Methodology for the New National Forecast

Overview

The central idea in making the new national forecasts revolves around projecting industry-by-industry input-output tables through 2050 for 169 sectors and aggregating then to 70 and 23 sectors.   Each projected table satisfies the identity that total final expenditures equal total value-added, and total expenditures equal the sum of personal consumption expenditures, investment expenditures, government expenditures and net exports.

Make and Use tables from the website of the Bureau of Labor Statistics (BLS) for historical years 1998 through 2006 and for projection year 2016 provide the data for constructing the historical and 2016 projected input-output tables. BLS produces the Make and Use tables every two years and the next round of tables will have 2008 as the last history year and 2018 as the projection year.

In the BLS tables, there are 204 industries and 109 columns of final consumption expenditures: 88 personal consumption commodities, 13 commodities of private investment in equipment and software, a column of private investment in nonresidential structures category, a column of private investment in residential structures category, a column of change in private investment category, a column of exports of goods, a column of exports of services, a column of imports of goods, a column of imports of services, and three columns of government expenditures --- federal government defense consumption and investment, federal government, non-defense consumption and investment, and state and local government consumption and investment.

From the BLS Make and Use tables, historical and 2016 projected input-output tables were constructed, initially with dimensions of 169 industries, 79 personal consumption columns, 4 investment columns (including CBI), 3 government expenditures columns, and exports and imports columns. The 169 industries were then aggregated to build tables of 70 and 23 industries.

The built tables provided the historical and the 2016 projected values of a number of macroeconomic variables, which enabled the calculation of their shares and growth rates. Projecting the variables beyond 2016 utilized the shares and growth rates. For some industries the growth rates were gradually modified beyond 2016.

It was considered at first to make the forecasts with econometric equations, but this idea was subsequently abandoned as it would have entailed projecting the independent variables to 2050.   Projections to 2050 of official economic statistics are virtually nonexistent.

Growth Rate Formula
The compound formula was used to calculate the average annual growth rate from the BLS historical (1998-2006) and projected (2016) data:

$$Y^{t+n} = Y^t * (1 + r)^n$$

which may be written as,

$$r = (Y^{t+n} / Y^t)^{1/n} - 1$$

where r is the average annual rate of growth.
Y^{t+n} is the value of the variable at year t+n
Y^t is the value of the variable at year t

Beyond 2016, r was gradually modified to r' for some industries:

$$r' = r * (1/(t-2016)^f) \qquad t=2017, 2018, 2019 \ldots 2050$$

f is a factor that ranges between 0.1 and 0.8 for these projections.

Following is a description of how the macroeconomic variables were projected. The FORTRAN program used for this purpose is *ProjIOto2050.for* located in m:\eg\specific\us\nation\inputs\projioto2050 (subsequently referred to as **"folder"**).

Detailed Forecasts

Initial Output
Using the general formula for calculating growth rates above, the average annual growth rate of output for each industry was calculated between 2006 and 2016 using the BLS data. The year 1998 was used for some industries where doing so gave a smooth transition between 2006 and 2007.

The initial projections of output for 2017 and beyond assumed the calculated growth rates with or without modifications. If an industry is growing slowly, for example oil and gas extraction growing at 0.7%, this growth rate was not modified. For industries that are growing fast such as computer and peripheral equipment manufacturing growing at 20% per year, the rate was gradually reduced in the forecast years. Due to inter-industry relationships in the input-output table, an industry's output growth affects the other industries, and it has been found that leaving the growth rates unmodified can produce negative input-output coefficients in the long term.

The availability of resources puts a constraint on the amount of output that can be produced. To be described later, it is primarily employment and the size of the labor force that were used to adjust the initial output projections.

Initial GDP

GDP is one of the first variables that was needed in projecting the input-output tables. The GDP initial values also come from the constructed 1998-2006 and 2016 input-output tables. Together with Census Bureau population projections, the growth rate of total GDP per capita was calculated and projected beyond 2016. Then simply multiplying the projected GDP per capita by the Census population projections to 2050 gave the projected total GDP to 2050.

Initial Final Demand Expenditures

The created input-output tables have 88 columns of final demand categories: 79 personal consumption columns, 3 fixed investment columns, 3 government expenditures columns, and exports, imports, and change in business inventory columns.

To project these items, their shares of total GDP were calculated for years 1998 through 2006 and 2016 and then projected to 2050. Initially, the shares were adjusted so that the sum would equal 1. However, this procedure was not used as it caused many industries to become discontinuous at various points in time. Multiplying these shares by the total GDP projected earlier produced initial forecasts of the final demand components.

The final demand expenditures by commodity were then transformed into final demand expenditures by the 169 industries using bridge matrices derived from the 2006 and 2016 input-output tables.

Initial Value-Added

In a balanced input-output table, the total of net final demand expenditures (i.e. net of imports) should equal the total of value-added. Towards this end, value-added as a share of output was calculated for each of the 169 industries for years 1998 –2006 and for 2016 and these shares were projected to 2050. Multiplying these shares by the projected output produced initial projected value-added. These were scaled to achieve equality between total net final demand expenditures and total value-added.

Input-Output Coefficients

For any year, given a vector of output by industry, a vector of final demand expenditures by industry, and a vector of value-added by industry, the estimation of the input-output coefficients is a matter of estimating the matrix of intermediate demand. This matrix was estimated initially using the input-output coefficients derived from the created input-output tables for 2006 and 2016, with the formula $I = A*Q^{-1}$; I is the matrix of intermediate demand, A is the matrix of 2006 or 2016 input-output coefficients, and Q^{-1} is the diagonal matrix of output. The resulting I matrix was adjusted using the bi-proportional adjustment procedure, RAS, where the target column vector of intermediate sales is equal to the vector of output minus the vector of final demand expenditures by industry and the target row of intermediate purchases is equal to the output vector minus the value-added vector. This process produced a balanced input-output table from where the new input-output coefficients were calculated.

Initial Employment

Initial employment numbers were projected as a product of projected output from the balanced input-output tables and the projected inverse of labor productivity. Labor productivity was projected separately outside of this system.

Adjustment Factor

The size of the labor force constrains the size of employment available to produce output. It is assumed that the ratio of employment to labor force is constant throughout the projection period. This ratio was calculated in the last history year where actual employment and actual labor force are known, which when divided by the ratio of projected employment to projected labor force gave an adjustment factor for each of the forecast years.

Final Output

The final output that can be produced by the available labor force was calculated as the initial output multiplied by the adjustment factor.

Final Employment

The final output multiplied by labor productivity determine the final employment.

Final Value-Added

This is equal to final output minus intermediate purchases, where intermediate purchases equal the input-output coefficients multiplied by output.

Compensation

Compensation (from USPREMOD.exe – m:\ussys\ypu.txt - for 1990-2006 in the "folder"\data\compensation.xlsx) as shares of final value-added were calculated for 1990-2006 for 169 industries. Initially, average annual growth rates of these shares were calculated and then used to extend the shares to 2050. However, these projected shares when applied to the projected final value-added did not produce good forecasts of compensation. Finally, the 2006 shares were assumed constant throughout the projection period.

Shares of value-added were used since compensation is a component of value-added and the value-added being used comes from the balanced input-output table. The compensation so projected is consistent with the output produced in the economy that is in turn constrained by the size of the available labor force. This consistency would not be easily achieved by projecting levels of compensation rather than shares.

Employer contributions to government social insurance

This component's (from the "folder") shares of compensation were calculated for 1990-2006 and the average annual growth rate of these shares was derived for this period.

Using this growth rate modified gradually into the future, the projected shares were obtained. Multiplying these shares by the projected compensation produced the forecast for this variable.

Employer contributions for employee pension and insurance funds

The same procedure was used here as with employer contributions to government social insurance above.

Earnings

The earnings (from the earnings tab of compensation.xlsx) to compensation ratios were calculated for 1990-2006 and the average annual growth rates of these ratios during this period were obtained. The ratios were then projected to 2050 using these growth rates modified to gradually slow down. The projected ratios multiplied by the projected compensation produced projected earnings.

Employee and Self-employed Contributions to Government Social Insurance

This component (from the "folder" – earnings tab) as a share of earnings was calculated for 1990-2006 and the average annual growth rate during this period was derived. To project these shares to 2050, the average growth rate modified gradually was applied.

Proprietors' Income; Dividend, Interest and Rent; Transfer Payments; Residence Adjustments

The same procedure was used here as with the employee and self-employed contributions to government social insurance.

Wage & Salary Disbursements

Wages and salaries (also from compensation.xlsx) as proportions of compensation were calculated for 1990-2006 and average annual growth rates of these proportions for this period were obtained The proportions were then extended to 2050 using these growth rates modified to gradually decrease in the long term. These projected proportions when multiplied by projected compensation produced projected wages and salary disbursements.

Personal Taxes

The ratio of personal taxes (from the"folder"-wages tab) to wage and salary disbursements was calculated for 1990-2006 and the average annual growth rate of these ratios was obtained. The ratios were then extended annually to 2050 by applying the average growth rate modified gradually.

Consumer Price Index

For years 1990 through 2006, the average annual growth rate of the index was calculated. Applying this growth rate modified gradually to 2050 produced the forecast for the consumer price index.

Exports and Imports

The projected values come from the projected balanced input-output tables.