THE FUGI GLOBAL MODEL 9.0 M200

Akira Onishi
Soka University, Institute for Systems Science, Hachioji-shi, Tokyo, Japan

Keywords: FUGI global model 9.0 M200, global economy, global population, unemployment, per-capita income disparity, real GDP share, CO_2 emissions, life expectancy, quality of life

Contents

Summary

The FUGI global model has been developed as a medium of providing global information to human society and of finding possibilities for policy coordination among countries to achieve sustainable development of the world economy under the constraints of the changing global environment in the twenty-first century. FUGI global model 9.0 M200 classifies the world into 200 countries and regional groupings where each national/regional model is globally interdependent through international trade,

financial flows, and information flows. Future simulations on global population, civilian labor force, employment, and real economic growth rates reveal the increasing international per capita income disparity among countries and the possibilities for increasing unemployment, as life expectancy at birth tends to improve around the world in the twenty-first century.

1. Model Structure

The FUGI Global Model 9.0 M200 classifies the world into 200 countries and regions. Each country or regional model is globally interdependent through direct linkages of the world trade matrices, export/import prices, primary commodities prices, foreign exchange rates, official development assistance, private foreign direct investment, external debt, GDP growth rates and stock market prices, and so on. It is also globally interdependent through indirect linkages such as population changes, economic development policies, energy policies, environmental polices, and so on.
Each national/regional model consists of nine integrated major subsystems: (I) Population, (II) Foods, (III) Energy, (IV) Environment, (V) Economic Development, (VI) Peace and Security, (VII) Human Rights, (VIII) Health Care, and (IX) Digital Divide (Information Technology). The Economic Development system as a major core of the model has eleven economic sub-blocs. It includes (1) labor and production at constant prices, (2) expenditure on GDP at constant prices, (3) income distribution: profit-wage, (4) prices, (5) expenditure on GDP at current prices, (6) money, interest rate, and financial assets, (7) government finance, (8) international balance of payments, (9) international finance, (10) foreign exchange rate, and (11) development indicators (see *Appendix 1: The FUGI Global Model 9.0 M 200: Theoretical Model*).

2. Population System

In the population system, there are key variables such as population, birth rates, total fertility rates (TFR), death rates, population under age 15, population above age 65, economically active population, age 15 to 65, life expectancy at birth for males and females.

Population changes can be explained by birth rates and death rates, and by net immigration rates. Natality depends upon birth rates, while mortality depends upon death rates. Both birth rates and total fertility rates are mostly explained by real GDP per capita, rates of government education expenditures to GDP, the death rates over the past five years, and life expectancy at birth. Death rates can be explained by real GDP per capita, rates of government health and welfare expenditures to GDP, the share of population aged over 65 to total population, the birth rates over the past five years, and life expectancy at birth.

The life expectancy at birth of both male and female can be explained by real GDP per capita, rates of government health, and welfare expenditures to GDP, rates of government education expenditures to GDP, and by total fertility rates. The ratio of urban population to total population is estimated by (1 – (rural population/total population)), which in turn can be explained by changes in the ratio of agricultural income to GDP.

4. Economic Development System

4.1. Labor and Production at Constant Prices

In this supply-side sub-bloc, special production functions are used to estimate real potential gross domestic product, i.e. GDPP# in a given country. In this supply-side system, productivity trends in the developed market economies are estimated not by the traditionally used neoclassical production functions, but rather by the author's own concept of "production functions." The value-added productivity per employed person, GDPP#/LCLF, is explained by nonhousing capital stock per employed person, NHFCS#/LCLF, educational assets per employed person, EDUA#/LCLF, technology assets per employed person, TECHA#/ LCLF, ratio of cumulative nonhousing capital investment for the previous five years to nonhousing capital stock, SUMT5 (NHI#) / NHFCS#, and ratio of petroleum prices (as expressed in domestic currency) relative to WPI, namely PEO*FERSI/WPI as a dummy variable for energy inputs.

Of course, value-added productivity will rise with higher ratios of capital to labor (i.e. with the advance of automation and the use of robots), and as seen in the case of high value-added products, productivity will rise with technology assets per employed person as a result of research and development expenditures. Also, a lessening of the vintage of capital stocks works to raise productivity. As for energy inputs as a factor in production, there is a tendency for production to lag when a given country's petroleum prices, expressed in its own currency (domestic energy cost), are high in comparison with its GDP deflator or WPI. Also, value-added productivity seems to be influenced by the capacity utilization rate, CUR, which reflects the current demand situation.

Shares of information technology investment over the past five years to nonhousing capital stock, SUMT5 (ITI#) / NHFCS#, tends to play a much greater role in increasing productivity in the economies of the US and Japan.

In the case of the developing market economies, production functions cannot be applied in the same way as to the developed market economies. In the developing countries, expenditures on research and development are in most cases almost negligible. Instead of R&D, technical cooperation over the previous three years, SUMT3 (ODATC), seems likely to increase labor productivity. As education may influence the productivity of developing countries, educational assets, EDUA#, seem rather more persuasive in their impact. The same is seen in government expenditure on health over the previous five years, SUMT5 (GH#). In the non-oil-producing developing countries, high-energy costs have the same negative impact on productivity growth as in the developed countries.

For economies in transition, the main explanatory variable is fixed capital stock per employed person. This is because in the countries in this category, data for expenditures on research and development, together with data for some other major explanatory variables, are unavailable.

Research and development expenditures, RD#, can be explained by operating surplus, OS#, minus corporate income tax in some countries and by government defense expenditures and economic services. In the following examples, it is seen that in Japan, unlike in the US, R&D expenditures are not notably influenced by government defense expenditures.

Unemployment rate, UNEMPR, tends to increase with rises in employment cost, WSEI/LPI, or WSEI/CPI/LPI<USA>, and with a decrease in overall economic climate in terms of GDP#.1/GDP#.2 and GFCF# /GDP#. The unemployment rate also tends to increase in line with supply of labor force, LCLF (adjusted by hours of work, HOW, in case of the EU, Japan, and the US). Using explanatory variables such as the above, changes in employment rates may be estimated from given time-series data.

The model's supply-side subsystem for looking at production with energy constraints gives special consideration to the possibility of unusual circumstances such as a sudden cut in oil supplies due to an intensification of warfare in the Middle East. Simulations can be made, for example, as to what kinds of impacts on a country's domestic production might be expected under such circumstances. For instance, in the case of sudden oil supply restrictions, supply-side questions would arise with regard to alternative domestic energy sources (e.g., the extent to which domestic oil production could be increased, or the degree to which alternative energy sources could be developed), and the extent to which oil reserves could or should be used.

At the same time, the model indicates how, in response to rising energy costs; a non-oil-producing country's domestic demand is kept down. In other words, effective domestic energy demand cannot increase to an extent greater than allowed by energy supplies (domestic and foreign), and there exists, so to speak, a built-in feedback system by which, if relative energy costs rise and cutbacks are made in energy use, growth in real GDP is likely to decline, putting a brake on energy demand.

Thus, in considering one or another possible degree of oil supply restriction, the model reflects, through a convergent process of computations, the "system" by which domestic prices rise in response to energy price rises and resultant cutbacks in energy use. Higher energy costs may bring lowered rates of real GDP growth and lowered energy demand until supply and effective demand come into balance.

Production by industrial origin is classified into three major sectors: agriculture, industry, and services. Industry is furthermore classified into manufacturing and other industrial activities. First of all, we obtain theoretical curves showing nonlinear relationships between per capita real GDP and ratios of each sector's real value added" to real GDP, by using cross-country analyses. Then, we forecast changes in industrial structures in each country or regional grouping using time-series analyses of deviations from the theoretical curves derived from cross country analysis.

3.2. Expenditures on GDP at Constant Prices

In this sub-bloc, the demand side of real GDP in each country or regional grouping is treated in terms of such major items within GDP as exports minus imports, private final consumption expenditures, government final consumption expenditures, nonhousing fixed investment, housing investment, and changes in inventories. Together, these factors in the model form an organic, interdependent, global economic system. In the

FUGI global model, global interdependent relationships among nations are expressed in terms of the world trade matrix, and also through a "multilateral trade coupling system" (MTCS). The most appropriate functions are chosen for elucidating various trade relationships, such as, for example, exports from each country to developed market economies, to developing market economies, and to economies in transition.

The model can also express and analyze trade flows between developed market economies. For example, Japan's real exports to the US E#MAT<JPN, USA> are explained by such variables as the US real gross domestic product GDP#<USA>, the ratio of Japan's export prices PES<JPN> to the US consumer price index CPI<USA> (indicating conditions of price competitiveness between Japan and the US). Japan's exports to the US are also influenced by Japan's research and development expenditures, RD#<JPN>, over the previous four years. The same thing is true of US exports to Japan.

At times when Japan's price competitiveness increases due to a devaluation of the yen against the US dollar, there is a tendency for Japan's exports to the US to show a temporary increase. Even at times when US business conditions are relatively inactive and real GDP is kept down, if US domestic prices should rise in comparison to Japan's export prices, it is possible that Japan's exports to the US might not slacken but would rather increase, possibly eventuating in greater US-Japan trade conflict. On the other hand, US exports to Japan are influenced not only by Japan's GDP and tariff and non-tariff barriers but also by US price competitiveness and non-price competitiveness, which could be strengthened by research and development expenditures.

In contrast to the case of Japanese exports to developed countries, for the case of Japan's exports to developing countries, the model introduces into its export functions the concept of "import capability," CAPM#. To determine the "import capabilities" of developing countries, their real exports, E#, adjusted by the terms of trade, PES/PMS, ought, first of all, to be considered. Also to be considered as factors in defining import capabilities of developing countries are financial inflows, FCI, such as bilateral ODA and private direct investments from developed countries, and multilateral development assistance from other international organizations (deflated in terms of dollar-base import prices, PMS, of the importing countries in question).

For instance, Japan's exports to a given developing country increase when that rises relative to import prices, so that there is an improvement in the terms of trade. On the other hand, if there is a worsening in the developing country's terms of trade (with drops in the prices of primary commodities under stagnant business situations), there import capabilities drop, and a "system" comes into being whereby Japan's exports to the country in question stagnate.

Similar conditions apply to Japan's exports to economies in transition. In other words, what determines exports to economies in transition is not just the scale of those countries' GDP# but rather considerations of import capability.

Thus Japan's total exports are derived from the trade matrices which include Japan's exports to the other countries and regional groupings of the model. Similarly, all the elements in trade matrices may be computed on the basis of estimated export functions. While trade between a given country and itself will of course be zero the diagonal elements of the matrix will indicate inter-regional trade among regions.

Private final consumption expenditures, CP#, in the case of the developed market economies, can be explained by such factors as GDP# or domestic disposable income, DFI#, compensation of employees, COMPE#, operating surplus, OS#, expected inflation rates, and short-term interest rates, IC. In this model, "private consumption functions" are classified into categories called the AME type, the Japan type, the USA type and the EU type, respectively. Both the Japan and the USA types have additional explanatory variables of financial assets.

In the case of most developing market economies for which a production-oriented model is used, and in the case of economies in transition, private consumption is calculated as what is left after subtracting savings from income. However, for some developing market economies demand-oriented models are used to incorporate both supply and demand sides, similar to those employed for the developed economies.

The increasing rate of nonhousing real investment, NHI#, in most of the developed market economies, can be explained by the expected increase in operating surplus, OS#, after deducting corporate income tax, TYC#, divided by non-housing fixed capital stock, NHFCS#, minus long-term interest rate (prime rate), IP. Other relevant explanatory variables are exports, ETFOB#, research and development expenditures, RD#, share of information technology investment to nonhousing investment, ITI#/NHI#, and capacity utilization rate, CUR, and so on. In most developed market economies, a nonlinear investment function is applied.

Housing real investment, HI#, in the case of developed market economies, can be mostly explained by gross domestic product, GDP#. Other relevant explanatory variables are long-term interest rates on housing loans, IH, and housing investment price deflator, PHI.

In the case of investment functions for developing market economies, GDP#, in some cases domestic savings is used in place of "operating surplus." Also, as mentioned previously, the concept of "capability to import" with respect to capital goods is also used as a relevant explanatory variable. In importing capital goods from developed countries for making investment in plant and equipment, most developing countries and planned market economies have restricted availability of foreign currency reserves—a matter to which the model gives due consideration.

4.2.Income Distribution—Profits and Wages

In the subsystem for determining income distribution, the major variables are operating surplus and wages. Factors determining real operating surplus, OS#, are GDP# (from which compensation of employees, COMPE#, is subtracted), interest rates, IP, and terms of trade, PES/PMS, and so on.

Factors affecting employed persons' nominal wage rates, WSEI, are rate of increase in consumer prices, CPI; rate of change in productivity, LPI; ratio of nominal operating surplus, OS, to nominal GDP; and unemployment rate, UNEMPR.

Needless to say, these variables are not all used for all countries; rather, those variables are chosen which appear to be the most appropriate and to have the highest descriptive capacity for a given country at a given time. In the above process of selecting variables, the most highly descriptive explanatory variable for nominal wages in many countries is consumer price index. This reflects the fact that in many countries in Europe "wage indexation" is a significant factor in labor-management agreements. Consequently, in such cases, changes in productivity may possibly have little effect on the determination of wages. Cases of unemployment rate affecting wages may be described by the Phillips Curve in post-Keynesian economic theory, but such would not always appear to be the reality at all times or in all developed market economies.

3.4. Prices

A number of price-related functions are incorporated into the model. These are wholesale price index, WPI, consumers' price index, CPI, and "deflators" for private final consumption expenditures, government final consumption expenditures, nonhousing investment, housing investment, exports and imports, and so on. The FUGI global model's most characteristic feature is that each country's export and import prices are endogenously determined. The "system" is one in which export prices are determined first, after which import prices are determined through the trade matrix, taking into account the weighted average of each country's export prices in accordance with the volume of trade with each other country.

The model also gives scope for the testing of a system whereby, according to recent monetarist contentions, wholesale prices could be influenced by changes in money supply, IV# (i.e. rate of expansion of M2 in relation to real GDP#). In other words, it should be possible to analyze, through such a system, the results of monetarist policy measures taken to combat inflation whereby, in an attempt to stabilize consumer prices and keep down wage hikes, wholesale prices are kept down through restrictions on money supply.

The percentage changes in export prices, PES, are explained by those of WPI, wage cost, WSEI/LPI, weighted average export prices of the developed countries, PESAME, foreign exchanges indices, FERSI, and primary commodities pries, PEC, and so on in developed market economies. On the other side, percentage changes in oil prices, PEO, in oil-exporting developing countries may be explained by changes in the weighted average export prices of the developed market economies, PESAME, and those of shares of global oil to global energy requirement, OILG/ENGYRG, in addition to the oil shock dummy variables.

On the other hand, percentage changes of non-oil commodities prices, PEC, is explained by those of the weighted average export prices of the developed market economies, PESAME, and the weighted average rates of interest of the developed market economies, ICAME.

3.5. Expenditures on GDP at Current Prices

Values for the various components of nominal GDP, when multiplied by the various corresponding deflators, yield corresponding nominal values of GDP. The GDP deflator, PGDP, is thus obtained by dividing this nominal GDP by real GDP#.

-
-
-

Bibliography

Onishi A. (1999). *FUGI Global Model 9.0 M 200/80—Integrated Global Model for Sustainable Development*, 423 pp. Tokyo: Soka University Institute for Systems Science. [This is a textbook for the FUGI Global Model M200/80.]

Onishi A. (2000). *FUGI Global Model 9.0 M 200—Integrated Global Model for Sustainable Development*, 415 pp. Tokyo: Soka University Institute for Systems Science. [This is a textbook for FUGI Global Model M200.]

Biographical Sketch

Akira Onishi is Vice-President of Soka University, and an economics and global modeling educator. His academic background is in both economics and systems engineering. He received his Ph.D. in Economics from Keio University and his Ph.D. in Systems Engineering from Tokyo Institute of Technology. He had an opportunity to work at UN ESCAP and at the International Labor Organization, during 1966–1970. Then he served at Soka University, Tokyo, as Dean, Department of Economics, 1976–1991; Dean, Graduate School of Economics, 1976–1991; Director, Soka University Institute for Systems Science (SUISS), 1990 on; Dean, Faculty of Engineering, 1991–1995; Dean, Graduate School of Engineering, 1995–1999; Vice President, 1989 on. He served as President of the Japan Association of Simulation and Gaming, 1993–1997. He has received many academic awards, including the International Biographical Roll of Honor to the Global Modeling Profession from the American Biographical Institute, US, 1989; the first Supreme Article Award from the Japanese Association of Administration and Planning, 1991; the 20th Century Award for Achievement from the International Bibliographic Centre, Cambridge, England, for Global Modeling, 1993; the Excellent Article Award from ECAAR, 1997; the Japan Association for Simulation and Gaming Award, 1998; 2000 Outstanding Intellectuals of the 20th Grand from the IBC, 1999, and he was selected as one of the First Five Hundred in 2000 for service to Economic Science by the IBC.

He is an original designer of the **FUGI** (*Futures of Global Interdependence)* Model. The UN Secretariat, Department of International Economic and Social Affairs, adopted this model for their long-term projections and policy simulations of the world economy from 1981 to 1991. During the period 1985 to 1986, he designed the Global Early Warning Systems for Displaced Persons (GEWS) under the auspices of the UN Human Rights Committee. The UNCTAD Secretariat has officially adopted the FUGI model for projections of the world economy and policy scenario simulations since 2000.