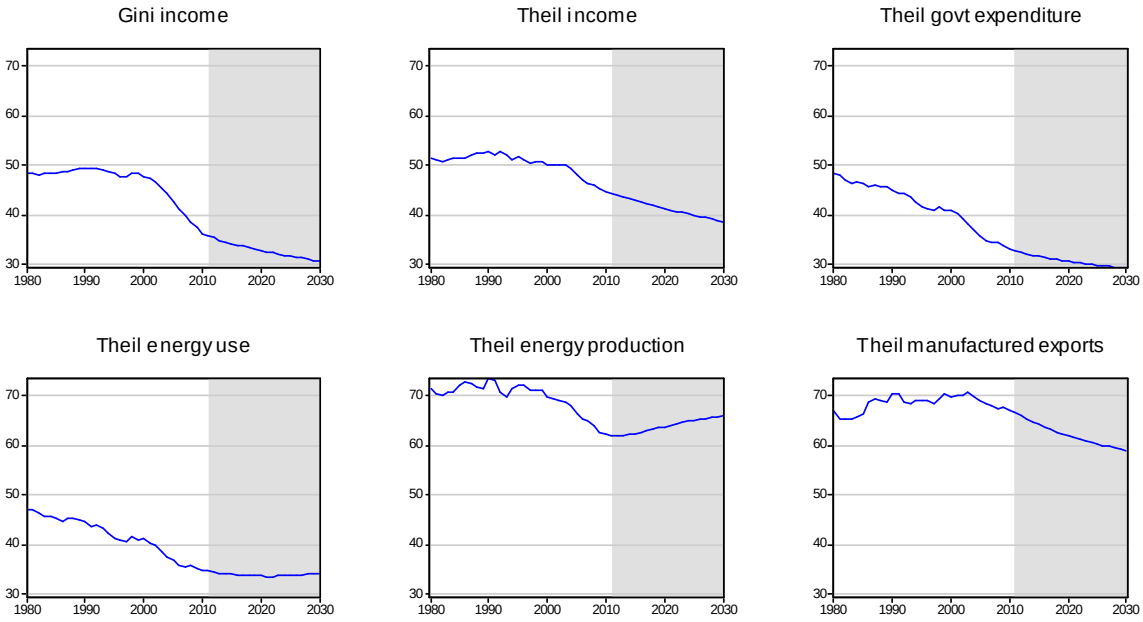
Cohesion and equality

Theil inequality measures may be used to give a broad indication of trends towards greater or lesser equality in average income and resources per capita across blocs. The charts below show significant equalization in the past decade due to rapid growth in China and East Asia. The momentum of equalization in coming decades may be much lower if there is a new trend of concentration of markets for manufactured exports.

Global inequality measures



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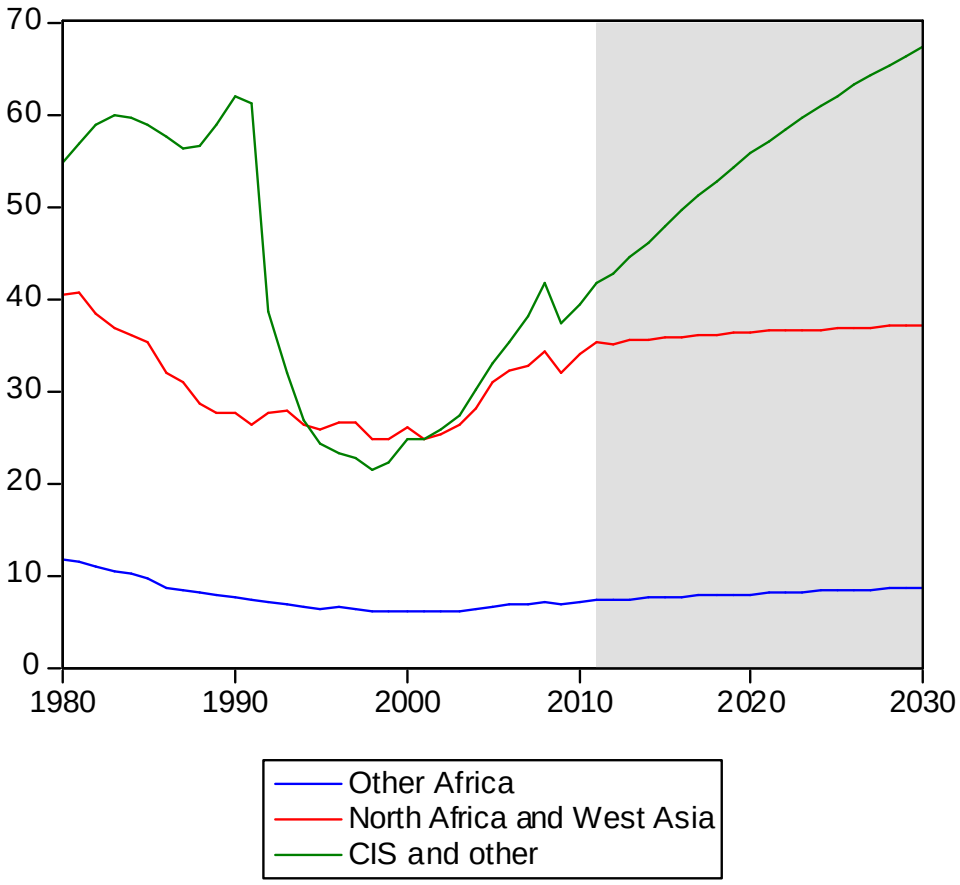
Per capita income in regions neighbouring Europe
as % of the European average



Regions neighbouring Europe have had a particularly bad experience over the past three decades as shown in the chart above. So far as the next two decades are concerned, the baseline shows average income in the CIS bloc catching up with the European average quite rapidly. But despite high energy prices, per capita incomes in North Africa and West Asia are projected to remain below 40% of the European level while average per capita income in the rest of Africa remains below 10% of the European level.

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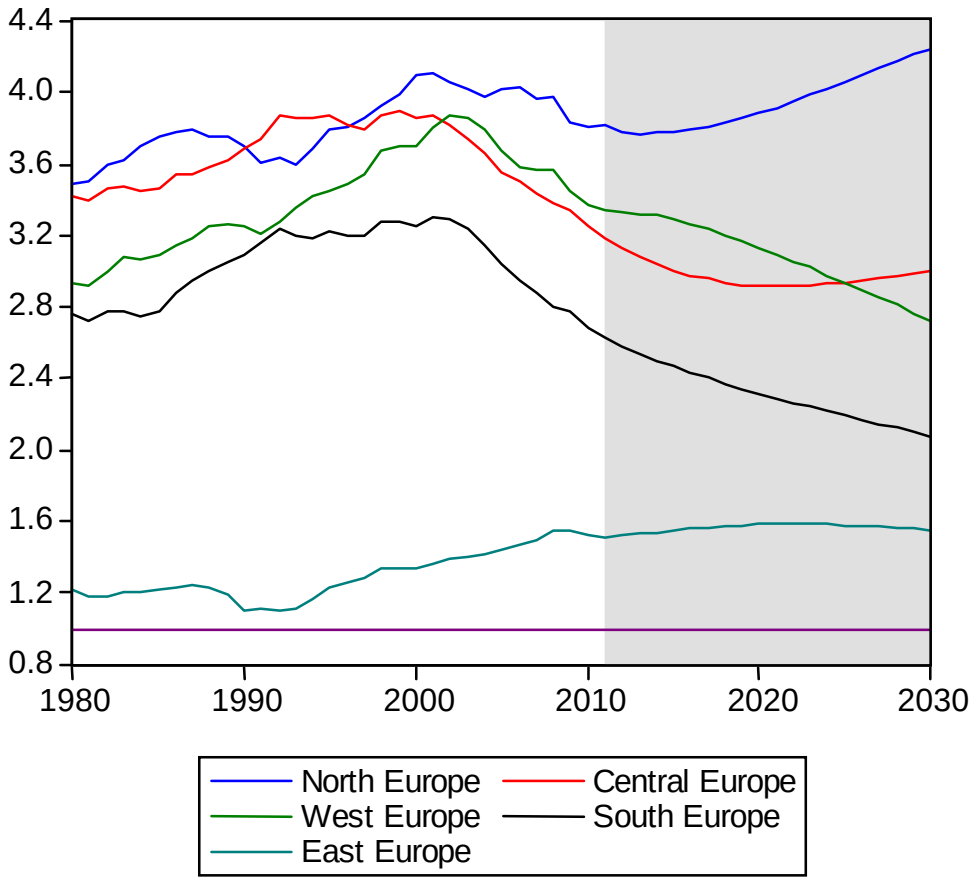
Per capita income of regions within Europe relative to the world average
(world average = 1)



Finally, reviewing average per capita income of different parts of Europe relative to the world average, the baseline projection implies growing divergence as North and Central Europe improve their position while West and South Europe fall behind and East Europe remains much poorer than other regions of Europe.

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Appendix A Notation and measurement conventions

Domestic income and expenditure

Variables measured in real terms are denoted by an upper-case symbol followed by a 2 or 3 character bloc code or **W** for the world total:

e.g. **V_JA** Japan's GDP

VW = sum(V_?) world GDP where ? denotes each bloc

GDP is measured at base-year dollar prices divided by a different base-year purchasing power parity adjustment **pp0** for each bloc. Real incomes and expenditures in each bloc are measured by dividing current dollar values by the domestic expenditure deflator for the bloc to convert the figures to base-year values and further dividing by the base-year purchasing power adjustment to make them more comparable across blocs.

It follows that current dollar values, denoted with a leading underscore, are equal to real values multiplied by the dollar price of domestic expenditure **ph** for each bloc:

e.g. **_Y_EU = ph_EU * Y_EU** income of Europe in current dollars

International trade and other external transactions

International transactions denoted by a **$** suffix are measured in terms of world purchasing power. The deflator used is the deflator for world expenditure aggregated over all blocs in purchasing power parity terms. The value of this deflator is set to 1 in the base year (2000) to facilitate comparison of **$** variables with current price series.

e.g. **X$_CN = _X_CN/phw** China's exports (international value)

The real exchange rate **rx** for each bloc is defined as the ratio betwen the local price deflator **ph** and the world price deflator **phw**. Thus international values may be converted to domestic purchasing power by dividing by the real exchange rate:

e.g. **rx_CN = ph_CN/phw** China's real exchange rate

X_CN = X$_CN/rx_CN China's exports (domestic value)

The latter figure **X_CN** represents the buying power of China's exports in terms of goods and services within China. This is considerably larger than the buying power of the same exports in terms of globally-consumed goods and services **X$_CN** which, taking an average for the world as a whole, are more expensive than in China.

Conversely the income of each bloc, normally measured in domestic purchasing power, is converted to world purchasing power by multiplying by the real exchange rate.

e.g. **Y_IN** India's income (domestic purchasing power)

Y$_IN = Y_IN * rx_IN India's income (world purchasing power)

The definitions above imply that the weighted average real exchange rate for the world as a whole is a constant (equal to the base-year value of the world expenditure deflator before the latter is set to 1). Thus with **n** blocs there are only **n-1** degrees of

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freedom for real exchange rates just as there are only **n-1** degrees of freedom for nominal exchange rates.

The 'volume' of exports and imports measured at base-year prices and exchange rates is denoted by suffix 0:

e.g. **XE0_WA** West Asia's energy exports at base-year international prices.

The contribution of West Asia's energy exports to West Asia's GDP measured in constant ppp units is given by

XE0_WA/pp0_WA

where **pp0_WA** is the base-year purchasing-power adjustment for West Asia.

World exports are equal to world imports in value and volume terms for each commodity group and for goods and services as a whole:

e.g. **XW$ = MW$ = sum(X$_?) = sum(M$_?)**
XW0 = MW0 = sum(X0_?) = sum(M0_?)
XAW$ = MAW$ = sum(XA$_?) = sum(MA$_?)
etc.

Similar identities hold for other components of balance of payments current and capital accounts and for cross-border holdings of assets and liabilities when the latter are valued in terms of the same global purchasing-power standard. But when international transactions and assets are valued in terms of their purchasing power within each country or country group, it is no longer true that totals balance out.

e.g. **CAW = sum(CA$_?/rx_?)** where **CA** represents the current account surplus (+) or deficit (-), is not equal to zero, although the same total valued in world purchasing power **CAW$ = sum(CA$_?)** is equal to zero for the world as a whole.

One implication is that when excess savings are transferred from one bloc to another, the value of the savings in terms of purchasing power in each bloc is not the same. Thus if savings are transferred from a low-income bloc where goods and services are cheap to a high-income bloc where goods and services are more expensive, the volume of expenditure foregone in the low-income bloc is greater than the volume of additional expenditure in the high-income bloc. Evidently the reverse is the case when savings are transferred from high-income to low-income blocs.

Prices and rates

Prices, rates of inflation, interest rates and exchange rates are denoted with lower-case symbols:

e.g. **pvi_EU** Europe's average local currency cost inflation rate (% p.a.)

is_EU Europe's average local ccy. short-term interest rate (% p.a.)

irsw world average 'real' short-term interest rate (% p.a.)

Values for each bloc are weighted averages of values for countries in the bloc.[29]

[29] Expenditure weights are used to average domestic price inflation and nominal interest rates across countries within each bloc. GDP weights are used to average cost inflation. Implicitly, bloc-level real interest rates are expenditure-weighted averages of rates in each country.

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Assets and liabilities

Assets and liabilities at end year are converted from current dollars to real values by dividing by the period expenditure deflator (the same deflator that is used for income and expenditure in the period). The real value of assets and liabilities may rise or fall from year to year on account of changes in their price or nominal value in the currency in which they are quoted or denominated, as well as changes in the dollar exchange rate for that currency and changes in the purchasing power of the dollar as measured by the domestic or world expenditure deflator. The valuation of assets and liabilities brought forward from the previous year is represented by a variable whose name begins with **rp**. Cash flows (net acquisition or sale) of assets are represented by a variable whose name begins with **I**.

e.g.	**LG_IN**	India's government debt at end-year
	rpfa_IN	valuation for prior-year assets
	LG_IN(-1)*rpfa_IN	value of debt brought forward
	ILG_IN	proceeds of debt issues less redemptions

End-year debt is equal to debt brought forward plus issues less redemptions:[30]

```
LG_IN = LG_IN(-1)*rpfa_IN + ILG_IN
```

External assets and liabilities are treated in a similar fashion using variable names suffixed with **$** to indicate an international value:

e.g.	**R$_JA**	Japan's exchange reserves at end year
	rpr$_JA	valuation ratio for exchange reserves brought forward
	IR$_JA	net purchases less sales of exchange reserves

Holding gains, identified explicitly for certain assets and measured in real terms, are denoted with the prefix **H**:

e.g.	**HAGF_US**	US government holding gains or losses on investment in banks

The relationship between stocks and flows may be written as

```
AGF_US = AGF_US(-1) + HAGF_US + IAGF_US
```

Actual and simulated values

Historical series (extended to include current-year estimates) are designated by the variable name and bloc code with no additional suffix. Baseline series projected into the future by the model have suffix **_0** or **_0a**. Series simulated in alternative scenarios have the relevant scenario suffix, e.g. **_1** or **_3a**.

[30] Holding gains or losses may occur on purchases and sales in the current year. Therefore the interpration of **rpfa** given here is not strictly precise. A more accurate definition would be that **(rpfa-1)** represents the ratio of holding gains and losses on current-year transactions and prior-year assets to the real value of prior-year assets at the end of the preceding year. In general the valuation **rp** is defined such that holding gains or losses **H = (rp-1)*A(-1)** where **A** represents the end-year value of an asset.

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Add factors and instruments

Values of behavioural variables simulated by the model may be influenced by add factors or instruments that modify the typical pattern of behaviour estimated on historical data. In the CAM add-factors and residuals are denoted by the variable name and bloc code with suffix **_ins**. The values of **_ins** series may be defined exogenously or modified by policy rules. The latter may create additional series suffixed with **_tar** (target values) or **_sav** (saved values of instruments).

Example: primary energy production in Europe (million tons of oil equivalent)

ED_EU	historical values and current year estimates
ED_EU_0	values in the baseline projection
ED_EU_1	values in scenario 1
ED_EU_ins	instrument (may take different values in each scenario)

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Appendix B Real values, volumes and price deflators

Series	*Description*	*Source or formula*
1. Expenditure and expenditure deflators		
APT	GDP in current dollars	databank
APT1	GDP at current purchasing power parity	databank
AXD	domestic expenditure in current dollars	databank
AXD0	domestic expenditure at Y2000 prices	databank
PXA	index of world prices for primary commodities	databank
PXE	index of world price of oil	databank
Model variables - bloc level		
pp0	base-year purchasing power parity adjustment	APT(base)/APT1(base)
H	domestic expenditure, Y2000 purchasing power	AXD0/pp0
ph	domestic expenditure deflator	AXD/H = AXD.pp0/AXD0
_H	domestic expenditure in current dollars	H.ph
Model variables - global		
HW	world expenditure, Y2000 purchasing power	sum(H)
pp0w	base-year PPP adjustment	sum(AXD(base))/sum(H(base))
phw	world expenditure deflator	sum(AXD)/(pp0w.sum(H))
paw	world price of primary commodities, Y2000 world value	PXA/phw
pew	world price of oil, Y2000 world value	PXE/phw
2. Real exchange rate, current account, national income and GDP		
APT0	GDP at Y2000 prices	databank
AXX	exports in current dollars	databank
AXX0	exports at Y2000 prices	databank
AXM	imports in current dollars	databank
AXM0	imports at Y2000 prices	databank
BCA	current account in dollars	databank
Model variables - bloc level		
rx	real exchange rate	ph/phw
CA$	current account, Y2000 world value	BCA/phw
_CA	current account in current dollars	CA$.phw
TB$	trade balance, Y2000 world value	(AXX-AXM)/phw
TB0	net exports at Y2000 prices	TB0 = AXX0-AXM0
BIT$	balance on income and transfers, Y2000 world value	CA$ - TB$
Y	national income, Y2000 purchasing power	(AXD+BCA)/ph
V	GDP, Y2000 purchasing parity	APT0/pp0
VV	Total domestic expenditure	H + TB$/rx
tt	terms of trade effect (ratio of GDP value to volume)	(H + TB$/rx)/V

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Series	*Description*	*Source or formula*
Bloc level theorems		
T1 Income, domestic expenditure and the current a/c		`H = C + IP + IV + G` `Y = H + CA$/rx`
T2 GDP, expenditure and net export volume		`V = H + TB0/pp0` `VV = H + TB$/rx`
T3 Income, GDP and the terms of trade		`Y = V.tt + BIT$/rx`
Theorem - world level		
T4 Weighted average real exchange rate		`sum(H.rx)/sum(H) = pp0w`

Proof	`H.rx = H.ph/phw`
	`= AXD.pp0w.sum(H)/sum(AXD)`
	`sum(H.rx) = pp0w.sum(H)`
		`definition of rx`
		`defns of ph and phw`
		`sum over blocs`

3. Inflation and nominal exchange rate appreciation		
APT3	GDP in domestic currency units	`(databank - internal)`
AXD3	domestic expenditure in domestic currency units	`(databank - internal)`
PPT	cost of constant dollar GDP in domestic currency units	`APT3/APT0`
PXD	price of constant dollar domestic expenditure in domestic currency units	`AXD3/AXD0`
RXN	exchange rate - dollars per domestic currency unit	`APT/APT3 = AXD/AXD3`
Model variables - bloc level		
pvi	domestic cost inflation (% p.a.)	`100(PPT/PPT(-1) - 1)`
pi	domestic price inflation (% p.a.)	`100(PXD/PXD(-1) - 1)`
rxna	nominal exchange rate appreciation (% p.a.)	`100(RXN/RXN(-1) - 1)`
Bloc level theorems		
T5 Price inflation, cost inflation and the terms of trade		`(1+pi/100) = (1+pvi/100)` `.tt(-1)/tt`

Proof	`PXD/PPT = (AXD/APT).(APT0/AXD0)`
	`= ph.V /(AXD+AXX-AXM)`
	`= V/(H + TB$/rx) = 1/tt`
		`defns of PXD, PPT and RXN`
		`defns of ph,V and APT`
		`defns of H, rx and tt`

T6 Nominal exchange rate appreciation		`(1+rxna/100) = (ph/ph(-1)` `/(1+pi/100)`
Proof	`RXN.PXD = AXD/AXD0` `= ph/pp0`	`defns of RXN, PXD` `definition of ph`
Theorem - world level		
T7 Movement of global dollar prices relative to US prices and real exchange rate movements		`phw = phw(-1)*(1+pi_us/100)` `.rx_us(-1)/rx_us`

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Appendix C Variables and identities

Note: variables with no suffix represent domestic purchasing power values, variables suffixed with **$** are measured in terms of world purchasing power, and variables suffixed with **0** denote volumes or quantities measured at base-year prices and exchange rates. Variables suffixed with **W** represent world indexes or totals.[31]

Model variables

Symbol	*Name*	*Units*	*Exogenous, behavioural or determined by identity*
AG	Total of bank deposits and capital held by government and government investment in the rest of the economy at end year	$m	AG = AGF + AGO
AGF	Bank deposits and capital held by government at end year	$m	AGF = NGI + max(NGF,0)
AGO	Government investment in the rest of the economy at end year	$m	behavioural [fiscal policy]
AXO$	Other external assets at end year (adjusted)	$m	AXO$ = AXOU$.AXOW$ / AXOUW$
AXOU$	Other external assets at end year (unadjusted)	$m	AXOU$ = NXI$ + max(NXFU$,0)
BA$	Net exports of primary commodities	$m	BA$ = XA$ - MA$
BA0	Net exports of primary commodities at base-year prices (adjusted)	$m	BA0 = XA0 - MA0
BAU0	Net exports of primary commodities at base-year prices (unadjusted)	$m	behavioural [structural policy]
BE$	Net exports of fuels	$m	BE$ = XE$- ME$
BE0	Net exports of fuels at base-year prices	$m	BE0 = XE0 - ME0
BIT$	Net income and transfers from abroad	$m	BIT$ = XIT$ - MIT$
BITU$	Net income and transfers from abroad (unadjusted)	$m	behavioural [structural policy]
BM$	Net exports of manufactures	$m	BM$ = XM$ - MM$
BM0	Net exports of manufactures at base-year prices	$m	BM0 = XM0 - MM0
BS$	Net exports of services (adjusted)	$m	BS$ = XS$ - MS$
BS0	Net exports of services at base-year prices	$m	BS0 = XS0 - MS0
BSU$	Net exports of services (unadjusted)	$m	behavioural [structural policy]
C	Consumers expenditure	$m	C = YP – SP
CA$	Current account balance of payments	$m	CA$ = TB$ + BIT$
DP	Bank deposits at end-year	$m	DP = NFI + max(NFF,0)
EB	Energy balance	mtoe	EB = EX - EM
ED	Energy demand	mtoe	behavioural [structural policy]

[31] Most variables are also available in current US dollars (variable name prefixed by _).

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Symbol	*Name*	*Units*	*Exogenous, behavioural or determined by identity*
EDW	World energy demand	mtoe	`EDW = sum(ED)`
EM	Primary energy imports	mtoe	`behavioural [trade policy]`
EP	Primary energy production	mtoe	`behavioural [structural policy]`
EPW	World energy production	mtoe	`EPW = sum(EP)`
EX	Primary energy exports	mtoe	`EX = EP + EM – ED`
G	Government expenditure	$m	`behavioural [fiscal policy]`
H	Domestic expenditure	$m	`H = C + IP + IV + G`
HAGF	Holding gain or loss on government investment in banks	$m	`HAGF = R(-1).rpr$/rx + (LN(-1)+ LGF(-1)–DP(-1)).rpfa – AGF(-1)- lnbail.LN(-1).wln.rpfa`
HDP	Holding gain or loss on other sectors' investment and deposits with banks	$m	`HDP = DP - DP(-1) – IDP`
HKP	Holding gain or loss on capital stock at end year	$m	`HKP = 0.965 (rpkp - 1).KP(-1)`
HNX	Holding gain or loss on external position	$m	`HNX = (R$(-1).rpr + AXO$(-1) .rpaxo - LX$(-1).rplx) / rx - (R$(-1)+AXO$(-1)-LX$(-1))/rx(-1)`
IAG	Government asset transactions	$m	`IAG = IAGF + IAGO`
IAGF	Government injections to banks	$m	`IAGF = AGF - AGF(-1) - HAGF`
IAGO	Other government asset transactions	$m	`IAGO = AGO - AGO.rpkp.(1-wago)`
IAXO$	Other external capital outflow	$m	`IAXO$ = ILX$ - IR$ + CA$`
IDP	Acquisition of bank deposits	$m	`IDP = IR$/rx - IN + ILGF - IAGF`
ILG	Net issues of government debt	$m	`ILG = IAG – NLG`
ILGF	Acquisition of government debt by banks	$m	`ILGF = ILG – ILGO`
ILGO	Non-bank acquisition of government debt	$m	`ILGO = LGO - LGO(-1).rpfa`
ILN	Net borrowing from banks	$m	`ILN = LN - LN(-1).rpfa.(1-wln)`
ILX$	Other external borrowing	$m	`ILX$ = LX$ - LX$(-1).rplx$`
im	Bond rate	% p.a.	`behavioural [confidence]`
IP	Private investment	$m	`behavioural [confidence]`
IR$	Net acquisition of exchange reserves	$m	`IR$ = R$ - R$(-1).rpr$`
irm	Real bond rate	% p.a.	`irm= 100((1+im/100)/(1+pi/100)-1)`
irs	Short term interest rate	% p.a.	`irs= 100((1+is/100)/(1+pi/100)-1)`
is	Short-term interest rate	% p.a.	`behavioural [monetary policy]`
IV	Change in inventories	$m	`behavioural [confidence]`
KP	Capital stock at end year	$m	`KP = 0.965 KP(-1).rpkp(-1) + IP + IV`
LG	Government debt at end year	$m	`LG = AGF – NGF`
LGF	Government debt held by banks at end year	$m	`LGF = LG – LGO`
LGO	Non-bank holdings of government debt at end year	$m	`behavioural [monetary policy]`
LN	Bank loans outstanding at end year	$m	`LN = DP – NFF`

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Symbol	*Name*	*Units*	*Exogenous, behavioural or determined by identity*
lnbail	Government bail-out losses as proportion of abnormal loan write-offs by banks	ratio	constant [assumption]
lpa	Domestic impact of world price of primary commodities	log	lpa = 0.3log(paw/rx) + 0.7lpa(-1)
lped	Demand impact of world price of oil	log	lped = 0.3 log(pew/(rx(pewmax-pew))) + 0.7 lped(-1)
lpep	Production impact of world price of oil	log	lpep = 0.15 log(pew/(rx(pewmax-pew))) + 0.85 lped(-1)
LX$	External liabilities at end year	$m	LX$ = AXOU$ - NXFU$
M$	Imports of goods and services	$m	M$ = MA$ + ME$ + MM$ + MS$
M0	Import of goods and services at base-year prices	$m	M0 = MA0 + ME0 + MM0 + MS0
MA$	Imports of primary commodities	$m	behavioural [price behaviour]
MA0	Imports of primary commodities at base-year prices (adjusted)	$m	MA0 = MAU0.XAW0/MAUW0
MAU0	Imports of primary commodities at base-year prices (unadjusted)	$m	MAU0 = XA0 - BAU0
ME$	Imports of energy products	$m	behavioural [price behaviour]
ME0	Imports of energy products at base-year	$m	behavioural [product mix]
mh	Import content of domestic expenditure	ratio	mh = M0/(pp0.H + 2.X0)
MIT$	Income paid abroad	$m	MIT$ = XITU$ - BITU$
MM$	Imports of manufactures	$m	behavioural [trade policy]
MM0	Imports of manufactures at base-year prices (adjusted)	$m	MM0 = MMU0.XMW0/MMUW0
MMU0	Imports of manufactures at base-year prices (unadjusted)	$m	behavioural [price behaviour]
MS$	Imports of services	$m	behavioural [trade policy]
MS0	Imports of services at base-year prices (adjusted)	$m	MS0 = MSU0.XSW0/MSUW0
MSU0	Imports of services at base-year prices (unadjusted)	$m	behavioural [price behaviour]
N	Population	millions	Exogenous
NFF	Bank deposits less loans at end year	$m	NFF = R$/rx + LGF + - AGF
NFI	Covered bank lending	$m	behavioural [confidence]
NGF	Government investment and deposits with banks less outstanding debt at end year	$m	NGF = NLG + AGF(-1) + HAGF – IAGO – LG(-1).rpfa
NGI	Covered government borrowing	$m	behavioural [monetary policy]
NIT$	Net income and transfers (adjusted)	$m	NIT$ = min(XIT$, MIT$)
NITU$	Net income and transfers (unadjusted)	$m	behavioural [external policy]
NLG	Government net lending	$m	NLG = YG – G
NLP	Private net lending	$m	NLP = SP - IP – IV
NX$	Net external assets	$m	NX$ = R$ + AXO$ - LX$
NXF$	Net external position at end year (excluding exchange reserves)	$m	NXF$ = AXO$ - LX$
NXI$	Covered external capital flow (excluding exchange reserve	$m	behavioural [confidence]

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Symbol	*Name*	*Units*	*Exogenous, behavioural or determined by identity*
	transactions)		
NXN$	Covered external capital flow (including exchange reserve transactions)	$m	NXN$ = min(R$ + AXO$, LX$)
paw	World price of primary commodities	index	behavioural [global markets]
paw$	World dollar price of primary commodities	index	paw$ = paw phw
pewmax	Oil price ceiling	index	constant (assumed level at which demand and supply elasticities become infinite)
pew	World price of oil	index	market-clearing price (brings EDW and EPW to equivalence)
pew$	World dollar price of oil	index	pew$ = pew phw
ph	Dollar price of domestic expenditure	ratio	ph = rx.phw
phw	World dollar price of expenditure	ratio	phw = phw(-1).(1+pi_us/100). rx_us(-1)/rx_us
pi	Domestic currency price inflation	% p.a.	pi = 100((1+pvi/100).tt(-1)/tt-1)
piw	World average domestic currency price inflation	% p.a.	piw = sum(pi.H)/HW
piw$	World dollar price inflation	% p.a.	piw$ = 100 (phw/phw(-1) - 1)
pmm$	Price of imports of manufactures	deflator	ppm$ = MM$ / MM0
pmm0	Average supplier price for imports of manufactures	deflator	ppm0 = sum(sxm*(XM$/XM0)*(XM0(-1)/XM$(-1))
pp0	Base-year ppp adjustment	ratio	Constant
pp0w	World base-year ppp adjustment	ratio	Constant
pvi	Domestic cost inflation	% p.a.	behavioural [supply, incomes policy]
pxm$	Price of exports of manufactures	index	pxm$ = XM$ / XM0
R$	Exchange reserves at end year	$m	behavioural (monetary policy)
rmlx$	Ratio of exchange reserves to imports and external liabilities	%	rmlx$ = 100 R$/(M$ + LX$)
rpax$	Valuation ratio for external assets brought forward	$m	rpax$ = rpr$ * r$(-1) + rpaxo$ * axo$(-1))/(r$(-1)+ axo$(-1))
rpaxo$	Valuation ratio for other external assets brought forward (adjusted)	$m	(AXO$-IAXO$)/AXO$(-1)
rpaxou$	Valuation ratio for other external assets brought forward (unadjusted)	$m	behavioural [price movements]
rpfa	Valuation ratio for domestic financial assets brought forward	ratio	rpfa = 1/(1+spvi) [assumption]
rpkp	Valuation ratio for capital stock brought forward	ratio	rpkp = (Y/Y(-1))^0.6 + u [assumption]
rplx$	Valuation ratio for external liabilities brought forward	ratio	behavioural [price movements]
rpr$	Valuation ratio for exchange reserves brought forward	ratio	behavioural [price movements]
rrf	Bank reserves as percent of lending	%	rrf = 100 LGF/LN
rx	Real exchange rate (adjusted)	ratio	rx = rxu pp0w.HW/sum(H.rxu)
rxna	Nominal exchange rate	% p.a.	rxna = 100((ph/ph(-1))

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Symbol	*Name*	*Units*	*Exogenous, behavioural or determined by identity*
	appreciation		/(1+pi/100)-1)
rxu	Real exchange rate (unadjusted)	ratio	behavioural [monetary policy, confidence]
SP	Private saving	$m	behavioural [confidence]
spvi	Inflation indicator	log	spvi = log(-0.718 + 3.436(1+pvi/100) /(2+pvi/100))
sxm	Market share of exports of manufactures in imports of each destination bloc (adjusted)	ratio	sxm = sxmu / sum(sxmu)
sxmm	Percent share of world exports of manufactures	%	sxmm = 100 XM$ / MMW$
sxmu	Market share of exports of manufactures in imports of each destination bloc (unadjusted)	ratio	behavioural [trade policy]
TB$	Trade balance	$m	TB$ = X$ - M$
TB0	Trade balance at base year prices	$m	TB0 = X0 - M0
tt	Terms of trade effect	ratio	tt = (H+TB$/rx) /(H+TB0/pp0)
ucx	Unit cost of exports	ratio	ucx = 2 mh M$/M0 + (rx H + X$-M$)(1–2 mh)/(pp0 V)
V0	GDP at base-year exchange rates	$m	V0 = V.pp0
V	GDP (domestic ppp)	$m	V = H + TB0/pp0
VV$	Consumption expenditure	$m	VV$ = H*rx + TB$
VV	Consumption expenditure (ppp)	$m	VV = H + TB$/rx
VN	GDP per capita	$	VN = V / N
VT	Productive capacity	$m	VT = 1.05 movav(V,6). (V/V(-6))^0.3
wago	Write-off rate for government loans and investments (excluding deposits and investment in banks)	% p.a.	exogenous [financial policy]
wln	Write-off rate for bank loans	% p.a.	exogenous [confidence]
WLNA	Lagged loan write-offs	$m	WLNA = 0.8 LN(-1).wln.rpfa + 0.2 WLNA(-1)
WP	Private wealth at end-year	ratio	WP = KP + LGO–AGO + DP–LN + (AXO$-LX$)/rx
X$	Exports of goods and services	$m	X$ = XA$ + XE$ + XM$ + XS$
X0	Exports of goods and services at base-year prices	$m	X0 = XA0 + XE0 + XM0 + XS0
XA$	Exports of primary commodities (adjusted)	$m	XA$ = XAU$.MAW$/XAUW$
XA0	Exports of primary commodities at base-year prices	$m	behavioural [trade policy]
XAU$	Exports of primary commodities (unadjusted)	$m	behavioural [price behaviour]
XE$	Exports of energy products	$m	XE$ = XEU$.MEW$/XEUW$
XE0	Exports of energy products at base- year prices (adjusted)	$m	XE0 = XEU0.MEW0/XEUW0
XEU$	Exports of energy products (unadjusted)	$m	behavioural [price behaviour]
XEU0	Exports of energy products at base- year prices (unadjusted)	$m	behavioural [product mix]

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Symbol	*Name*	*Units*	*Exogenous, behavioural or determined by identity*
XIT$	Income and transfers from abroad (adjusted)	$m	`XIT$ = XITU$.MITW$/XITUW$`
XITU$	Income and transfers from abroad (unadjusted)	$m	`XITU$ = NITU$ + max(BITU$, 0)`
XM$	Exports of manufactures	$m	`XM$ = sum(sxm MM$)`
XM0	Exports of manufactures at base-year prices	$m	`behavioural [price behaviour]`
XS$	Exports of services (adjusted)	$m	`XS$ = XSU$.MSW$/XSUW$`
XS0	Exports of services at base-year prices	$m	`behavioural [price behaviour]`
XSU$	Exports of services (unadjusted)	$m	`XSU$ = BSU$ + MS$`
Y	National income (domestic purchasing power)	$m	`Y = H + CA$/rx`
Y$	National income (international purchasing power)	$m	`Y$ = Y / rx`
YG	Government net income	$m	`behavioural [fiscal policy]`
YN	Income per capita	$m	`YN = Y / N`
YP	Private disposable income	$m	`YP = Y – YG`
YR	Relative income per capita	$m	`YR = YN / YNW`

Additional variables for policy evaluation

Variables listed below are calculated after solution of the core model. In addition to these variables, many growth rates and ratios are computed for display in graphs. Growth rates have the prefix D before the variable name and ratios have the name of the denominator after the name of the numerator.

Symbol	*Name*	*Units*	*Exogenous, behavioural or determined by identity*
GY	Population-weighted Gini coefficient for distribution of income between blocs	index	`computed on blocs in ascending sequence by income per capita`
rylow	average income of bottom quartile as a fraction of global average income	ratio	`rylow = sum(Q1,y)NW/(sum(Q1,N)YW)` where Q1 is the first quartile by population of between-bloc income distribution
TH_ED	Theil inequality coefficient for energy absorption	index	`TH_ED = 100(1-exp(-sum(ED/EDW log(N/NW))))`
TH_EP	Theil inequality coefficient for energy production	index	`TH_EP = 100(1-exp(-sum(EP/EPW log(N/NW))))`
TH_G	Theil inequality coefficient for government expenditure	index	`TH_G = 100(1-exp(-sum(G/GW log(N/NW))))`
TH_XM$	Theil inequality coefficient for exports of manufactures	index	`TH_XM$ = 100(1-exp(-sum(XM$/XMW$ log(N/NW))))`
TH_XS$	Theil inequality coefficient for exports of services	index	`TH_XS$ = 100(1-exp(-sum(XS$/XSW$ log(N/NW))))`
TH_Y	Theil inequality coefficient for income	index	`TH_Y = 100(1-exp(-sum(Y/YW log(N/NW))))`