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# THE EMERGENCE AND USE OF QUARTERLY PATTERNS

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## Abstract

*The study done by the authors and presented in this paper had as its main objective the highlighting of the main quarterly models and how they can be used. Of course, the article includes a staged presentation from the appearance of the first models, followed by their development stages. Thus, if the first models included a reduced set of equations, they gradually developed to include other elements such as the investment function, on the basis of which the exchange rate equations were developed. Variables such as consumption, income, consumer prices, employment, financial markets, international trade and more were also subsequently considered. Of course, many models have systematically supported forecasts and economic analyzes of changes in the world economy. In macroeconomic modeling that has been developing worldwide for over 60 years, almost every country has built and maintains its own national macro model. Industrialized countries have several or even several country models. Macroeconometric models have become an indispensable tool for forecasting and programming economic development, as well as for analyzing the impact of economic policy at the national and international level. This trend seems to be permanent and the applications of the models are likely to increase in number with the progress of globalization.*

**Keywords:** *quarterly patterns, macroeconomics, investment, inflation, labor force, developments in dynamics.*

**JEL Classification:** *E10, E20*

## Introduction

The Federal Reserve Bank (FRB) was the first central bank to note the need to analyze the economic situation of a country in the context of its links with the main partners of the world economy. The quarterly MCM (Multi-Country Model) model of the world economy was already built in 1976. It covered Canada, Germany, Japan, the UK, the US and the rest of the world

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(ROW) and had about 1,000 equations in total. It has been used systematically to perform policy simulations since 1979.

In the 1980s, the model equations underwent a major change, especially the investment function. The equations explaining capital flows are replaced by the exchange rate equations. Following changes in monetary policy, the detailed specification of the banking sector is abandoned, but the equations explaining interest rates are introduced instead. Estimating the equation parameters passed to ECM.

In the early 1990s, the MCM model incorporated the models of the G-7 countries and Mexico, as well as four regions, which were composed of other OECD countries, newly industrialized countries, OPEC and ROW. Research projects launched in the late 1980s aimed to build a new model in which neoclassical concepts were used more widely, assuming interactive decision-making and the more extensive application of rational expectations in specified equations.

The project consisted primarily of building a small quarterly MX3 model that covered only three countries, ie Japan, USA, West Germany and the ROW. The model had 32 equations, 11 of which were stochastic. Their feature was that they distinguished long-run relationships and clearly used rational expectations, with one-period lags introduced.

#### **Literature review**

Bardsen G. et al (2005) considered macroeconomic models, highlighting the important place of wages, prices and inflation. They also considered time series econometrics from the last twenty years. Collins D.W., Pungaliya R.S. (2017) are concerned with the refinement of Jones-type models that deal with non-linear growth and performance effects and point out that the extended models are well specified and perform well in quarterly settings where earnings management is tested. Damjanovi'c M. (2023) is concerned with providing an overview of a quarterly macroeconomic model for Slovenia (SiQM). The model follows a country version of BCE-BASE. Of course, the model aims at forecasting the Eurosystem's general macroeconomic projection exercises (BMPE) and applicability in terms of government policy. Garratt A. and others (2006) were concerned with modeling techniques for global and national economies. They had a long-term structural approach useful in generating forecasts for decision makers. McCracken M., Serena N. (2017) analyzed a quarterly frequency database at the macroeconomic level and highlighted that factor extracted from the dataset are useful for forecasting a range of macroeconomic series and also that the choice of transformation codes can contribute substantially to the accuracy of these forecasts. Rogerson

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R., Shimer R. (2011) considered macroeconomic models, which can be a framework for understanding how wage-setting processes influence aggregate labor market outcomes.

### **Data, Results and Discussion**

#### **• FRB/WORLD model**

The quarterly model was rebuilt and it was then decided that the US model and the world model would be combined into one system. Thus, a new macroeconomic FRB/WORLD model was built, in which rates and exchange rates, but also wages and prices are taken into account. Long lags are included in short-run equations accounting for wages and prices.

In the G-7 models, the parameters of the consumption and investment functions are estimated, and the models for the other countries had a simplified standard structure, where the parameters of the equations are calibrated.

Below, a DSGE type macromodel was built. This model called SIGMA is a quarterly model with 7 blocks of countries. It is largely Keynesian in the short run, but in the long run the neoclassical orientation prevails. Adaptive and rational expectations are used alternately in the model, and the parameters of the long-run equations are calibrated.

#### **• Deutsche Bundesbank's MEMMOD model**

At the end of the last century, the multinational quarterly model of the world economy called MEMMOD was built at Deutsche Bank. It covered nine countries (including the G-7) and country groups with the rest of the EU and OECD countries and the rest of the world.

It had a mixed orientation. In the country models final demand (consumption, investment) determined production and indirectly employment and imports. On the other hand, production functions are used to generate potential output and its utilization rate affecting prices.

The models had specified equations that explained the financial flows. The MEMMOD model has been used in the preparation of short-term forecasts and government policy simulations.

#### **• The GEM models**

In the mid-1980s, the UK Treasury launched a research project to build a global multinational model.

This gave rise to the world models built at NIESR and Oxford. NIESR named its model the GEM (Global Econometric Model) and maintained it jointly with the London Business School (LBS). The GEM was a quarterly model, containing large models for the G-7 countries and small models for the remaining three OECD countries.

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- **The models of the National Institute of Economic and Social Research**

Country models were basically demand oriented and had rational expectations that are mainly used to determine exchange rates. Consumer demand was dependent on real disposable income, personal wealth and interest rates. Investment demand was derived according to the profit maximization rule, assuming imperfect competition. Employment depended on output and real wages. Prices are determined by unit costs plus a markup affected by capacity utilization.

The models contained equations explaining money demand and exchange rates, and the links between the country models are mainly expressed through commodity flows. The GEM model has been used systematically in the preparation of quarterly forecasts of the world economy and numerous policy simulations.

- **The NIGEM model**

The decision was made to merge the quarterly models of the UK and world economy. Thus, a multinational model of the world economy NIGEM (National Institute Global Econometric Model) was built. The model covered all OECD countries and, in addition, nine countries (including China and Russia) and six regions. All country and country group models included at least equations explaining domestic demand, exports and imports, prices, and balance of payments components.

The models of OECD countries included the neo-Keynesian concepts of forward expectations and lags of nominal variables, making adjustment processes slow. They had blocks of equations that determined household consumption, income, and personal wealth, the production process (production functions), and blocks that explained prices and wages, budget revenues and expenditures, financial markets, and international trade. Rational expectations are fed into the equations that explain consumption, wages, and exchange rates.

The central role in the structure of the models was given to production functions, i.e. CES functions with constant returns to scale and labor-related technical progress. These are used to derive functions representing demand for factors of production and to estimate capacity utilization rates.

Producer prices are dependent on unit costs, including import prices, and markups. The CPI was determined by producer prices, import prices and unit labor costs. Real wages were assumed to result from wage bargaining, so their determinants are labor productivity and the unemployment rate and, in the short run, the difference between expected and actual inflation rates.

In the model, consumption was dependent on real disposable income and real personal wealth, consisting of financial assets and residential real estate. There was a block of equations on financial flows and financial assets.

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#### • **The MIMOSA multinational model**

The annual model MIMOSA (Macroeconomic Integrated Model for Simulation and Analysis) was built as a result of the cooperation between two French research institutions, the Center d'Etudes Prospectives et d'Informations Internationales (CEPII) and the Observatoire Français des Conjonctures Economiques (OFCE). Its authors are a special MIMOSA research team. Since 1989, the model has been used to make medium-term forecasts and analyzes of world economic developments.

The model was deeply restructured in 1994, which involved the addition of new countries. In addition to the six major countries (France, Italy, Japan, UK, USA and West Germany), the model included five groups of EU and OECD countries and seven other regions. In the industrialized countries, four sections were established, i.e., agriculture and food industry, fuel industry, manufacturing industry and other industries, and foreign trade was broken down into four commodity groups. The model thus produced was large, with about 5000 equations. Certain country models had a unified structure, those describing the six major countries had 400–500 equations, while the other country models had a smaller number of equations. The parameters of the equations in the country models are estimated using three-stage OLS, NLS, and LS.

The country models had a neo-Keynesian orientation, with fairly well-extended specifications for large countries. Consumer demand (per capita) was dependent on lagged consumption to allow for inertia, current and lagged real disposable income (per capita). It also depended on real interest rates and the rate of inflation replacing unavailable financial wealth. Consumer demand for certain groups or sections of goods was further determined by relative prices, such as investment demand for residential real estate. The labor supply was determined using the exogenous coefficients of the active population broken down by sex and age (5 groups). In the long term, their dynamics were described by a logistic function, but in the short term their changes depended linearly on the unemployment rate.

The supply sector was modeled assuming the maximization of the intertemporal profit of the enterprises. Potential industrial output was estimated using survey data, and its growth was dependent on cumulative investment. Investment demand depends on cumulative growth in output (the accelerator), the effects of technology substitution for labor (fixed capital), and cumulative real profits (i.e., profitability). Employment was determined by output, the ratio of labor costs to capital costs, the exogenous growth rate of technical progress (trend), and changes in average working time per employee.

The models are provided with simple descriptions of the processes generating budget revenues (fiscal systems) and expenditures, including social transfers.

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The country models were linked by commodity flows into four commodity groups and two service groups. Imports from the country are dependent on domestic demand, its competitiveness and capacity utilization rate. Exporting countries allocated commodity flows following the components of the international export share matrix, which was updated annually. The multinational MIMOSA system is frequently used in international economic analyses, for example to investigate the effects of fiscal and monetary expansion in Europe and/or the world economy.

• **FUGI model**

In the early 1960s, A. Onishi of Japan's SOKA University built the GEM (Global Economic Model) annual macro model system to make periodic forecasts. Initially covering 15 Asian countries, the system was expanded over the next decade to the rest of the world. Its version represented 62 countries/regions, and the total number of equations was about 37,000. This model was used in the 1980s by the UN DIESAP to prepare long-term forecasts and policy simulations of the world economy.

The economic subsystem comprised developed and developing countries as well as centrally planned economies. Developed country models were assumed to be demand-driven (potential GDP > actual GDP) and had more detailed structures. The patterns of developing countries and CEP (potential GDP < actual GDP demand) were determined. Therefore, all models had global supply and demand generating blocks. The specifications of the equations were universal, but the special properties of large countries were taken into account.

Potential output was calculated from labor productivity functions, which were dependent on capital-labour ratios, actual R&D expenditure per employee, ratios of total 5-year investment to fixed capital and energy constraints. The models explained unemployment rates and indirectly employment.

The country's GDP demand was obtained by adding final domestic demand and net exports. Consumption demand was dependent on either domestic GDP or real disposable income and short-term real interest rates. For some developing countries consumption was residual. Investment demand was largely a function of available funds and interest rates on long-term loans. Exports resulted from international trade transaction matrices.

Country models explain the major components of distributed national income, i.e. operating surplus and wage funds. The real operating surplus depended on GDP (less wage funds), interest rates, and terms of trade, and the average nominal wage depended on the CPI, labor productivity, the unemployment rate, and the share of the operating surplus in GDP.

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The models contained blocks of equations explaining the demand for money as well as interest rate systems. Public finances were included through equations that explain the revenues and expenditures of certain state budgets. An attempt has been made to explain the changes in the major components of the balance of payments and exchange rates.

The FUGI system has been used in numerous policy simulations of world economic developments, particularly in the context of the linkages between the Japanese and American economies and in forecasting.

• **The Oxford Economic Forecasting Model**

In the early 1990s, a forecasting system incorporating the OEF (Oxford Economic Forecasting) multinational quarterly model of the world economy was built in the United Kingdom. The OEF model was a medium-sized model with 780 equations, including 15 countries and 4 regions

Country models were driven by demand. Household consumer demand was dependent on real disposable income, personal wealth and interest rates. Production functions were used to derive equations explaining employment. Average real wages were driven by lagged labor productivity and unemployment rates. Prices resulted from unit costs plus a mark-up that depended on the rate of potential capacity utilization. Exchange rates were dependent on interest differentials and current account surpluses. Interest rates were largely exogenous. Equations explaining the demand for money in the major countries have been specified.

• **The multinational PRIAMO model**

In the early 1990s, the annual small multinational model of the world economy PRIAMO was built at the PROMETEIA research institution in Bologna, Italy. It was mainly designed for simulation analyzes exploring changes in the world economy with effects on the Italian economy, which could be carried out in tandem with policy simulations based on Italy's macroeconometric model.

The multinational model included 7 large OECD countries (France, Germany, Italy, Japan, Spain, United Kingdom, USA), 5 remaining OECD countries and country groups, and 8 regions covering the rest of the world. The country models were determined by demand, their structure being characteristic of the dominant dominant models. The structure was most detailed for the 7 large OECD countries, moderately detailed for the other OECD countries and simplified for the rest of the world.

In the large country models, consumer demand was dependent on real disposable income, real personal wealth, and real interest rates. Investment

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demand was driven, following the accelerator rule, by the smoothing of GDP and user costs (primarily short-term real interest rates). Final domestic demand plus net exports determined GDP demand. On the other hand, the models had equations that generated potential output using Cobb-Douglas production functions. Emerging capacity utilization rates were used to determine prices which also depend on unit labor costs and import prices.

The patterns of certain countries have been linked through transaction matrices in international trade.

• **The MC models**

This model was composed of macro models for 39 countries. Depending on their availability, either quarterly or annual data were used, the first year of the sample being basically 1960.

Unlike the US model, the other country models were specified as structural models of neo-Keynesian orientation. Lagged endogenous variables were entered into most equations as explanatory variables so that short-term and long-term impacts could be distinguished from each other. The disadvantage of this specification was that the estimates of the autoregressive coefficient were frequently extremely large and the estimates of the other parameters barely significant. The estimation process was based on the Cowles Commission methodology, assuming that deviations from the deterministic trend are stationary.

Per capita consumption demand was dependent on GDP per capita, the ratio of financial assets to potential output, the interest rate, and lagged consumption per capita. Investment demand was determined by its lagged volume, GDP (accelerator rule) and interest rate. Aggregate demand (sales) was obtained from an identity and GDP demand was generated from a stochastic equation, allowing for changes in inventories.

Employment growth is achieved in a rather complex manner. The starting point is a lagged ratio of actual to potential employment, which is calculated by dividing GDP by exogenous labor productivity. It is modified by current and lagged increases in GDP. Labor supply is obtained using the coefficients of economically active populations, being mainly dependent on real wages, and the unemployment rate is residual.

Prices are represented by the GDP deflator, being dependent on the lagged value of the deflator, import prices and the rate of capacity utilization (represented by deviations from the GDP trend).

Nominal wages are determined by the GDP deflator, labor productivity and the unemployment rate.

Export prices relative to world prices are dependent on the ratio of domestic prices to world prices. The exchange rates, estimated separately for

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the US and DM, are dependent on the ratios of domestic prices to the respective US and DM deflators and on interest rate differentials. In the country models, interest rates were endogenous.

Short-term interest rates are dependent on the growth rates of GDP deflators, the capacity utilization rate, and interest rates in the US and Germany.

Long-term interest rates were determined by their lagged values. The models also contain the equations that explain the money supply.

Import per capita was dependent on its lagged value, domestic demand per capita and relative prices, and export is generated in the system using the international trade export quota matrix. Quarterly shares are available depending on the ratios of certain countries' export prices to world prices.

#### • Other multi-year models

In the last years of the previous century, the ATLAS model was built at the Ministry of Finance in France. It was a large quarterly model that included 10 regions and had 1450 equations, of which 540 were stochastic. It has been used in forecasting and government policy simulations.

The EPA (Economic Planning Agency, Tokyo) Multinational Quarterly Model was of similar size. The EPA model covered 9 countries and 6 regions, having about 1,200 equations. It had the same goals and structure as Project LINK, but all of its country models were built to common standards developed at the University of Tsukuba.

Multinational models include 23 countries, respectively 6 regions and 3 countries and Europe as a single region and were developed at Wharton Associates and Data Resources Inc. (DRI), and at the beginning of the 21st century they merged into a single system maintained by Global Insight.

Unlike in the early 1980s, macroeconomic models are no longer the subject of disputes. The size of the model depends on the purpose it has to fulfill. Computing power has ceased to be a limiting factor. Annual models are basically large, especially if sub-models have been included. Among the quarterly models, medium-sized models predominate. Lunar models that have been built in recent years have a small number of equations, however.

The development of macroeconomic modeling activities has been neither smooth nor regular, especially in the last 10 years. In the first 25 years after macromodels began to be constructed, academic centers played a major role in developing macroeconometric modeling rules and modeling model structures. In the lead were the American centers, among which L.R. Klein and the University of Pennsylvania played the central role, followed by university centers in the UK. These centers gave birth to mainstream, demand-driven models. Initially annual and then quarterly, the models have systematically

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grown in size from several hundred to several thousand equations, along with substantial disaggregation of economic activities.

Lucas' well-known criticism has provoked extensive discussion of the role of expectations. The rational expectations conception has attracted many adherents and enriched the specifications of many macroeconomic models. However, many research institutions continued to use the concept of adaptive expectations or, alternatively, tried to apply the idea that economic agents develop systematically. It has largely been realized that knowledge of the theoretical mechanisms governing economic adjustments remains the exclusive domain of experts in large corporations. In many countries, information on the expectations of economic agents, collected from regular surveys of firms and households, is used.

In the last 20 years, international organizations, research institutes and central banks of certain countries have built many multinational models of the world economy, in which the number of countries varies from a few to several hundreds. The models have detailed structures for the large industrialized countries, but the structures for the other countries are less developed. Large models have many thousands of equations in total. The models are operational and are primarily used to run government policy simulations. In many developed countries, world economic models have absorbed their country models. This trend has been increasingly common.

The main macroeconomic models had well-developed structures. In the real sector, the models distinguished the demand sector, on the one hand, and the slowly developing supply sector, on the other hand, as well as the financial flows sector. This framework has recently characterized many macro-models of developed countries and newly constructed models of developing countries and is maintained for several reasons. It facilitates sectoral disaggregation, linking patterns, expanding the supply sector to include the endogenous effects of technological progress and, last but not least, ecological ones.

DSGE models were and are mainly developed at central bank research centers because banks are interested in their possible applications for investigating the impact of monetary and fiscal policy. The structure of the models has become special, somewhat different from that which characterizes the mainstream models. In the manufacturing sector, flows of domestic and imported goods are clearly distinguished. Therefore, the production of intermediate goods is distinguished, that is, domestic production is explained by the production functions and the production of final goods, which cover the flows of domestic and imported goods to end users. Domestic production is often broken down into protected industries and those open to foreign competition.

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In the models, the demand equations following the neo-Keynesian approach induce nominal rigidities. Consumption functions usually include lags (the Brown effect), as do investment functions, taking into account the impact of adjustment costs.

The specification process based on theoretical assumptions usually led to parameter calibration in the long-run equations, less often in the short-run equations. The latter have been estimated mostly with ECM and more recently with Bayesian methods. This opened new perspectives for the applications of this class of estimation methods.

The development of macro-modeling activities associated with the use of DSGE models raised hopes for the revival of activities in academic centers.

The new trends developed in estimation theory, which are based on methods from time series analysis to cointegration analysis of economic relations, have evoked the revival of modeling activities in academic centers. In applications, they have been limited to the construction and analysis of systems of small equations describing relatively isolated economic relationships. They have been applied mainly to systems exhibiting inflationary dynamics. Therefore, attempts to use this methodology in macroeconometric modeling have been rare and limited to money market analyses. The authors of the models expressed hopes that suitable sub-models of other economic sectors can be built in the future and integrated into an extended system representing the national economy as a whole.

### **Conclusions**

Some conclusions can be drawn from this study. First, the large number of countries and regions made the MIMOSA model one of the largest multinational models of the world economy. The model represented a neo-Keynesian orientation. The models of the six largest countries had detailed and extended structures, while the other country models had a simplified structure.

Another conclusion is that in some models that included the price system, value-added deflators played a decisive role, so that there is a dependence on unit labor costs modified by variations in capacity utilization rates or changes in debt service. In these models, the wage equations are specified using an extended Phillips curve approach in that the rate of wage growth depended on the lagged rate of inflation and the unemployment rate, taking into account the rate of labor productivity growth.

Another conclusion is that some models included extensive price systems and deflators, and the equations explaining wholesale prices reflected

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the impact of money supply and changes in unit costs. Thus, import prices were endogenized through the matrix of transactions in international trade, allowing predetermined export prices.

Last but not least, the wide variety of macroeconomic models that exist today has several sources. First of all, they differ in terms of domains and dimensions that depend on their purpose. Second, they have different structures and specifications that result from their theoretical basis. Third, they are used for different estimation methods, which range from traditional ones based on the Cowles Commission methodology to methods based on time series cointegration analysis.

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