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Macroeconomic Activity Module of the National Energy Modeling System: Model Documentation 2018

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Update Information

This edition of the Macroeconomic Activity Model (MAM) – Model Documentation 2018 reflects changes made to the MAM over the past two years for the Annual Energy Outlook 2017 and 2018. These changes include the following:

- Updates to industrial and employment historical data
- New regional industry and employment model
- Industry and employment start year changed based on data availability
- Employment model aggregation changed
- Addition of renewable energy and energy trade variables to the US model

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Introduction

The National Energy Modeling System (NEMS) is a comprehensive, mid-term energy forecasting and policy analysis tool used by the EIA. The NEMS projects energy supply, demand, prices, and environmental emissions, by region, given assumptions about the state of the economy, international markets, and energy policies. The Macroeconomic Activity Module (MAM) links the NEMS to the rest of the economy by providing projections of economic driver variables for use by the supply, demand, and conversion modules of the NEMS. The MAM's baseline economic projection contains the initial economic assumptions used in the NEMS to help determine energy demand and supply. The MAM can also provide the NEMS with alternative economic assumptions representing a range of uncertainty about economic growth. Different assumptions regarding the path of world oil prices or of the penetration of new technologies can also be modeled in the MAM. The resulting economic impacts of such assumptions are inputs to the remaining supply and demand modules of the NEMS (Table B14 in Appendix B on page 127). Outside of the *Annual Energy Outlook* (AEO) setting, the MAM represents a system of linked modules capable of assessing the potential impacts on the economy of changes in energy events or of policy proposals as specified by a non-EIA requestor. These economic impacts result from assumptions about energy events resulting from policy proposals built into the NEMS. The linked modules of the NEMS then iterate to a solution.

This report documents the objectives and analytical approach of the MAM that is used to develop the *Annual Energy Outlook for 2018* (AEO2018). It serves as a reference document providing a description of the MAM used for the AEO2018 production runs for model analysts, users, and the public. It also facilitates continuity in model development by providing documentation from which energy analysts can undertake model enhancement and modifications. This documentation report is divided into two separate components.

Part A presents the structural models comprising the MAM. These include:

- IHS Markit's model of the U.S. economy
- IHS Markit's models of industrial output and of employment by industry
- U.S. Energy Information Administration's models of the regional economies

Part B focuses on the MAM's interface with the NEMS. This section identifies the set of model levers and simulation rules used to operate the system. It also provides a discussion of three types of integrated simulations carried out with the NEMS. This section also views the MAM from the perspective of a programmer focusing on the ties that link the various models together to form the MAM and how the MAM communicates with the NEMS.

Appendices A and B provide detailed information on variable listings and sectoral definitions.

Appendix C provides a detailed listing of the equations for the regional models.

Part A. Macroeconomic Activity Module (MAM) of the National Energy Modeling System

1. Modeling system overview

Economic activity driving the National Energy Modeling System (NEMS) is determined by an economic modeling system comprised of three sets of models:

- IHS Markit's model of the U.S. economy
- IHS Markit's industrial output and employment by industry models
- U.S. Energy Information Administration's (EIA) regional models

IHS Markit's model of the U.S. economy is the same model used by IHS Markit to produce its economic forecasts for the company's monthly assessment of the U.S. economy. The IHS Markit U.S. model used for the AEO2018 is the US2017A version. EIA's Industrial Output and Employment by Industry Models are derivatives of IHS Markit's industrial output and employment by industry models. The models have been tailored in order to provide the industrial output and employment by industry detail required by the NEMS modeling system. EIA's regional models consist of models of economic activity, industrial output, employment by industry and commercial floor space. The first two models were developed during 2004 for use in the preparation of the AEO2005 and are updated annually. The regional models were last re-estimated for the AEO 2010 except for the commercial floor space model which was re-estimated for the AEO 2016.

All of the MAM models are linked to provide a fully integrated approach to estimating economic activity at the national, industrial and regional levels. IHS Markit's model of the U.S. economy determines the national economy's growth path and the final demand mix. EIA's Industrial Output Model ensures that supply by industry is consistent with the final demands (consumption, investment, government spending, exports and imports) calculated in the U.S. model. Industrial output is the key driver of the employment estimation in EIA's Employment by Industry model. The employment by industry projection also uses aggregate hours per week and productivity trends found in the U.S. model. The employment by industry projection is aligned with the aggregate employment estimation of the U.S. model. Key inputs to EIA's regional models include projections of national output, employment by industry, population, national income and housing activity. EIA's regional models then calculate levels of industrial output, employment by industry, population, incomes, and housing activity for each of the nine Census Divisions. The sum of each of these concepts across the nine Census Divisions is aligned with the national totals estimated by the U.S. model. Together, these models of the U.S. economy, industrial output, employment by industry and of regional economic activity constitute the Macroeconomic Activity Module (MAM) of the National Energy Modeling System (NEMS).

Before the MAM can execute its suite of models, it requires exogenous assumptions regarding energy prices, consumption and domestic production. Over seventy energy prices and quantities are extracted from the output of the demand and supply modules of the NEMS. Transformations of the exogenous assumptions are necessary to map these inputs from the NEMS into more aggregated concepts in the MAM. After the appropriate transformations are done, the U.S., Industrial Output, Employment by Industry and Regional Models execute in sequence to produce an estimate of economic activity at the national, industrial and regional levels. Drawn from the projections are economic driver variables that are then passed to the supply, demand and conversion modules of the NEMS (Table B14 in Appendix B on page 127). The NEMS then reacts to the new economic activity assumptions. Estimates of energy prices and quantities based upon these new economic assumptions are then passed back to the MAM. A NEMS "cycle" is completed once all the modules of the NEMS solve. Cycles are repeated as the NEMS iterates to a stable solution.

There are a few industrial output and employment by industry concepts whose projections in the MAM are determined by the NEMS. The MAM's results for industrial output of the five energy-related sectors are based upon growth rates extracted from the appropriate modules in the NEMS. The growth rates in output of petroleum refining, coal mining, oil and gas extraction, electric utilities and gas utilities are applied to the last historical value of the appropriate series in the MAM's Industrial Output Model (Table B4 in Appendix B on page 109). A similar computation is done for employment by industry but for only two of the five energy sectors. Growth in employment is computed for coal mining and for oil and gas extraction using projections from the appropriate NEMS modules. These growth rates are then applied to the last historical value of the appropriate series in the MAM's employment by industry model.

IHS Markit's Model of the U.S. Economy

Key Inputs: National population by age cohort, total factor productivity, federal tax rates and nominal expenditures, money supply, energy prices and quantities and GDP of major and other important trading partners.

Key Outputs: Final demands (consumption, investment, government purchases, exports, imports), inflation, foreign exchange and interest rates, incomes, employment, federal and state/local government revenues and expenditures and balance of payments.

IHS Markit's Industrial Output Model

Key Inputs: Final demands, prices and productivity measures from IHS Markit's model of the U.S. economy and input-output coefficient matrices.

Key Outputs: Real output value (defined by value of shipments or revenue) for 73 industrial and service sectors.

IHS Markit's Employment by Industry Model

Key Inputs: Industrial outputs from the industrial output model, capital service cost determinants, productivity measures and total employment from IHS Markit's model of the U.S. economy.

Key Outputs: Employment for 49 industrial and service sectors.

U.S. Energy Information Administration's Regional Economic Activity Model

Key Inputs: National gross domestic product, wages, incomes, population, housing activity and prices from IHS Markit's model of the U.S. economy. State population estimates and projections from the U.S. Bureau of the Census.

Key Outputs: Wages and salaries, personal income, disposable income, population and housing activity for the nine Census Divisions.

U.S. Energy Information Administration's Regional Industrial Output and Employment by Industry Models

Key Inputs: National sectoral output and employment from the industrial output and employment by industry models; regional shares.

Key Outputs: Output values for 58 industrial sectors and employment for 37 industrial output and service sectors for the nine Census Divisions.

U.S. Energy Information Administration's Regional Commercial Floor Space Model

Key Inputs: Gross domestic product, consumer spending, employment, private non-residential investment, interest rates, productivity, personal disposable income, population and lagged values of the dependent variable.

Key Outputs: Commercial floor space in rates of growth for 13 commercial floor space types in each of the nine Census Divisions.

Each of these models is discussed below, with further detail presented in the Appendices to this document.

2. IHS Markit's Model of the U.S. Economy

The model's theoretical position

Econometric models built in the 1950s and 1960s were largely Keynesian income-expenditure systems that assumed a closed domestic economy. High computation costs involving statistical estimation and model manipulation, along with the underdeveloped state of macroeconomic theory, limited the size of the models and the richness of the linkages of spending to financial conditions, inflation, and international developments. Since that time, however, computer costs have fallen; macroeconomic theory has also benefited from five decades of postwar data observation and from the intellectual attention of many eminent economists.

An Econometric Dynamic Equilibrium Growth Model: IHS Markit's model of the U.S. economy strives to incorporate the best insights of many theoretical approaches to the business cycle: Keynesian, neoclassical, monetarist, supply-side and rational expectations. In addition, IHS Markit's model of the U.S. economy embodies the major properties of the long-term growth models presented by James Tobin, Robert Solow, Edmund Phelps and others. This structure guarantees that short-run cyclical developments will converge to a robust long-run equilibrium.

In growth models, the expansion rates of technical progress, the labor force and the capital stock, both physical capital and human capital, determine the productive potential of an economy. Both technical progress and the capital stock are governed by investment, which in turn must be in balance with post-tax capital costs, available savings and the capacity requirements of current spending. As a result, monetary and fiscal policies will influence both the short- and the long-term characteristics of such an economy through their impacts on national saving and investment.

A modern model of output, prices and financial conditions is melded with the growth model to present detailed, short-run dynamics of the economy. In specific goods markets, the interactions of a set of supply and demand relations jointly determine spending, production, and price levels. Typically, the level of inflation-adjusted demand is driven by prices, income, wealth, expectations and financial conditions. The capacity to supply goods and services is keyed to a production function combining the basic inputs of labor hours, energy usage, and the capital stocks of business equipment and structures and government infrastructure. The "total factor productivity" of this composite of tangible inputs is driven by expenditures on research and development that produce technological progress.

Prices adjust in response to short-run gaps between current production and supply potential and to changes in the cost of inputs. Wages adjust to labor supply-demand gaps (indicated by a demographically-adjusted unemployment rate), current and expected inflation (with a unit long-run elasticity), productivity, tax rates and minimum wage legislation. The supply of labor responds positively to the perceived availability of jobs, to the after-tax wage level and to the growth and age-gender mix of the population. Demand for labor is keyed to the level of output in the economy and to the productivity of labor, capital and energy. Because the capital stock does not change much in the short run, a higher level of output requires more employment and energy inputs. Such increases are not necessarily equal to the percentage increase in output because of the improved efficiencies typically achieved during an

upturn. Tempering the whole process of wage and price determination is the exchange rate; a rise signals prospective losses of jobs and markets unless costs and prices are reduced.

For financial markets, the model predicts exchange rates, interest rates, stock prices, loans and investments interactively with the preceding GDP and inflation variables. The Federal Reserve sets the supply of reserves in the banking system and the fractional reserve requirements for deposits. Private sector demands to hold deposits are driven by national income, expected inflation and by the deposit interest yield relative to the yields offered on alternative investments. Banks and other thrift institutions, in turn, set deposit yields based on the market yields of their investment opportunities with comparable maturities and on the intensity of their need to expand reserves to meet legal requirements. In other words, the contrast between the supply and demand for reserves sets the critical short-term interest rate for interbank transactions, the federal funds rate. Other interest rates are keyed to this rate, plus expected inflation, Treasury borrowing requirements and sectoral credit demand intensities.

The old tradition in macroeconomic model simulations of exogenous fiscal policy changes was to hold the Federal Reserve's supply of reserves constant at baseline levels. While this approach makes static analysis easier in the classroom, it sometimes creates unrealistic policy analyses when a dynamic model is appropriate. In IHS Markit's model of the U.S. economy, "monetary policy" is defined by a set of targets, instruments and regular behavioral linkages between targets and instruments. The model user can choose to define unchanged monetary policy as unchanged reserves, or as an unchanged reaction function in which interest rates or reserves are changed in response to changes in such policy concerns as the price level and the unemployment rate.

Monetarist aspects: The model pays due attention to valid lessons of monetarism by carefully representing the diverse portfolio aspects of money demand and by capturing the central bank's role in long-term inflationary trends.

The private sector may demand money balances as one portfolio choice among transactions media (currency, checkable deposits), investment media (bonds, stocks, short-term securities) and durable assets (homes, cars, equipment, structures). Given this range of choices, each asset's implicit and explicit yield must therefore match expected inflation, offset perceived risk and respond to the scarcity of real savings. Money balances provide benefits by facilitating spending transactions and can be expected to rise nearly proportionately with transactions requirements unless the yield of an alternative asset changes.

Now that even demand deposit yields can float to a limited extent in response to changes in Treasury bill rates, money demand no longer shifts quite as sharply when market rates change. Nevertheless, the velocity of circulation (the ratio of nominal spending to money demand) is still far from stable during a cycle of monetary expansion or contraction. Thus the simple monetarist link from money growth to price inflation or nominal spending is considered invalid as a rigid short-run proposition.

Equally important, as long-run growth models demonstrate, induced changes in capital formation can also invalidate a naive long-run identity between monetary growth and price increases. Greater demand for physical capital investment can enhance the economy's supply potential in the event of more rapid money creation or new fiscal policies. If simultaneous, countervailing influences deny an expansion of the economy's real potential, the model will translate all money growth into a proportionate increase in prices rather than in physical output.

Supply-side economics: Since 1980, supply-side political economists have pointed out that the economy's growth potential is sensitive to the policy environment. They focused on potential labor supply, capital spending and savings impacts of tax rate changes. IHS Markit's model of the U.S. economy embodies supply-side hypotheses to the extent supportable by empirical evidence embodied in the available data. This is considerable in the many areas that supply-side hypotheses share with long-run growth models. These features, however, have been fundamental ingredients of the model since 1976.

Rational expectations: As the rational expectations school has pointed out, much of economic decision-making is forward looking. For example, the decision to buy a car or a home is not only a question of current affordability but also one of timing. The delay of a purchase until interest rates or prices decline has become particularly common since the mid-1970s when both inflation and interest rates were very high and volatile. Consumer sentiment surveys, such as those conducted by the University of Michigan Survey Research Center, clearly confirm this speculative element in spending behavior.

However, households can be shown to base their expectations, to a large extent, on their past experiences: they believe that the best guide to the future is an extrapolation of recent economic conditions and the changes in those conditions. Consumer sentiment about whether this is a "good time to buy" can therefore be successfully modeled as a function of recent levels and changes in employment, interest rates, inflation and inflation expectations. Similarly, inflation expectations (influencing financial conditions) and market strength expectations (influencing inventory and capital spending decisions) can be modeled as functions of recent rates of increase in prices and spending.

This largely retrospective approach is not, of course, wholly satisfactory to pure adherents of the rational expectations doctrine. In particular, this group argues that the announcement of macroeconomic policy changes would significantly influence expectations of inflation or growth prior to any realized change in prices or spending. If an increase in government expenditures is announced, the argument purports, expectations of higher taxes to finance the spending might lead to lower consumer or business spending in spite of temporarily higher incomes from the initial government spending stimulus. A rational expectations theorist would thus argue that multiplier effects will tend to be smaller and more short-lived than a mainstream economist would expect.

These propositions are subject to empirical evaluation. IHS Markit's conclusions are that expectations do play a significant role in private sector spending and investment decisions; but, until change has occurred in the economy, there is very little room for significant changes in expectations in advance of an actual change in the variable about which the expectation is formed. The rational expectations school

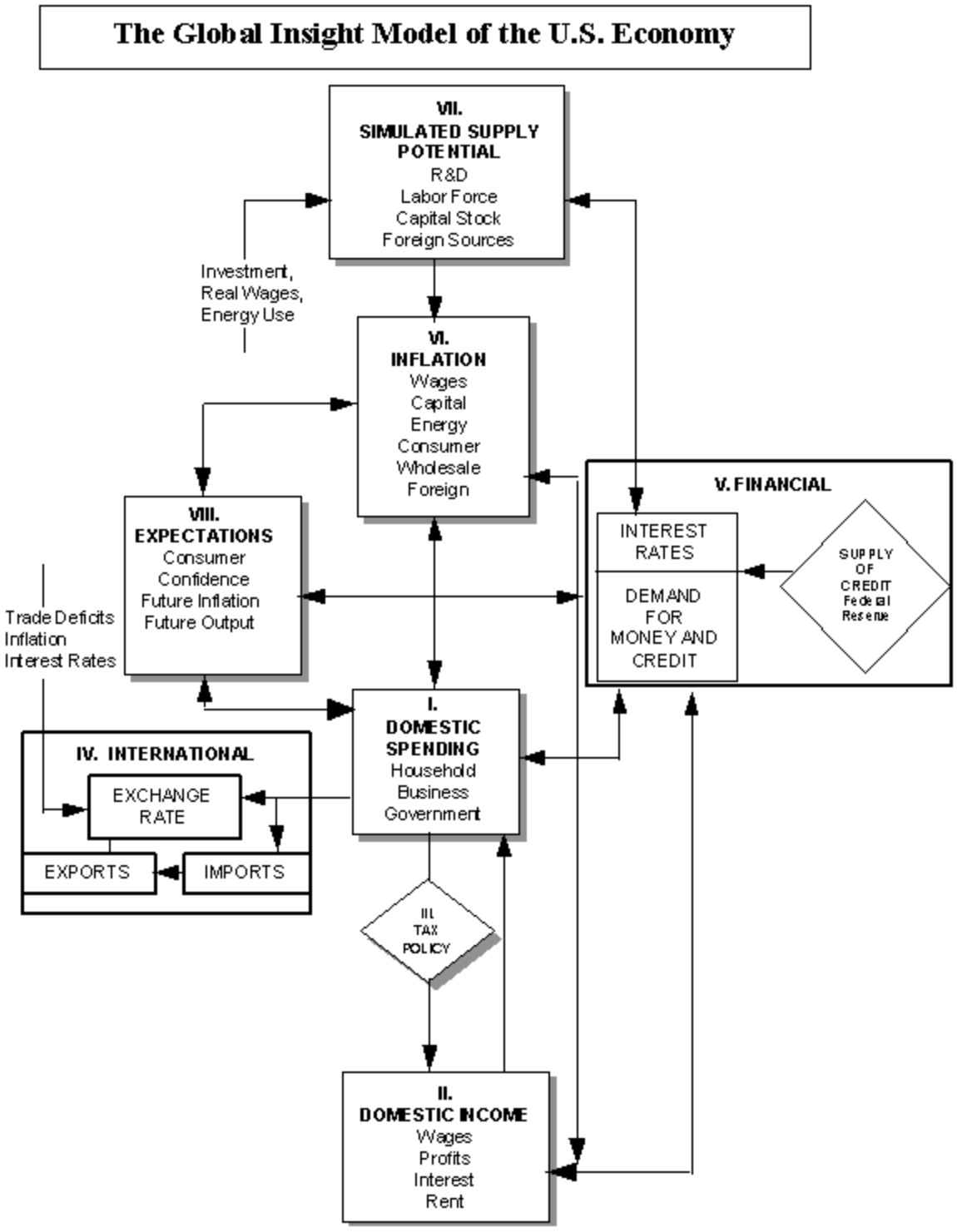
thus correctly emphasizes a previously understated element of decision-making, but exaggerates its significance for economic policy-making and model building.

IHS Markit's model of the U.S. economy allows a choice in this matter. On the one hand, the user can simply accept IHS Markit's judgments and let the model translate policy initiatives into initial changes in the economy, simultaneous or delayed changes in expectations, and subsequent changes in the economy. On the other hand, the user can manipulate the clearly identified expectations variables in the model, i.e., consumer sentiment, and inflation expectations. For example, if the user believes that fear of higher taxes would subdue spending; the user could reduce the consumer sentiment index.

Theory as a constraint: The conceptual basis of each equation in IHS Markit's model of the U.S. economy was thoroughly worked out before the regression analysis was initiated. The list of explanatory variables includes a carefully selected set of demographic and financial inputs. Each estimated coefficient was then thoroughly tested to be certain that it met the tests of modern theory and business practice. This attention to equation specification and coefficient results has eliminated the "short circuits" that can occur in evaluating a derivative risk or an alternative policy scenario. Because each equation will stand up to a thorough inspection, IHS Markit's model is a reliable analytical tool and can be used without excessive iterations. The model is not a black box: it functions like a personal computer spreadsheet in which each interactive cell has a carefully computed, theoretically consistent entry and thus performs logical computations simultaneously.

Major sectors

IHS Markit's model of the U.S. economy captures the full simultaneity of the U.S. economy, forecasting over 1700 concepts spanning final demands, aggregate supply, prices, incomes, international trade, industrial detail, interest rates and financial flows. The chart below summarizes the structure of the eight interactive sectors (in Roman numerals). The following discussion presents the logic of each sector and significant interactions with other sectors.


The Global Insight Model of the U.S. Economy
VII.
SIMULATED SUPPLY POTENTIAL
R&D
Labor Force
Capital Stock
Foreign Sources
Investment,
Real Wages,
Energy Use
VI.
INFLATION
Wages
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Inflation
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I.
DOMESTIC SPENDING
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Business
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IV. INTERNATIONAL
EXCHANGE RATE
EXPORTS
IMPORTS
III.
TAX POLICY
II.
DOMESTIC INCOME
Wages
Profits
Interest
Rent

Spending - consumer: The domestic spending (I), income (II) and tax policy (III) sectors model the central circular flow of behavior as measured by the national income and product accounts. If the rest of the model were "frozen", these blocks would produce a Keynesian system similar to the models pioneered by Tinbergen and Klein, except that neoclassical price factors have been imbedded in the investment and other primary demand equations.

Consumer spending on durable goods is divided into nine categories: light vehicles; used automobiles; motor-vehicle parts; other vehicles; computers; software; other household equipment and furnishings; ophthalmic and orthopedic products and "other". Spending on non-durable goods is divided into nine categories: three food categories, clothing and shoes, gasoline and oil, fuel oil and coal, tobacco, drugs and "other". Spending on services is divided into 16 categories: housing, six household operation subcategories, four transportation categories, medical care, recreation, two personal business service categories and other services (see Table A1 in Appendix A on page 76). In nearly all cases, real consumption expenditures are motivated by real income and the consumer price of a particular category relative to the prices of other consumer goods. Durable and semi-durable goods are also especially sensitive to current financing costs, and consumer speculation on whether it is a "good time to buy". The University of Michigan Survey of Consumer Sentiment monitors this last influence; with the index itself modeled as a function of current and lagged values of inflation, unemployment and the prime rate.

Spending - business investment: Business spending includes nine fixed investment categories for equipment and seven for construction: four information processing equipment categories, industrial equipment, three transportation equipment categories, other producers' durable equipment, four building categories, mines and wells, and two public utility structures (see Table A2 in Appendix A on page 77). Equipment and business structures (non-utility, non-mining) spending components are determined by their specific effective post-tax capital costs, capacity utilization and replacement needs. The cost terms are sophisticated blends of post-tax debt and equity financing costs (offset by expected capital gains) and the purchase price of the investment good (offset by possible tax credits and depreciation-related tax benefits). This updates the well-known work of Dale Jorgenson, Robert Hall and Charles Bischoff.

Given any cost/financing environment, the need to expand capacity is monitored by recent growth in national goods output weighted by the capital intensity of such production. Public utility structure expenditures are motivated by similar concepts except that the output terms are restricted to utility output rather than total national goods output. Net investment in mining and petroleum structures responds to movements in real domestic oil prices and to oil and natural gas production.

Inventory demand is the most erratic component of GDP, reflecting the pro-cyclical, speculative nature of the private sector, which accumulates during booms and is drawn down during downturns. The forces that drive the five non-farm inventory categories are changes in spending, short-term interest rates and expected inflation, surges in imports and changes in capacity utilization or the speed of vendor deliveries. Unexpected increases in demand lead to an immediate draw down of stocks that are then rebuilt over time; the reverse naturally holds for sudden reductions in final demand. Inventory demands are sensitive to the cost of holding the stock, measured by such terms as interest costs adjusted for

expected price increases and by variables monitoring the presence of bottlenecks. The cost of a bottleneck that slows delivery times is lost sales: an inventory spiral can therefore be set in motion when all firms accelerate their accumulation during a period of strong growth but then try to deplete excessive inventories when the peak is past.

Spending - residential investment: The residential investment sector of the model includes two housing starts (single and multi-family starts) and three housing sales categories (new and existing single family sales and new single family units for sale). Housing starts and sales, in turn, drive investment demand in five GDP account categories: single family housing; multi-family housing; improvements; other residential structure and residential equipment (see Table A3 in Appendix A on page 78).

Residential construction is typically the first sector to contract in a recession and the first to rebound in a recovery. Moreover, the magnitude of the building cycle is a prominent determinant of the subsequent macroeconomic cycles. The housing sector of IHS Markit's model of the U.S. economy explains new construction as a decision primarily based upon the after-tax cost of home ownership relative to disposable income. This cost is estimated as the product of the average new home price adjusted for changes in quality; and the mortgage rate, plus operating costs, property taxes and an amortized down payment. "Lever variables" allow the model user to specify the extent to which mortgage interest payments, property taxes and depreciation allowances (for rental properties) produce tax deductions that reduce the effective cost.

The equations also include a careful specification of demographic forces. After estimating changes in the propensity of specific age-gender groups to form independent households, the resulting "headship rates" are multiplied by corresponding population statistics to estimate the trend expansion of single- and multi-family households. The housing equations are then specified to explain current starts relative to the increase in trend households over the past year, plus pent-up demand and replacement needs. The basic phenomenon being scrutinized is therefore the proportion of the trend expansion in households whose housing needs are met by current construction. The primary determinants of this proportion are housing affordability, consumer confidence and the weather. Actual construction spending in the GDP accounts is the value of construction "put-in-place" in each period after the start of construction (with a lag of up to six quarters in the case of multi-family units), plus residential improvements and brokerage fees.

Spending - government: The last sector of domestic demand for goods and services, that of the government, is largely exogenous (user-determined) at the federal level and endogenous (equation-determined) at the state and local level. The user sets the real level of federal non-defense and defense purchases (for compensation, consumption of fixed capital, Commodity Credit Corporation inventory change, other consumption and gross investment), medical and non-medical transfer payments, and medical and non-medical grants to state and local governments. The model calculates the nominal values through multiplication by the relevant estimated prices. Transfers to foreigners, wage accruals and subsidies (agricultural, housing and other) are also specified by the user, but in nominal dollars. One category of federal government spending – net interest payments – is determined within the model because of its dependence on the model's financial and tax sectors. Net federal interest payments are

determined by the level of privately-held federal debt, short and long-term interest rates and the maturity of the debt (see Table A4 in Appendix A on page 79).

The presence of a large and growing deficit imposes no constraint on federal spending. This contrasts sharply with the state and local sector where legal requirements for balanced budgets mean that declining surpluses or emerging deficits produce both tax increases and reductions in spending growth. State and local purchases (for compensation, consumption of fixed capital, other consumption and construction) are also driven by the level of federal grants (due to the matching requirements of many programs), population growth and trend increases in personal income (see Table A5 in Appendix A on page 80).

Income: Domestic spending, adjusted for trade flows, defines the economy's value-added or gross national product (GNP) and gross domestic product (GDP). Because all value-added must accrue to some sector of the economy, the expenditure measure of GNP (GDP plus net exports of factor services) also determines the nation's gross income. The distribution of income among households, business, and government is determined in sectors II and III of the model.

Pre-tax income categories include private and government wages, corporate profits, interest, rent and entrepreneurial returns. Each pre-tax income category except corporate profits is determined by some combination of wages, prices, interest rates, debt levels and capacity utilization or unemployment rates. In some cases such as wage income, these are identities based on previously calculated wage rates, employment and hours per week.

Profits are logically the most volatile component of GNP on the income side. When national spending changes rapidly, the contractual arrangements for labor, borrowed funds and energy imply that the return to equity holders is a residual that will soar in a boom and collapse in a recession. The model reflects this by calculating wage, interest and rental income as thoroughly reliable near-identities (e.g., wages equal average earnings multiplied by hours worked) and then subtracting each non-profit item from national income to solve for profits (see Tables A6 and A7 in Appendix A on pages 81 and 82).

Taxes: Since post-tax rather than pre-tax incomes drive expenditures, each income category must be taxed at an appropriate rate; the model therefore tracks personal, corporate, payroll and excise taxes separately. Users may set federal tax rates; tax revenues are then simultaneously calculated as the product of the rate and the associated pre-tax income components. However, the model automatically adjusts the effective average personal tax rate for variations in inflation and income per household and the effective average corporate rate for credits earned on equipment, utility structures and R&D. Substitutions or additions of “flat” taxes and value-added taxes for existing taxes are accomplished with specific tax rates and new definitions of tax bases. As appropriate, these are aggregated into personal, corporate or excise tax totals.

State and local corporate profits and social insurance (payroll) tax rates are exogenous in the model, while personal income and excise taxes are fully endogenous: the U.S. model makes reasonable adjustments automatically to press the sector toward the legally-required approximate budget balance. The average personal tax rate rises with income and falls with the government-operating surplus. Property and sales taxes provide the bulk of state excise revenue and reflect changes in oil and natural

gas production, gasoline purchases and retail sales, as well as revenue requirements. The feedback from expenditures to taxes and taxes to expenditures works quite well in reproducing both the secular growth of the state and local sector and its cyclical volatility (see Table A8 in Appendix A on page 83).

International: The international sector (IV) is a critical, fully simultaneous block that can either add or divert strength from the central circular flow of domestic income and spending. Depending on the prices of foreign output, the U.S. exchange rate and competing domestic prices, imports capture varying shares of domestic demand.

Depending on similar variables and the level of world gross domestic product, exports can add to domestic spending on U.S. production. The exchange rate itself responds to international differences in inflation, interest rates, trade deficits and capital flows between the U.S. and its competitors. In preparing forecasts, IHS Markit's U.S. Economic Service and the World Service collaborate in determining internally consistent trade prices and volumes, interest rates and financial flows.

Eight categories of goods and one of services are modeled separately for both imports and exports, with one additional goods category for oil imports (see Table A9 in Appendix A on page 84). For example, export and import detail for business machines is included as a natural counterpart to the inclusion of the office equipment component of producers' durable equipment spending. The business machines detail allows more accurate analysis because computers are rapidly declining in effective quality-adjusted prices relative to all other goods, and because such equipment is rising rapidly in prominence as businesses push ahead with new production and information processing technologies.

Investment income flows are also explicitly modeled. The stream of huge current account deficits incurred by the U.S. has important implications for the U.S. investment income balance. As current account deficits accumulate, the U.S. net international investment position and the U.S. investment income balance deteriorate. U.S. foreign assets and liabilities are therefore included in the model, with the current account deficit determining the path of the net investment position.

The reactions of overseas prices, interest rates and GDP to U.S. development are robust and automatic. In the case of depreciation in the dollar, for example, U.S. activity may expand at the expense of foreign activity and U.S. inflation may rise while the rate in other countries slows.

Financial: The use of a detailed financial sector (V) and of interest rate and wealth effects in the spending equations recognizes the importance of credit conditions on the business cycle and on the long-run growth prospects for the economy.

Interest rates, the key output of this sector, are modeled as a term structure, pivoting off the federal funds rate. As noted earlier, the model gives the user the flexibility of using the supply of reserves as the key monetary policy instrument, reflecting the Federal Reserve's open market purchases or sales of Treasury securities, or using a reaction function as the policy instrument. If the supply of reserves is chosen as the policy instrument, the federal funds rate depends upon the balance between the demand and supply of reserves to the banking system. Banks and other thrift institutions demand reserves to meet the reserve requirements on their deposits and the associated (exogenous) fractional reserve requirements. The private sector in turn demands deposits of various types, depending on current yields, income, and expected inflation.

If the reaction function is chosen as the monetary policy instrument, the federal funds rate is determined in response to changes in such policy concerns as inflation and unemployment. The reaction function recognizes that monetary policy seeks to stabilize prices (or to sustain a low inflation rate) and to keep the unemployment rate as close to the natural rate as is consistent with the price objective. A scenario designed to display the impact of a fiscal policy change in the context of unchanged monetary policy is arguably more realistic when unchanged or traditional reactions to economic cycles are recognized, than when the supply of reserves is left unchanged.

Longer-term interest rates are driven by shorter-term rates as well as factors affecting the slope of the yield curve. In IHS Markit's model of the U.S. economy, such factors include inflation expectations, government borrowing requirements and corporate financing needs. The expected real rate of return varies over time and across the spectrum of maturities. An important goal of the financial sector model is to both capture the persistent elements of the term structure and to interpret changes in this structure. Twenty-four interest rates are covered in order to meet client needs regarding investment and financial allocation strategies (see Table A10 in Appendix A on page 85).

Inflation: Inflation (VI) is modeled as a carefully controlled, interactive process involving wages, prices and market conditions. Equations embodying a near accelerationist point of view produce substantial secondary inflation effects from any initial impetus such as a change in wage demands or a rise in foreign oil prices. Unless the Federal Reserve expands the supply of credit, real liquidity is reduced by any such shock. Given the real-financial interactions described above, this can significantly reduce growth. The process also works in reverse: a spending shock can significantly change wage-price prospects and then have important secondary impacts on financial conditions. Inspection of the simulation properties of IHS Markit's model of the U.S. economy, including full interaction among real demands, inflation and financial conditions, confirms that the model has moved towards a central position in the controversy between fiscalists and monetarists, and in the debates among neoclassicists, institutionalists and rational expectationists.

The principal domestic cost influences are labor compensation, non-farm productivity (output per hour) and foreign input costs. Foreign input costs are driven by the exchange rate, the price of oil and foreign wholesale price inflation. Excise taxes paid by the producer are an additional cost fully fed into the pricing decision. This set of cost influences drives each of the 19 industry-specific producer price indexes, in combination with a demand pressure indicator and appropriately weighted composites of the other 18 producer price indexes. In other words, the inflation rate of each industry price index is the reliably weighted sum of the inflation rates of labor, energy, imported goods and domestic intermediate goods; plus a variable markup reflecting the intensity of capacity utilization or the presence of bottlenecks. If the economy is in balance--with unemployment near 5%, manufacturing capacity utilization steady near 80 to 85%, and foreign influences neutral--then prices will rise in line with costs and neither will show signs of acceleration or deceleration.

Supply: The first principle of the market economy is that prices and output are determined simultaneously by the factors underlying both demand and supply. As noted above, the "supply-siders" have not been neglected in IHS Markit's model of the U.S. economy; indeed, substantial emphasis on this side of the economy (VII) was incorporated as early as 1976. In IHS Markit's model of the U.S. economy, aggregate supply is estimated by a Cobb-Douglas production function that combines factor input growth and improvements in total factor productivity. Factor input equals a weighted average of labor, business fixed capital, public infrastructure and energy provided by the energy sector. Based upon each factor's historical share of total input costs, the elasticity of potential output with respect to labor is 0.65 (i.e., a 1% increase in the labor supply increases potential GDP 0.65%); the business capital elasticity is 0.26; the infrastructure elasticity is 0.025; and the energy elasticity is 0.07. Factor supplies are defined by estimates of the full employment labor force, the full employment capital stock, end-use energy demand and the stock of infrastructure. To avoid double-counting energy input, the labor and capital inputs are both adjusted to deduct estimates of the labor and capital that produce energy. Potential GDP is the sum of the aggregate supply concept derived from the production function, less net energy imports, plus housing services and the compensation of government employees. Total factor productivity depends upon the stock of research and development capital and trend technological change.

Taxation and other government policies influence labor supply and all investment decisions, thereby linking tax changes to changes in potential GDP. An expansion of potential GDP first reduces prices and then credit costs, thus spurring demand. Demand rises until it equilibrates with potential output. Therefore, the growth of aggregate supply is the fundamental constraint on the long-term growth of demand. Inflation, created by demand that exceeds potential GDP or by a supply-side shock or excise tax increase, raises credit costs and weakens consumer sentiment, thus putting the brakes on aggregate demand.

Expectations: The contributions to the model of the U.S. economy and its simulation properties of the rational expectations school are as rich as the data will support. Expectations (Sector VIII) impact several expenditure categories in IHS Markit's model of the U.S. economy, but the principle nuance relates to the entire spectrum of interest rates. Shifts in price expectations or the expected capital needs of the government are captured through price expectations and budget deficit terms, with the former impacting the level of rates throughout the maturity spectrum, and the latter impacting intermediate and long-term rates, and hence affecting the shape of the yield curve. On the expenditure side, inflationary expectations impact consumption via consumer sentiment, while growth expectations affect business investment.

3. IHS Markit's Industrial Output and Employment by Industry Models

Industrial Output Model overview

The Industrial Output Model is a combination input-output/stochastic model of activity for 73 industries and service sectors in the United States. The model estimates the real value of shipments, or revenue, as a measure of output for each sector. The output level generated in the Industrial Output Model reflects a level of domestic production that is consistent with the economic expenditures generated in IHS Markit's model of the U.S. economy. Table A11 in Appendix A on page 86 identifies the economic expenditure categories driving the Industrial Output Model. Table A12 in Appendix A on page 88 lists the nonmanufacturing and manufacturing industries modeled in the Industrial Output and Employment Models. In addition, this table maps the codes for each industry as used by IHS Markit, the North American Industry Classification System (NAICS) and NEMS.

The industrial and service sectors are defined according to NAICS codes. The industry details follow the manufacturing industries reported by the Department of Commerce in its monthly Manufacturers' Shipments, Inventories and Orders survey. Details are mostly three or four-digit NAICS aggregations with some disaggregation beyond four digits. The non-manufacturing industries and the service sectors are two, three or four-digit NAICS aggregations. The real value of shipments is based in 2009 dollars, compatible with the 2009-based final demands from the model of the U.S. economy.

The input-output block of the model translates macroeconomic estimates from IHS Markit's model of the U.S. economy into demand by industry. All other model concepts are projected by statistical equations and identities.

The model projections are at an annual frequency. Historical data supporting the model are, for the most part, quarterly series released by various government agencies typically within a few months of the observation. All data, unless otherwise specified, are seasonally adjusted at annual rates.

The input-output block

Standard input-output analysis proceeds in two steps. First, the vector of economic expenditures from the Macroeconomic Model (the components of GDP) is converted into a vector of industrial deliveries to final demand. This conversion is represented for any time period as

$$F = H * G,$$

where

F = vector of industrial deliveries to final demand;

H = benchmark bridge matrix recording the industrial composition of each expenditure category; and

G = vector of the real final expenditure components of GDP.

A dynamic bridge matrix, constructed from the 2007 input-output table[1] that was based on the NAICS and the standard model known as the RAS algorithm[2,3] was implemented to perform an I/O extension from the 2007 baseline to the end of the forecast using the BEA Intermediate Demand Tables to the most recent history year[1], is used in this step. Once the final demand vector, F, has been calculated, standard input-output techniques are used to derive estimates of the industrial output required to produce this bill of goods for final use. According to the basic input-output model, intermediate inputs, industrial deliveries to final demand and gross output are related as follows:

$$A * X + F = X,$$

where

A = matrix of direct input coefficients describing the amount of each input industry's product required per unit of industrial output; and

X = vector of gross output by industry.

This equation can be considered an equilibrium condition; that is, total demand equals total supply. The product A * X is equal to intermediate demand, and F is equal to final demand. The sum of the two is total demand; which, in equilibrium, is equal to total supply or production.

Following standard input-output conventions, it is assumed that the technology of production as reflected by the matrix of direct input coefficients, A, remains relatively stable over time. This inter-industry matrix also uses 2007 baseline values extended to the end of the forecast using RAS methodology[2, 3] and North American Industrial Classification System and uses the 2007 Input-Output benchmark accounts[1]. The RAS method accounts for the effects of absorption, commodity substitutions, and production process changes with aggregate data sets available more frequently for recent history. The basic input-output equation is then solved for output:

$$X = \frac{F}{I - A}.$$

This equation describes the relationship between final demand and industrial output levels that would be required to deliver this bill of goods under the restrictive assumptions detailed above. The vector *X* should equal total demand and supply for each industry, in equilibrium. In the Industrial Output Model, 132 industries satisfy 59 macroeconomic final demands.

Revenue/output for manufacturing industries

Industry revenues are measured in billions of constant dollars and are available for each of the manufacturing industries in the model. The current dollar historical series are annual averages of the BEA's quarterly GDP by industry that are converted to annual rates. Constant dollar historical values are

[1] U.S. Bureau of Economic Analysis, *Benchmark Input-Output Accounts of the U.S. Economy, 2007*, http://bea.gov/newsreleases/industry/io/ionewsrelease.htm.

[2] Morrison and Smith, 1974, "Nonsurvey input-output techniques at the small area level: An evaluation", Journal of Regional Science Vol. 14 No. 1

[3] O'connor and Henry, 1975, "Input-output analysis and its applications", London and High Wycombe

the current dollar series deflated using each industry's price index. These indexes are computed outside of the model by IHS Markit's U.S. Industry Service, which produces short-term industry forecasts. To attain consistency with the economic variables in the Macroeconomic Model, industry revenues are converted into constant 2009 dollars during initial model estimation.

Constant-dollar revenue by industry is modeled as a function of total demand from the input-output analysis, relative prices, cyclical variables and a time trend. The functional form used imposes a unitary elasticity on the demand term, which embodies most of the explanatory power of the equations. Generally, the economic expenditure categories from the Macroeconomic Model have incorporated in them the effect of changes in prices. However, a relative price variable is used in select industries to explicitly capture the industry-specific effect of changes in producer prices.

Additional non-demand terms are included in the equation used to explain patterns not well accounted for by the input-output model and its demand cyclicality and technological change indicators. Macroeconomic variables feed down into the Industrial Output Model equations through demand, but these weighted demand terms are in most cases smoother and less cyclical than industrial production indexes. Therefore, cyclical variables, such as capacity utilization, housing starts, unemployment rate, or interest rates, are included in most equations. Cyclical variables were chosen with care to reflect the appropriate business cycle for each industry.

The functional form of the estimator of the ratio of revenues to output, as well as the specific cyclical variables used, may vary by industry. The general form of the estimator is given by

$$\log\left(\frac{R_{ind}}{D_{ind}}\right) = f\big(\log(x), y_1, \dots, y_j, \log(p_1), \dots, \log(p_k), g(t)\big),$$

where

R_{ind} = constant dollar revenue for industry ind;

D_{ind} = total input-output demand for industry ind;

x = cyclical variable;

$y_1, \dots, y_j$ are other cyclical variables selected for industry ind;

$p_1, \dots, p_k$ are relative prices; and

$g(t)$ = trend term.

Output is measured in real dollars for all industries except two. Rapid increases in computer technology in the last two decades have led to sharp declines in the quality-adjusted price deflators for computer manufacturing (NAICS 3341) and semiconductor manufacturing (NAICS 334413). This in turn results in steep increases in the industries' real dollar output measures. This makes the real output value an inappropriate proxy for volume measure. Consequently, nominal dollars rather than real dollars are used for these two sectors.

The revenue equations of industries affected by energy prices, and are therefore influenced by NEMS price variables, are listed below. Specifically, certain bulk chemicals are directly affected by the relative price of natural-gas-based feedstock (primarily ethane) and oil-based feedstock (primarily naphtha), which are explicitly included in the revenue equations.

NAICS Code	Industry	Price
3115	Food: Dairy	Natural gas
32511a9	Bulk chemicals: Organic	Feedstocks
3252	Bulk chemicals: Resins	Feedstocks
3253	Bulk chemicals: Agriculture	Natural gas
325o	Other chemicals	Natural gas
326	Plastic products	IFPP
32731	Cement	IFPP
3311a2	Iron and steel	IFPP
3313	Aluminum	Electricity
331o	Other primary metals	IFPP
335	Electrical equipment and appliances	Electricity
336	Transportation equipment	Natural gas

Index of Fuel and Purchased Power (IFPP): a combination of oil, natural gas, coal and electricity prices

On rare occasions it becomes necessary to adjust industry output using analyst judgement manually. The current model includes these adjustments for the pulp and paper industry (NAICS 322) based on research[4].

Revenue/output for non-manufacturing industries/services

For non-manufacturing industries and service sectors, sales revenue is the main activity indicator available. Historical data are collected primarily from the Bureau of Labor Statistics and BEA. The common criterion for the data is that conceptually it should be as close as possible to the measure of value of production or total gross output, rather than value added, and the current dollar measure is roughly equivalent to revenue.

Estimates of the revenue to output ratios for non-manufacturing industries are calculated from equations of the same form as those used for manufacturing industries:

$$\log\left(\frac{R_{ind}}{D_{ind}}\right) = f\left(\log(x), y_1, \ldots, y_j, \log(p_1), \ldots, \log(p_k), g(t)\right),$$

where

R_{ind} = constant dollar revenue for industry ind;

D_{ind} = total input-output demand for industry ind;

[4] J. Ralbovsky, "Domestic Industrial Paper Projections: Uncertainty and Inconsistency in Major Economic Models", U.S. Energy Information Administration 2017, available upon request.

x = cyclical variable;

$y_1, \ldots, y_j$ are other cyclical variables selected for industry ind;

$p_1, \ldots, p_k$ are relative prices; and

$g(t) =$ trend term.

Aggregation to the NEMS sectors

The sectoral classification in the MAM is more aggregate than IHS Markit's classification. It comprises 48 industrial sectors and ten service sectors. Of the 48 industrial sectors, 41 are manufacturing sectors and seven are non-manufacturing industrial sectors. Five of the sectors are energy sectors. For these energy sectors, production estimates are available from other NEMS modules and their projected growth rates are applied to the historical data in place of the MAM's model estimate.

One of the main users of the output values is the NEMS's Industrial Demand Module (IDM). In that module, the 48 industries are further aggregated into 26 categories. Below is a list of the 58 industries maintained in the MAM and their corresponding IDM categories. The concordance between IHS Markit's codes and the 58 industries is presented in Table A12 in Appendix A on page 88.

NEMS Macroeconomic Activity Module	NEMS Industrial Demand Module
Manufacturing Industries:	
Food products (sum of next four)	Food products
Grain and oilseed milling	NA
Dairy products	NA
Animal slaughter and seafood products	NA
All other food products	NA
Beverage and tobacco products	Balance of manufacturing
Textile mills and products, apparel, and leather products	Balance of manufacturing
Wood products	Wood products
Furniture and related products	Balance of manufacturing
Pulp and paper products (sum of the next three)	Paper and allied products
Pulp and paper mills	NA
Paperboard and container	NA
All other paper and allied products	NA
Printing	Balance of manufacturing
Basic inorganic chemicals	Inorganic chemicals
Basic organic chemicals	Organic chemicals
Ethanol	NA
Plastic and synthetic rubber materials	Resins
Agricultural chemicals	Agricultural chemicals
Other chemical products (sum of next four)	Balance of manufacturing
Pharmaceuticals and medicines	NA
Paints, coatings, and adhesives	NA

Soaps and cleaning products	NA
Other chemical products	NA
Petroleum refineries *	Petroleum refining
Other petroleum and coal products	Balance of manufacturing
Plastics and rubber products	Plastics and rubber products
Glass and glass products	Glass and glass products
Flat glass manufacturing	NA
Cement manufacturing	Cement
Lime and gypsum manufacturing	Lime
Other non-metallic mineral products	Balance of manufacturing
Iron and steel mills, ferroalloy and steel products	Iron and steel
Alumina and aluminum products	Aluminum
Other primary metals	Balance of manufacturing
Fabricated metal products	Fabricated metal products
Machinery	Machinery
Other electronic and electric products	Computer and electronic products
Transportation equipment	Transportation equipment
Measuring and control instruments	Electrical equip., appliances and components
Miscellaneous manufacturing	Balance of manufacturing
Non-manufacturing Industries:	
Crop production	Agriculture production – crops
Animal production	Agriculture production – animals
Forestry	Added to other agriculture
Other agriculture, fishing and hunting	Other agriculture including Forestry
Coal mining *	Coal mining
Oil and gas extraction and support activities *	Oil and gas extraction
Other mining and quarrying	Metal and other non-metallic mining
Construction	Construction

NEMS Macroeconomic Activity Module	**NEMS Industrial Demand Module**
Services:	
Transportation and warehousing	NA
Broadcasting and telecommunications	NA
Electric power generation and distribution *	NA
Natural gas distribution *	NA
Water, sewage and related systems	NA
Wholesale trade	NA
Retail trade	NA
Finance and insurance, real estate	NA
Other services	NA

Public administration	NA

* Energy sectors that come from other NEMS modules

Employment by Industry Model Overview

The Employment Model determines employment in 37 industries and service sectors in the United States (see Table A12 in Appendix A on page 88), consistent with the projection of non-farm employment (EEA) from the Macroeconomic Model. Industrial output, relative factor prices and productivity, and average workweek trends are the key determinates of industrial employment. Real outputs in the industries are from the Industrial Output Model. Productivity trends, average workweek trends, labor compensation, capital service cost determinants, other factor prices, and cyclical variables are determined in the Macroeconomic Model.

The basic behavioral equations in the Employment Model are the total manufacturing employment (EMF) and unconstrained employment (XXX_E{ind}) equations for each of the detailed industries (ind). Employment is based upon production theory. Consistent with production theory, the key determinant of employment by industry is industrial output. Both current and lagged output values enter in the employment specification, reflecting the tendency of firms to hire employees in response to lagged output growth and to lay off employees in response to lagged output declines. The labor-to-output ratio varies with changes in relative factor prices, productivity, the national average workweek, cyclical factors and technological change. Relative factor prices are represented by labor cost, capital cost, energy and other factor prices and interest rates. National productivity trends and industry-specific time trends are used to capture changes in the employment-to-output relationship due to technological advances. Change in the average length of the workweek also alters this relationship. Some industries' workweek tends to increase relative to the national average with declines in the cyclical unemployment rate and with increases in manufacturing capacity utilization rates. Both factors cause industries to increase their utilization of existing labor.

Total non-farm, private non-farm, and government employment

Projections for total non-farm (EEA) and government federal and state and local employment (EG91 and EGSL) are established in the Macroeconomic Model. Private non-farm employment (EEAPIO) is determined by subtracting government employment from total non-farm employment:

$$EEAPIO = EEA - EG91 - EGSL.$$

Manufacturing employment

The model assumes that changes in total manufacturing employment are directly proportional to current and lagged changes in manufacturing output and inversely proportional to increases in current and lagged manufacturing productivity:

$$\begin{aligned}\Delta\log(EMF) = A &+ (1-B_2)*\Delta\log(MfgOutput)\\ &+(1-B_1)*\Delta\log(MfgProductivity)\\ &+B_1*\Delta\log\left[@movavg\left(MfgProductivity_{-1,15}\right)\right]\\ &+B_2*\Delta\log\left[@movavg\left(MfgOutput_{-1,3}\right)\right],\end{aligned}$$

where

Δ is the first difference operator, i.e.,$\Delta x_t = x_t - x_{t-1}$, where t is the reference year;

$@movavg$ is a lagged moving average operator defined by

$$@movavg\left(x_{-j,n}\right) = \frac{\sum_{k=j}^{n+j-1} x_{t-k}}{n};$$

$EMF =$ manufacturing employment;

$MfgOutput =$ real dollar value of manufacturing output;

$MfgProductivity =$ labor productivity for the manufacturing sector

$\equiv JQPCMHM * HPMF,$

where

$JQPCMHM =$ index for output per hour in manufacturing, and

$HPMF =$ average weekly hours in manufacturing.

Output is measured in 2009 dollars for all industries except for two aggregates (see Table B-6 in Appendix B on page 112).

Employment in each manufacturing industry is first estimated independent of total manufacturing employment. Unconstrained manufacturing industry employment is modeled as a function of current and lagged output, manufacturing productivity and average workweek, relative factor prices, and such cyclical variables as the unemployment rate and capacity utilization rates (with the sum of the elasticities on current and lagged values set equal to 1).

$$\Delta \log\left(\frac{XXX_{E\{ind\}}}{\left[\frac{R\{ind\}R}{LaborProductivity}\right]}\right) = A + B_1 * \Delta \log\left[\frac{@movavg\left(LaborProductivity_{-j,n}\right)}{LaborProductivity}\right]$$
$$+B_2 * \Delta \log\left[\frac{@movavg\left(R\{ind\}R_{-j,n}\right)}{R\{ind\}R}\right]$$
$$+B_3 * \Delta \log(RelativeFactorPrices)$$
$$+B_4 * \Delta(Cyclical\ Variable),$$

where

Δ is the first difference operator, i.e., $\Delta x_t = x_t - x_{t-1}$, where t is the reference year;

$@movavg$ is a lagged moving average operator defined by

$$@movavg\left(x_{-j,n}\right) = \frac{\sum_{k=j}^{n+j-1} x_{t-k}}{n};$$

$XXX_{E\{ind\}} =$ employment in industry *ind*;

$R\{ind\}R =$ real dollar value of output of industry *ind*;

$RelativeFactorPrices =$ ratio of labor compensation in non-farm business to relevant producer prices (or energy prices, for energy-intensive industries);

$$LaborProductivity = \begin{cases} JQPCMHMD * HPMD, & \text{if } ind \text{ is durable manufacturing} \\ JQPCMHMN * HPMN, & \text{if } ind \text{ is non-durable manufacturing,} \end{cases}$$

where

$JQPCMHMD(N) =$ index for output per hour in durable (non-durable) manufacturing, and

$HPMD(N) =$ average weekly hours in durable (non-durable) manufacturing.

The parameters j and n used in computing the moving averages may vary by industry.

Unconstrained manufacturing employment (*XXX_EMF*) is computed by summing unconstrained employment across the manufacturing industries.

The difference between the manufacturing employment total computed in the first step (*EMF*) and the unconstrained total (*XXX_EMF*) is denoted by *EMRESID*. Employment in each manufacturing industry (*E*{*ind*}) is set equal to its unconstrained employment plus a share of the difference between the employment total and the unconstrained total (*EMRESID*):

$$EMRESID = EMF - XXX_{EMF};$$

$$E\{ind\} = XXX_{E\{ind\}} + EMRESID * \left(\frac{XXX_{E\{ind\}}}{XXX_{EMF}}\right).$$

This estimation process ensures that the sum of the detailed manufacturing industries is consistent with the aggregate EMF. The value of EMRESID is within one percent of EMF, indicating that the alignment process does not distort the calculation results in any significant way.

Non-manufacturing employment

Employment in each non-manufacturing industry or service sector is modeled in a two-step process similar to that for manufacturing industrial employment. That is, unconstrained non-manufacturing employment (*XXX_E{ind}*) is modeled as a function of current and lagged output, non-farm productivity and average workweek, relative factor prices, and such cyclical variables as the unemployment rate and capacity utilization rates (with the sum of the elasticities on current and lagged values set equal to 1).

$$\Delta \log\left(\frac{XXX_{E\{ind\}}}{\left[\frac{R\{ind\}R}{LaborProductivity}\right]}\right) = A + B_1 * \Delta \log\left[\frac{@movavg\left(LaborProductivity_{-j,n}\right)}{LaborProductivity}\right] + B_2 * \Delta \log\left[\frac{@movavg\left(R\{ind\}R_{-j,n}\right)}{R\{ind\}R}\right] + B_3 * \Delta \log(RelativeFactorPrices) + B_4 * \Delta(CyclicalVariable),$$

where

Δ is the first difference operator, i.e., $\Delta x_t = x_t - x_{t-1}$, where *t* is the reference year;

$@movavg$ is a lagged moving average operator defined by

$$@movavg\left(x_{-j,n}\right) = \frac{\sum_{k=j}^{n+j-1} x_{t-j}}{n};$$

$XXX_{E\{ind\}} =$ employment in industry *ind*;

$R\{ind\}R =$ real dollar value of output of industry *ind*;

$RelativeFactorPrices =$ ratio of labor compensation in non-farm business to relevant producer prices (or energy prices, for energy-intensive industries);

$$LaborProductivity = \begin{cases} JQPCMMHM * HPMF, & \text{if } ind \text{ produces manufacturing inputs} \\ JQPCMHNF * HRNFPRI, & \text{otherwise,} \end{cases}$$

where

$JQPCMHM =$ index for output per hour in manufacturing;

$HPMF =$ average weekly hours in manufacturing;

$JQPCMHNF =$ index for output per hour in non-farm business; and

$HRNFPRI =$ average weekly hours in non-farm business.

The parameters j and n used in computing the moving averages may vary by industry. Unconstrained private non-farm employment (*XXX_EEAPIO*) is computed by summing unconstrained non-manufacturing employment by sector and total manufacturing employment.

The difference between total private non-farm employment and this unconstrained total (*XXX_EEAPIO*) is denoted by *EEAPRESID*. Employment in each non-manufacturing industry (*E{ind}*) is set equal to its unconstrained employment plus a share of EEAPRESID:

$$EEAPRESID = EEAPIO = XXX_{EEAPIO};$$

$$E\{ind\} = XXX_{E\{ind\}} + EEAPRESID * \left(\frac{XXX_{E\{ind\}}}{XXX_{EEAPIO} - EMEMFG}\right).$$

The value of *EEAPRESID* is within one percent of *EEAPIO*, indicating that calculation results from the employment model match fairly well with the aggregated employment projection from the Macroeconomic Model.

Total non-farm employment within the Employment Model (*EEAIO*) is defined as the sum of all employment other than agricultural employment. *EEAIO* should match the level of non-farm employment (*EEA*) derived in the Macroeconomic Model, except for rounding errors.

$$EEAIO = EMF + ENM + EMIN + E23 + EG91 + EGSL$$

$$= EEA,$$

where

$EMF =$ manufacturing employment;

$ENM =$ sum of employment in the service sectors;

$EMIN =$ employment in the mining sector;

$E23 =$ employment in the construction sector;

$EG91 =$ federal government employment; and

$EGSL =$ state and local government employment

Aggregation to the NEMS sectors

As in the case of industrial output, employment estimates are also aggregated to the coarser level of the NEMS categories. The classification for employment is the same as that for output (see Page 21), except that the public sector is further disaggregated into two categories – Federal Government, and State and Local Government.

Among the five energy sectors, employment projections for coal mining and for oil and gas extraction are available from other NEMS Modules. Their estimated growth rates are applied to the historical data in place of the MAM calculations (Table B4 in Appendix B on page 109).

4. U.S. Energy Information Administration's Regional Models

Overview

Economic concepts below the national level are required by NEMS demand modules. The level of regional detail is defined by the nine Census Divisions:

1. New England (NENG)
2. Middle Atlantic (MATL)
3. South Atlantic (SATL)
4. East North Central (ENC)
5. East South Central (ESC)
6. West North Central (WNC)
7. West South Central (WSC)
8. Mountain (MTN)
9. Pacific (PAC)

A suite of regional models has been developed to provide projections for the following concepts by Census Divisions:

1. Macroeconomic variables – population, economic activity, prices and wages
2. Industry variables – output and employment by sector
3. Building variables – residential housing starts and commercial floor space rates of growth

The regional models are downstream models in the Macroeconomic Activity Module. That is, they run after the national models. There is no feedback mechanism to revise the national estimates based upon the regional results. Instead, an alignment process is introduced to calibrate the regional calculations so that the sum of the regional estimates equals the corresponding national estimate, if the national model computes the latter. This "top-down" approach is adopted because only selected macroeconomic variables are covered in the regional models, and because the national variables are used as explanatory variables. Without a complete regional economic framework, it is not possible to adopt a "bottom-up" approach for selected variables.

Detailed descriptions of the variables are listed in Tables A13-A15 in Appendix A on pages 91 through 94.

Detailed structural forms and coefficients for the regional models are presented in Appendix C.

Macroeconomic variables

The following macroeconomic concepts are projected for each of the nine Census Divisions:

1. Population
2. Real Gross State Product
3. Real Personal Disposable Income
4. Personal Income Tax
5. Personal Income Tax Rate
6. Personal Income
7. Wage and Salary Disbursements
8. Manufacturing and Non-manufacturing Wages
9. Consumer Price Index

Estimates of the two population variables are based on population projections published by the U.S. Census Bureau. The other variables are calculated in the regional macroeconomic model. The regional model is a quarterly model with historical data beginning as early as 1970. It uses inputs from the U.S. model and supplies outputs to the regional industrial output and employment models. Model equations are listed in Appendix C1 of Appendix C beginning on page 132.

Population

Forecasts of the population series are exogenous to the NEMS. For the AEO2018, the source of the historical population data is the U.S. Census Bureau. IHS Markit's February 2010 forecast is the source of the regional population shares. To get Census Division population projections, the February 2010 regional share is applied to the IHS Markit's November 2015 national population projection.

Gross state product

The MAM projects gross regional product in real per capita terms. The equations are in log form. There is an estimated equation for each of the nine Census Divisions. Explanatory variables include lags of state-level and domestic national-level gross product. The general form of the gross regional product equations is

$$\Delta\log\left[\frac{GSPRZNP_d(t)}{GDPRZNP(t)}\right] = b1_d * \log\left[\frac{GSPRZNP_d(t-1)}{GDPRZNP(t-1)}\right] + b2_d * @movav\left[\log\left(\frac{GSPRZNP_d(t-1)}{GDPRZNP(t-1)}\right), 3\right],$$

where

d = 1 to 9 Census Divisions;

$b1_d, b2_d$ = estimated coefficients for the explanatory variables in the equation for gross regional product, for region d;

$GDPRZNP(t)$ = real per capita gross domestic product for quarter t, in billions of 2009 dollars, national; and

$GSPRZNP_d(t)$ = real per capita gross regional product for quarter t, in billions of 2009 dollars, for region d.

$@movavg$ is a lagged moving average operator defined by

$$@movavg(x_{-j,k}) = \frac{\sum_{l=j}^{k+j-1} x_{t-l}}{k}.$$

Historical data for real gross state product comes from the Bureau of Economic Analysis. The last historical data is for the fourth quarter of 2009. The remaining data comes from IHS Markit's December 2010 forecast. The EViews software uses a quadratic-match average method to convert the data from annual to quarterly intervals. The real gross domestic product data comes from IHS Markit's model of the U.S. economy. Quarterly gross domestic product is available for 1959 and later years, in billions of 2009 dollars. IHS Markit uses real gross domestic product data from the Bureau of Economic Analysis. The equations were estimated using least squares. The sample range was from 1990 to 2015. The sample includes almost 100 observations.

Income and taxes

Regional disposable income is in real terms and is estimated by allocating the national forecast to the Census Divisions using shares. There is an equation for each of the nine Census Divisions. The general form of the real disposable income equations is

$$YPDR_d(t) = YPDR(t) * \frac{YPDR\_IHSGI_d(t)}{\sum_{d=1}^{9} YPDR\_IHSGI_d(t)},$$

where

d = 1 to 9 Census Divisions;

$YPDR_d(t)$ = real disposable income for quarter t, in billions of 2009 dollars, for region d;

$YPDR\_IHSGI_d(t)$ = IHS Global Insight forecast of real disposable income for quarter t, in billions of 2009 dollars, for region d;

$YPDR(t)$ = real disposable income for quarter t, in billions of 2009 dollars, national;

Nominal personal disposable income is personal income less taxes. Regional nominal personal disposable income is computed by allocating the national forecast to the Census Division using shares.

$$YPD_d(t) = YPD(t) * \frac{YPD\_IHSGI_d(t)}{\sum_{d=1}^{9} YPD\_IHSGI_d(t)},$$

where

d = 1 to 9 Census Divisions;

$YPD_d(t)$ = personal disposable income for quarter t, in billions of dollars, for region d.

$YPD\_IHSGI_d(t)$ = IHS Global Insight forecast of personal disposable income for quarter t, in billions of dollars, for region d.

$YPD(t)$ = personal disposable income for quarter t, in billions of dollars, national;

Personal income is the sum of wage and salary disbursements by government and by the private sector plus income from other sources. Regional nominal personal income is computed by allocating the national forecast to the Census Divisions using shares.

$$YP_d(t) = YP(t) * \frac{YP\_IHSGI_d(t)}{\sum_{d=1}^{9} YP\_IHSGI_d(t)},$$

where

d = 1 to 9 Census Divisions;

$YP_d(t)$ = personal income for quarter t, in billions of dollars, for region d.

$YP\_IHSGI_d(t)$ = IHS Global Insight forecast of personal income for quarter t, in billions of dollars, for region d.

$YP(t)$ = personal income for quarter t, in billions of dollars, national;

Other personal income (non-wage and non-salary) is the difference between personal income and total wage and salary disbursements. This is computed for each of the Census Divisions.

$$YPOTH_d(t) = YP_d(t) - YPCOMPWSD_d(t),$$

where

d = Census Division (1 through 9);

$YPOTH_d(t)$ = other personal income for quarter t, in billions of dollars, for region d.

$YP_d(t)$ = personal income for quarter t, in billions of dollars, for region d.

$YPCOMPWSD_d$ = total wage and salary disbursements in billions of dollars, for region d;

The Bureau of Economic Analysis (BEA) provides quarterly historical income data at the regional level for 1970 and subsequent years. Nominal income series, measured in billions of dollars, are adjusted to reflect real income in billions of 2009 dollars. IHS Markit's model of the U.S. economy extends the national-level BEA series back to 1959, in both current and 2009 dollars, on a quarterly basis.

Personal income tax is the difference between personal and disposable incomes. IHS Markit's model of the U.S. economy provides quarterly national-level data on personal and disposable incomes, in billions of dollars, for 1959 and subsequent years. These are based on BEA data. The personal tax rate is the share of personal income paid in taxes. The model uses BEA's personal and disposable income figures, at the national and Census Division levels, to compute historical national and regional tax rates. Quarterly historical data are available for 1970 and subsequent years.

The model computes tax rates at the national level.

$$TAX(t) = YP(t) - YPD(t),$$

$$TAXRATE(t) = \frac{TAX(t)}{YP(t)},$$

where

d = Census Division (1 to 9);

TAX = personal income tax, in billions of dollars, national;

$TAXRATE$ = personal income tax rate, as a proportion, national;

YP = personal income, in billions of dollars, national;

YPD = disposable income, in billions of dollars, national;

Wage and Salary Disbursements

The model computes total, private and government salary disbursements at the Census Division level by allocating the national wage and salary disbursements using shares. Wage and salary disbursements are measured in billions of dollars.

$$YPDCOMPWSD_d(t) = YPDCOMPWSD(t) * \frac{YPDCOMPWSD\_IHSGI_d(t)}{\sum_{d=1}^{9} YPDCOMPWSD\_IHSGI_d(t)},$$

$$YPDCOMPWSDP_d(t) = YPDCOMPWSDP(t) * \frac{YPDCOMPWSDP\_IHSGI_d(t)}{\sum_{d=1}^{9} YPDCOMPWSDP\_IHSGI_d(t)},$$

$$YPDCOMPWSDG_d(t) = YPDCOMPWSDG(t) * \frac{YPDCOMPWSDG\_IHSGI_d(t)}{\sum_{d=1}^{9} YPDCOMPWSDG\_IHSGI_d(t)},$$

where

d = Census Division (1 to 9);

$YPCOMPWSD_d$ = total wage and salary disbursements in billions of dollars, for region d;

$YPCOMPWSD\_IHSGI_d$ = IHS Global Insight forecast of total wage and salary disbursements in billions of dollars, for region d;

$YPCOMPWSD$ = total wage and salary disbursements in billions of dollars, national;

$YPCOMPWSDG_d$ = government wage and salary disbursements in billions of dollars, for region d;

$YPCOMPWSDG\_IHSGI_d$ = IHS Global Insight forecast of government wage and salary disbursements in billions of dollars, for region d;

$YPCOMPWSDG$ = government wage and salary disbursements in billions of dollars, national d;

$YPCOMPWSDP_d$ = private wage and salary disbursements in billions of dollars, for region d;

$YPCOMPWSDP\_IHSGI_d$ = IHS Global Insight forecast of private wage and salary disbursements in billions of dollars, for region d;

$YPCOMPWSDP$ = private wage and salary disbursements in billions of dollars, national.

Quarterly data on wage and salary disbursements for all Census Divisions are available from the BEA for 1970 and subsequent years. The model uses quarterly national wage and salary disbursements data from IHS Inc.'s model of the U.S. economy. These data are available for all quarters beginning with 1959.

The Bureau of Labor Statistics (BLS) publishes the Employment Cost Index (ECI) as well as data on hours worked. The EIA regional model uses these quarterly data as provided by the IHS Markit's model of the U.S. economy. The ECI data series begins with the first quarter of 1975, while the data series on hours worked in non-farm establishments goes back to 1964.

Refer to the previous section "Gross State Product" on page 33 for the description of regional and national population.

Manufacturing and non-manufacturing wages

The model projects regional average annual manufacturing wages in nominal terms. The regional estimation equations use a first difference log formulation with the private sector wage and salary employment cost index as an explanatory variable. The general form of the average annual manufacturing wages equations is

$$\Delta \log(RWM_d(t)) = b1_d * \Delta \log(JECIWSP(t)),$$

where

d = Census Division (1 to 9);

$b1_d$ = estimated regression coefficient for the explanatory variable in the equation for average annual manufacturing wages, for region d;

$JECIWSP(t)$ = employment cost index, private sector wages and salaries, index – December 2005 = 1.0, national;

$RWM_d(t)$ = average annual manufacturing wages, in thousands of dollars, for region d; and

Δ = first difference operator, i.e., $\Delta x_t = x_t - x_{t-1}$, where t is the reference year.

The historical average annual manufacturing wage estimates are computed from BEA's quarterly manufacturing wage data, which are available by Census Division for 1970 and subsequent years. The employment cost index for private sector wages and salaries comes from IHS Markit's model of the U.S. economy. The historical employment cost index is quarterly beginning in 1975 and is an index with December 2005 = 1.0.

For non-manufacturing wages, the model uses data from the same sources, and the equation is analogous:

$$\Delta \log(RWNM_d(t)) = b1_d * \Delta \log(JECIWSP(t)),$$

where

d = Census Division (1 to 9);

$b1_d$ = estimated regression coefficient for the explanatory variable in the equation for average annual manufacturing wages, for region d;

$JECIWSP(t)$ = employment cost index, private sector wages and salaries, index – December 2005 = 1.0, national;

$RWNM_d(t)$ = average annual non-manufacturing wages, in thousands of dollars, for region d; and

Δ = first difference operator, i.e., $\Delta x_t = x_t - x_{t-1}$, where t is the reference year.

Consumer price index

For each Census Division, the model estimates a Consumer Price Index (CPI) by applying a regional share to the national CPI. The base year for the index is 1982-84 = 1.0.

$$CPI_d(t) = CPI(t) * \frac{CPI\_IHSGI_d(t)}{\sum_{d=1}^{9} CPI\_IHSGI_d(t)},$$

where

d = Census Division (1 to 9);

$CPI_d(t)$ = estimated CPI (all urban consumers, base = 1982-84) for Census Division for region d; and

$CPI\_IHSGI_d(t)$ = IHS Global Insight forecast of estimated CPI (all urban consumers, base = 1982-84) for Census Division for region d; and

$CPI(t)$ = national CPI (all urban consumers, base = 1982-84).

The source for the regional and national consumer price index is IHS Markit. The historical national index is quarterly beginning in 1959, and the average of the index from 1982 to 1984 is 1.0. The historical regional index is quarterly beginning in 1982, and the average of the index from 1982 to 1984 is 1.0. IHS Markit's source for the national consumer price index is the Bureau of Labor Statistics.

Industry variables

The industry block of the Regional Model estimates values of 48 industrial output sectors and of 27 employment by industry sectors as well as ten service sectors for each of the nine Census Divisions. Table A14 in Appendix A on page 85 lists the descriptions of the sectors and the corresponding NAICS codes.

Historical value of shipments and employment data for the manufacturing sectors are from the Economic Census databases, Annual Survey of Manufacturing databases, and the Bureau of Labor Statistics. As for the non-manufacturing and service sectors, gross state product and employment data from the BEA (http://www.bea.gov/regional/rims/) are used to supplement the value of output and employment data from the Economic Census, which covers all sectors.

Output

Regional output shares are purchased from IHS Markit and applied to the national-level real output values in constant 2009 dollars from the national industry model. Sectoral price information at the region level are not available to EIA.

$$RealOutputValue_{x,d}(t) = RealOutputValue_{x,national}(t) * Share_{x,d}(t),$$

where

d = Census Division (1 to 9); and

x = industrial or service sector

The start year for estimation is 1997. Historical data for all equations ends in 2017. So, in general there is twenty years of data per Census Division.

Employment

Regional employment shares are purchased from IHS Markit and applied to the national-level employment values the national employment model.

$$Employment_{x,d}(t) = Employment_{x,national}(t) * Share_{x,d}(t),$$

where

d = Census Division (1 to 9); and

x = industrial or service sector

The start year for estimation is 1997. Historical data for all equations ends in 2017. So, in general there is twenty years of data per Census Division.

Building variables

Other regional variables required by the NEMS Demand Modules are housing starts and commercial floor space rates of growth.

Housing Starts:

1. Single Family Housing Starts
2. Multi-Family Housing Starts
3. Mobile Home Shipments

Commercial floor space (rates of growth) types:

1. Stores – stores and restaurants
2. Warehouse – manufacturing and wholesale trade, public and federally-owned warehouses
3. Office – private, federal, and state and local offices
4. Automotive – auto service and parking garages
5. Manufacturing
6. Education – primary/secondary and higher education
7. Health – hospitals and nursing homes
8. Public – federal and state and local
9. Religious
10. Amusement
11. Miscellaneous, non-residential – transportation related and all other not elsewhere classified
12. Hotel – hotels and motels
13. Dormitories – educational and federally-owned (primarily military)

Housing starts

The regional residential housing projection for single and multi-family housing starts and for mobile home shipments are done using shares supplied by the NEMS's Residential Module manager. The shares are derived from annual changes in regional population relative to that for the nation. Population estimates are exogenous to the MAM models. Starts and shipments are measured in millions of units. Beginning in 2002, there is an annual share value for single and for multi-family housing starts as well as for mobile home shipments in each of the nine Census Divisions. The shares are applied to the respective national total from IHS Markit's model of the U.S. economy. Historical data for housing starts and manufactured housing shipments are quarterly and begin in 1959. The Census Bureau is IHS Markit's source for single-family starts and manufactured housing shipments. IHS Markit constructs estimates of multi-family housing starts. Since the frequency of the shares is annual and IHS Markit's U.S. and EIA's regional models are quarterly, the shares are converted to a quarterly frequency. Constant-match average (i.e., repeating the annual value for each quarter) is the method used in EViews to convert the frequency to quarterly from annual.

Commercial floor space

The Commercial Floor Space model of the MAM contains 170 equations of which 117 (corresponding to the 13 commercial floor space types in each of nine Census Division levels) project growth in national floor space stocks using historical data beginning in 1970. The remaining 53 equations are definitional. Of these equations, 36 sum to Census Division totals or to aggregates required by other NEMS modules. The final 17 equations sum to national totals by floor space type plus aggregates required by other NEMS modules.

The Commercial Floor Space model calculates the growth in the stocks of 13 floor space types in each of the 9 Census Divisions. The units are rates of growth in the stock of commercial floor space, and the frequency is annual. The annual growth rates in the stocks are written to the NEMS common block as the reported annual floor space estimate. Model equations are listed in Appendix C2 of Appendix C on page 136.

The commercial floor space model is a growth rate model. The endogenous variable is the second difference in the log of the stock of commercial floor space in thousands of square feet by floor space type. The explanatory variables include lagged values of growth in commercial floor space stocks, trends of growth in own commercial floor space stocks, real gross domestic product, consumption of goods and services, private non-residential fixed investment, interest rates, productivity, personal disposable income, and population. The general form of the estimated commercial floor space equations is as follows.

$$\Delta(\Delta\log(COMFLRSTK_i(t))) = intercept_i$$
$$+b1_i * \Delta(\Delta\log(COMFLRSTK(t-1))),$$
$$+b2_i * (\Delta log(COMFLRSTKTREND_i(t)) - \Delta\log(COMFLRSTK_i(t-1)))$$
$$+b3_i * \Delta log\left(\frac{CONSR(t)}{NP16A(t)}\right)$$
$$+b4_i * \Delta log\left(\frac{GDPR(t)}{NP16A(t)}\right)$$
$$+b5_i * \Delta log\left(\frac{IFNRER(t)}{NP16A(t)}\right)$$
$$+b6_i * \Delta log(JQPCMHFE(t))$$
$$+b7_i * \Delta log(RMCORPAAA(t))$$
$$+b8_i * \Delta log(YPDR(t)/NP16A(t))$$

where

i = commercial floor space type (1 to 13);

$COMFLRSTK_i(t)$ = stock of commercial floor space type i for quarter t; in thousands of square feet, national;

$COMFLRSTKTREND_i(t)$ = long-term trend of stock of commercial floor space type i for quarter t; in thousands of square feet, national;

$CONSR(t)$ = real consumer spending on all goods and services for quarter t, in billions of chained 2009 dollars, national;

$GDPR(t)$ = real gross domestic product for quarter t, in billions of chained 2009 dollars, national;

$IFNRER(t)$ = private fixed nonresidential investment for quarter t, in billions of chained 2009 dollars, national;

$JQPCMHFE(t)$ = full-employment productivity in nonfarm business for quarter t, index - 2009 = 100, national;

$NP16A(t)$ = population aged 16 and over for quarter t, millions of persons, national;

$RMCORPAAA(t)$ = yield on AAA-rated corporate bonds for quarter t; in percent per annum, national;

$YPDR(t)$ = disposable income for quarter t, in billions of chained 2009 dollars, national; and

Δ = first difference operator, i.e., $\Delta x_t = x_t - x_{t-1}$, where t is the reference year.

Part B. THE MAM INTERFACE WITH THE NEMS

5. Integrated simulations using the MAM

This section first describes the types of integrated simulations of the Macroeconomic Activity Module (MAM) within the National Energy Modeling System (NEMS). It then briefly lays out the setup of the models constituting the MAM and the aspects that are common to all the simulations. As indicated above, the set of models is designed to run in a recursive manner. EIA's version of IHS Markit's model of the U.S. economy, the Macroeconomic Model, provides estimates of over 1700 concepts spanning final demands, aggregate supply, prices, incomes, international trade, industrial detail, interest rates, and financial flows.

The Industrial Output Model takes the final demand projections from the Macroeconomic Model as inputs and provides projections of output for 73 industries, covering the entire economy, at the three and sometimes four-digit NAICS code levels. The Employment Model projects employment levels for 67 industries, based on the output projections from the Industrial Output Model, national wage rates, productivity trends, and average workweek trends from the Macroeconomic Model. The non-farm employment projections are calibrated to sum to the national total projected by the Macroeconomic Model. The Regional Model allocates the national totals of output and employment to the nine Census Divisions. The Commercial Floor Space Model calculates growth in regional floor space, by Census Division, for 13 commercial floor space types.

Integrated simulations of alternative energy conditions or events

The integrated NEMS projections center on estimating the state of the energy-economic system given a set of alternative energy conditions. Typically, the projections fall into the following five types of integrated NEMS simulations:

1. Reference case projection
2. Alternative world oil prices
3. Changes in or proposed energy fees or emissions permits
4. Proposed changes in Combined Average Fuel Economy (CAFE) standards or technology assumptions
5. Alternative macroeconomic growth cases

In these integrated NEMS simulations, estimated values for over 240 macroeconomic and demographic variables from MAM are passed to NEMS. After making any transformations required by the simulation, the modules of NEMS solve for demand, supply, and prices of energy over the projection period. These energy prices and quantities are then returned to MAM and a new calculation, Scenario 1, is solved in the MAM's U.S., Industrial Output, Employment by industry, Regional and Commercial Floor Space Models. Details of each type of integrated simulation are discussed below.

Reference projection: The development of the MAM's Reference case is an iterative process requiring many integrated simulations of the NEMS before global convergence is attained. But before the first integrated run can be done, it is necessary to create a baseline for the U.S. Model. Modifications are made to IHS Inc.'s model of the U.S. economy so that it includes EIA's assumption about the path of the

world oil price. The results of this model solution become the preliminary baseline, Scenario 0, of the U.S. Model.

At this point, the MAM is included in integrated simulations of the NEMS. Energy market conditions as supplied by the modules of the NEMS are assumptions exogenous to the U.S. Model. The U.S. Model is simulated using these assumptions. The resulting projection is labeled "Scenario 1" in the EViews workfile. The MAM is a collection of models, with the U.S. Model (also referred to as the Macroeconomic Model) being the first to execute. Models of industrial output and employment by industry at the national level are solved sequentially using the U.S. Model results. Simulations of regional models of economic activity, housing starts, commercial floor space, industrial output, and employment by industry then follow.

Once all the models of the MAM are solved, a subset of the projection is written to the global data structure so that the modules of NEMS can react to these new economic assumptions (Table B14 in Appendix B on page 92). This is a "cycle" of the NEMS. Cycles are repeated until convergence factors are satisfied. At some point, following many runs of the NEMS, the Reference case is declared to be frozen. The "Scenario 1" solution in the U.S. Model then becomes the final baseline used as the starting point for analyzing policy proposals and changes in energy markets. These results are reported in the AEO as the Reference case.

Clean Energy Standards: Clean Energy Standards mandate that a certain percentage of electricity generation is produced by 'clean energy sources,' where the definition of these clean sources may vary among studies. Imposing standards that utilities must use may result in a fuel mix that deviates from a market-based solution. Clean Energy Standards are not assumed in the reference case as well as in every other scenario in AEO 2018.

Investment in more expensive generation technologies is required with no underlying increase in total generation capability. Resources must be diverted in order to fund these technologies that would not have been used if the standards were not imposed. Aggregate supply should be lower, because electricity is now being produced by costlier techniques. These techniques use more resources, so there are fewer resources available to produce other goods and services.

The key equation of aggregate supply is a concept of non-housing, non-government GDP. The drivers of this aggregate supply concept are non-energy capital stock, non-energy potential labor hours, energy usage, and trend total factor productivity. The U.S. macroeconomic model does not capture all of the inherent costs when a given volume of energy is produced by more costly methods which may not be totally captured by increased energy costs. In this instance, labor and capital are diverted into the production of more expensive energy sources so that less 'non-energy' labor and capital are used to produce other goods and services.

The Electricity Market Module in the National Energy Modeling System (NEMS) has estimates of the incremental investment required to generate the mandated clean energy. The increase in investment represents the amount of resource costs diverted from the rest of the economy. To represent these costs, potential aggregate supply is decreased by the change in investment, and then the amount by

which trend productivity would have to be reduced in order to yield that reduced aggregate supply is computed.

Annual estimates of expense and capital payments are available in the Electricity Market Module. These include installed capacity, transmission, retrofits, fixed O&M, capital additions, non-fuel variable O&M, fuel expenses, purchased power, and RPS credit expenses. Costs of installed capacity, transmission, and retrofits are summed up. The change in investment is then computed using the appropriate reference case levels. Non-housing, non-government GDP (aggregate supply) is adjusted by the amount of the changed investment for the AEO 2016 scenario. The trend factor productivity is then altered so as to yield the reduced aggregate supply.

Alternative world oil prices: Crude oil prices are determined in the international market and are influenced by production decisions in OPEC and non-OPEC nations. Two simulations are normally performed in conjunction with the reference projection for the AEO. These are based on a High World Oil Price scenario and a Low World Oil Price scenario. These high and low prices are based on different assumptions about the world's liquids market. For each of these cases, the MAM starts from the Reference case, as explained above, and passes the values of the required macro variables to the modules of NEMS. The NEMS reacts to the alternative world oil price and various measures of economic activity. A new set of energy variables, including new oil prices, are passed back to the MAM, which then re-solves its series of models.

Changes in or proposed energy taxes or emission permits: This class of simulations levies some kind of tax on an energy sector. It could be a per-unit tax (x-cents per gallon) or an ad-valorem tax (x% of revenues). It could be a tax on a fuel by type or on emissions by type. When taxes are levied on an industry, prices are expected to rise in proportion to the tax. These taxes, if collected by the federal government, will change the budget deficit relative to the baseline. Since these taxes are not levied for revenue raising purposes, although the raising of revenue has also been considered in previous years, assumptions are made as to how these are returned to the economy. Generally, three alternative schemes are implemented. First, it can be assumed that taxes are retained within the business sector (grandfathered). Second, they can be returned to households. Third, a fraction can be returned to the households while the remaining fraction is retained within the business sector. In practice, these alternative schemes have also included spending on government research and development projects as well as transfers to help ameliorate the impacts of the tax.

The grandfathered case is easiest to implement since the revenues stay in the business sector. Here, as in all simulations, reference scenario values for macroeconomic and demographic variables are passed to the NEMS. Increases in or introductions of new energy taxes raise energy prices and reduce production and consumption in the NEMS, which returns the newly estimated values to the MAM. The increase in federal revenues due to energy taxes is also returned to the MAM. In this case the business sector retains all tax revenues.

In the case where revenues are returned to the consumers, the increased revenues are subtracted from corporate profits before taxes (ZB) by increasing federal excise tax accruals other than for a value added tax (TXIMGFOTH) through the add factor associated with it (TXIMGFOTH_A). Second, the add factor

associated with federal personal tax receipts (TXPGF_A) is reduced by the same amount as the increase in the excise tax. Essentially these two procedures imply that the federal government takes the energy tax revenues away from the business sector as a lump sum amount and then returns them to consumers in the form of a lump sum.

In the case where a portion of the tax revenue is allowed to stay in the business sector and the remaining amount is returned to consumers, the add factor for TXIMGFOTH is increased by the amount that has to be returned to the consumers. Then the add factor for TXPGF is reduced by the same amount.

Proposed changes in CAFE standards: This class of simulations is based on changing (increasing) the combined average fuel economy of new light vehicles relative to the baseline CAFE standards. Increases in the CAFE standards are associated with an increase in the cost of production of new light vehicles, which are calculated by the Transportation Module of the NEMS. This increased cost is passed to the MAM. The additional cost per new light vehicle is added to the reference average price of new light duty vehicles (PLVAVG).

Once the MAM solves its series of models using the new assumption, it writes its new projection to the global data structure. The other modules of the NEMS read the new MAM and CAFE assumptions and recalculate their projections. The resulting new energy prices and quantities along with the incremental cost for new light vehicles are returned to the MAM. The MAM uses the newly estimated energy market assumptions to re-solve. This process continues until the NEMS forecast converges.

Model levers and simulation rules

IHS Markit provides a series of levers and simulation tools in its models that permit change in key assumptions. All these levers and simulation rules are presented below along with a discussion of how they are modified in the MAM.

Energy prices and quantities: The projected values for energy prices and quantities appearing in the MAM's U.S. Model are exogenous assumptions provided by the supply and demand modules of the NEMS. The production and end-use demand of energy is measured in quadrillion BTUs. Similarly, projections of output for five energy-related industries and of employment in two energy-related industries are determined by the NEMS. The estimated values of the following energy variables are exogenous to the MAM and are determined in the supply and demand modules of the NEMS:

a. Production of energy

ENDUSEPCCOAL	= Coal share of electric utility fuel use
ENDUSEPCNG	= Natural gas share of electric utility fuel use
ENDUSEPCPET	= Petroleum share of electric utility fuel use
ENGDOMBIO	= Domestic production of energy from biomass, quadrillion BTUs
ENGDOMCOAL	= Domestic production of energy from coal, quadrillion BTUs

ENDDOMNG =Domestic production of energy from natural gas, quadrillion BTUs

ENGDOMOO = Domestic production of energy from other fuels, quadrillion BTUs

ENGDOMPET = Domestic production of energy from petroleum, quadrillion BTUs

ENGRESIDUAL = Inventory change and statistical discrepancy

b. Trade in energy

ENGEXPBIO = Export of biofuels, quadrillion BTUs

ENGEXPCOAL = Export of coal, quadrillion BTUs

ENGEXPNG = Export of natural gas, quadrillion BTUs

ENGEXPOO = Export of other fuels quadrillion BTUs

ENGEXPPET = Export of petroleum, quadrillion BTUs

ENGIMPBIO = Import of biofuels, quadrillion BTUs

ENGIMPCOAL = Import of coal, quadrillion BTUs

ENGIMPNG = Import of natural gas, quadrillion BTUs

ENGIMPOO = Import of other fuels quadrillion BTUs

ENGIMPPET = Import of petroleum, quadrillion BTUs

c. End-use demand for energy

DALLFUELSBIO = Total demand for biofuels, quadrillion BTUs

DALLFUELSCOAL = Total demand for coal, quadrillion BTUs

DALLFUELSNG = Total demand for natural gas, quadrillion BTUs

DALLFUELSOO = Total demand for other fuels, quadrillion BTUs

DALLFUELSPET = Total demand for petroleum, quadrillion BTUs

DENDUBIO = End-use demand for biofuels, quadrillion BTUs

DENDUCOAL = End-use demand for coal (excludes electricity generation), quadrillion BTUs

DENDUELC = Sales of electricity to ultimate consumers, quadrillion BTUs

DENDUNG = End-use demand for natural gas, quadrillion BTUs

DENDUPET = End-use demand for petroleum, quadrillion BTUs

d. Consumer spending on energy

CNEFAOR = Real consumer spending on fuel oil and other fuels, billion 2009 dollars

CNEGAOR = Real consumer spending on motor vehicle fuels, lubricants and fuels, billion 2009 dollars

CSVUER = Real consumer spending on electricity, billion 2009 dollars

CSVUGR = Real consumer spending on natural gas, billion 2009 dollars

QGASASF = Highway consumption of gasoline & special fuels, billions of gallons

e. Prices of energy

JPCNEFAO = Chained price index, consumer fuel oil & coal, 2009=100

JPCNEGAO = Chained price index, consumer gasoline & oil, 2009=100

JPCSVUE = Chained price index, household electricity, 2009=100

JPCSVUG = Chained price index, household natural gas, 2009=100

PNGHH = Henry Hub spot market price of natural gas, dollars per million BTU

POILIMP = Weighted average price of imported crude received in refinery inventories, dollars per barrel

POILWTI = Average price of West Texas intermediate crude, dollars per barrel

WPI051 = Producer price index coal, 1982=1.0

WPI053 = Producer price index, industrial natural gas, 1982=1.0

WPI054 = Producer price index, electric power, 1982=1.0

WPI055 = Producer price index, utility natural gas, 1982=1.0

WPI0561 = Producer price index, crude petroleum, 1982=1.0

WPI057 = Producer price index, refined petroleum products, 1982=1.0

WPI0574 = Producer price index, residual petroleum fuels, 1982=1.0

f. Industrial production indices

IPSG211A3 = Industrial production index oil & gas extraction & support activities, 2012=100

IPSN2121 = Industrial production index coal mining, 2012=100

g. Industrial output

Though the output projections of the following energy-related industries are endogenously determined in the MAM's Industrial Output Model, its values are overwritten. The MAM's final results are computed by applying the growth rates from the NEMS projections to the last historical data point in the MAM's Industrial Output Model.

R2121R = Real output of coal mining

R211R and R213R = Real output of oil and gas extraction and support activities

R32411R = Real output of petroleum refining

R2211R = Real output of electric utilities

R2212R = Real output of gas utilities

h. Employment by industry

Though the employment projections of the following energy-related industries are endogenously determined in the MAM's employment model, its values are overwritten. The MAM's final results are computed by applying the growth rates from the NEMS projections to the last historical data point in the MAM's employment model.

E2121 = Employment of coal mining industry

E211 and E213 = Employment of oil and gas extraction industry

Fiscal policy assumptions: Unless mentioned otherwise, the MAM retains IHS Markit's default settings for fiscal policy levers and assumptions.

a. Federal purchases

Real federal government spending for each spending category is an exogenous input in the model. The price deflator associated with each of the goods categories reflects goods inflation in the private sector of the economy. Price deflators associated with the federal wage categories (JPGFMLCWSS and JPGFOCWSS) are closely tied to legislated pay increases; this pay increase concept explains 70-80% of

the inflation in government wages while wage inflation in the private sector of the economy explains the remainder.

The determination of federal government pay increases (GFMLPAY and GFOPAY) is controlled by model lever GFPAYLEV. If GFPAYLEV is set to 1, federal government pay increases are specified exogenously by the model user (they should supply values for exogenous variables GFMLPAYEXO and GFOPAYEXO that are annual percent pay increases for the two categories respectively). If GFPAYLEV is set to 0, federal government pay increases are modeled to rise with inflation as indicated by the chained price index of consumer purchases (JPC). The default value for GFPAYLEV is 1.0.

b. Federal transfer payments

The model lever JSSLEV allows users to simulate Congressional decisions to trim (negative annual percentage rate) or augment (positive annual percentage rate) the cost-of-living adjustment (COLA) on social security payments (YPTRFGFSISS) based upon CPI inflation. For example, setting the lever value to 1 increases the social security COLA by 1%. The default value for JSSLEV is 0.

c. Personal income tax rates

Tax rates in the model are largely exogenous at the federal level and endogenous at the state and local level. However, the model lever TXINFLEV allows the user to raise personal income tax rates if consumer prices rise. If TXINFLEV is set to 0, changes in the federal personal income tax rate (RTXPGF) are controlled through the add factor RTXPGF_A. If TXINFLEV is set to 1, the tax rate is indexed to CPI inflation. The default value for TXINFLEV is 1. The add factor RTXPGF_A can be used to target search the full employment federal budget surplus (NETSAVGFFE).

Monetary policy assumptions: The model lever RMFFLEV gives the user the flexibility of using the supply of reserves as the key monetary policy instrument, reflecting the Federal Reserve's open market purchases or sales of Treasury securities, or of using a reaction function as the policy instrument. If RMFFLEV is set to 0, the model uses non-borrowed reserves as the monetary policy instrument and the federal funds rate is determined by the balance between the demand and supply of reserves existing in the banking system (equation RMFFRES). The Federal Reserve does not engage in an active policy to stabilize the economy. The federal funds rate is determined by the demand for federal funds existing in the banking system. If the lever is set to 1, the model uses a Federal Reserve reaction function. This is an econometrically estimated equation which models the past behavior of the Federal Reserve in setting the federal funds rate in response to changes in inflation and unemployment (equation RMFFRCT). This implies that the Federal Reserve targets interest rates trading off changes in inflation and the unemployment rate.

In the baseline forecast of IHS Markit's model of the U.S. economy, both the RMFFRES equation and the RMFFRCT equation yield the same federal funds rate forecast. Therefore, setting the lever at any value will not alter these baseline projections. For policy simulations, setting the value anywhere between 0 and 1 reflects the model user's view about the degree of active monetary policy undertaken by the

Federal Reserve. In the simulations described above the lever is set at 0.9 to allow for a fairly active monetary policy. This reflects the view that the Federal Reserve will act quickly to stabilize the economy in the case of energy events that have the potential to disrupt the economy significantly.

Foreign assumptions: In general, IHS Markit's default values are used. Exceptions are discussed below.

a. Interest rates

The long-term government bond yield in rest-of-world industrial economies (RMGBLMTP) is exogenous and equal to its baseline value RMGBLMTPB if the model lever RMGBLMTPLEV is set to 0. If RMGBLMTPLEV is set to 1, this rate changes by the same amount as the rate on the 10-year U.S. Treasury note. If it is assumed that there is international monetary policy coordination between the United States and the other major industrial economies, then RMGBLMTPLEV should be set to 1. The default value for this lever is 0. This setting indicates that the interest rate differential between the U.S. and the rest-of-world industrial economies may differ.

b. Foreign prices

Export and import demands are highly sensitive to changes in U.S. prices relative to foreign prices. While U.S. prices are modeled in considerable detail with a high level of sophistication, the prices of our major trading partners are largely exogenous assumptions in the model. At times, policy or event-related simulations can cause relative (U.S./foreign) prices to deviate significantly from baseline when foreign prices are fixed, causing trade volumes to respond strongly. In the case of a carbon tax that impacts our major trading partners to equal degrees, for example, relative prices should not be changing. Hence simple simulation rules have been added to the model to allow for movements in foreign prices relative to baseline levels.

b.1. Producer prices and relative prices.

The model lever TRADEPLEV was introduced to allow users to negate any changes in relative prices on export and import demands. When TRADEPLEV is set to 1, export and import demands are determined by foreign output demand and relative (U.S./trading partner) prices. When TRADEPLEV is set to 0, relative prices are assumed to remain at baseline levels; export and import demands change from baseline levels only in response to changes in output, not relative prices. The default value for TRADEPLEV is 1.

The producer price index for the rest of the industrialized world (WPIWMTP) is both the key determinant of import prices and the key foreign price index driving the U.S. exchange rate with industrialized countries. WPIWMTP is determined by one of two simulation rules based upon the value of the model lever WPIWLEV. If WPIWLEV is set to 0, foreign producer prices are changed relative to

baseline levels with changes in imported oil prices (JPMGPET), U.S. merchandise export prices (JPXGXCPP), exchange rates (JEXCHMTP), and foreign economic activity (JGDPMTPR and JGDPOITPR). If WPIWLEV is set to 1, foreign producer prices move in line with U.S. merchandise export prices. The default value for WPIWLEV is 0.

b.2. Exchange rates.

There are two nominal exchange rates in IHS Markit's model of the U.S. economy. These are JEXCHMTP and JEXCHOITP and are defined as trade-weighted exchange rates (in U.S. $) for industrialized countries and for developing countries, respectively. In the MAM, these variables are set exogenously to their baseline projected values for all simulations.

c. Foreign GDP

There are two foreign real GDP variables in the Macroeconomic Model. These are real GDP in the rest of the industrialized world (JGDPMTPR) and real GDP in developing countries (JGDPOITPR). If the model levers corresponding to JGDPMTPR and JGDDPOITPR (JGDPMTPRLEV and JGDPOITPRLEV, respectively) are set to 0, the values of the GDP variables are exogenous. When JGDPMTPRLEV and JGDPOITPRLEV levers equal 1, both foreign real GDP concepts change in the same proportion as the changes in U.S. real GDP. The default values for JGDPMTPRLEV and JGDPOITPRLEV are 0. In the Alternative World Oil Price Simulations, discussed above, the model assumes that the elasticity of the two foreign real GDP variables with respect to world oil prices is 0.02. This implies that these GDPs change by 0.02 percent for every 1 percent change in the world oil price from the Reference Case price. The value of 0.02 for the GDP elasticity with respect to world oil price is based on empirical research findings.

Flowcharts of MAM

The following seven flowcharts show the flow of information from the NEMS to the MAM and how the energy data and economic information are passed among the components of the MAM. This set of flowcharts identifies the tasks performed by each of the MAM's models and may not necessarily follow the actual programming sequence. The latter will be discussed in the next section, along with another set of flowcharts presenting the programming steps and subroutines.

Figure 1 summarizes the entire NEMS-MAM integrated system. The remaining six figures focus on the various models contained in the Macroeconomic, Industrial Output, Employment, and Regional Models of the MAM. In each model, a reference economic forecast using the structural models described in Part A was created and linked to the NEMS to initialize the system.

The MAM is a feedback system that modifies the Reference scenario based on assumed changes in energy events or policies. This approach is applied to all NEMS runs including the Reference and

sensitivity cases of the AEO. Alternative NEMS values of energy prices and quantities are first transformed into concepts compatible with those in the MAM models. The growth rates of these alternative NEMS series are applied to the most recent historical data values to create new energy projections. These new series are put into the MAM as predetermined variables, and a new scenario is run.

The models in the MAM are run sequentially. The Macroeconomic Model is the first to run with the new energy market assumptions. It is followed by the Industrial Output and Employment Models, and finally by the Regional Models. The downstream models in the MAM use the projections generated by the models further upstream as predetermined variables. There is no feedback loop within MAM. That is, the estimate of an upstream model is not affected by the results of a downstream model in the same NEMS cycle. When one cycle of the MAM is complete, the projection is written to the global data structure of the NEMS for use by other modules. Subsequent energy market estimates from the NEMS are returned to the MAM, if model convergence criteria are not satisfied.

Figure 1. Macroeconomic Activity Module Flow

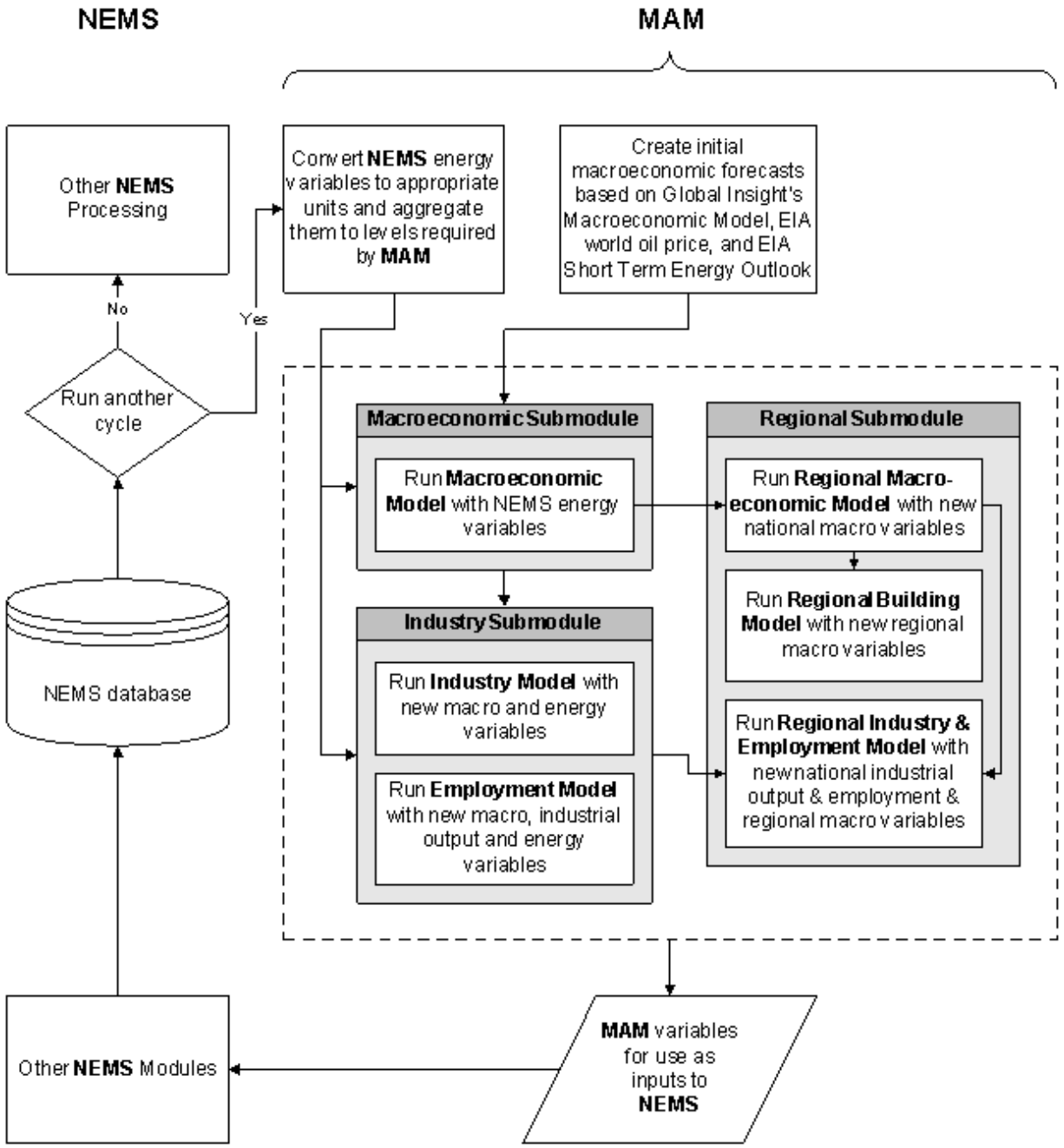


Figure 2. Macroeconomic Submodule Flow

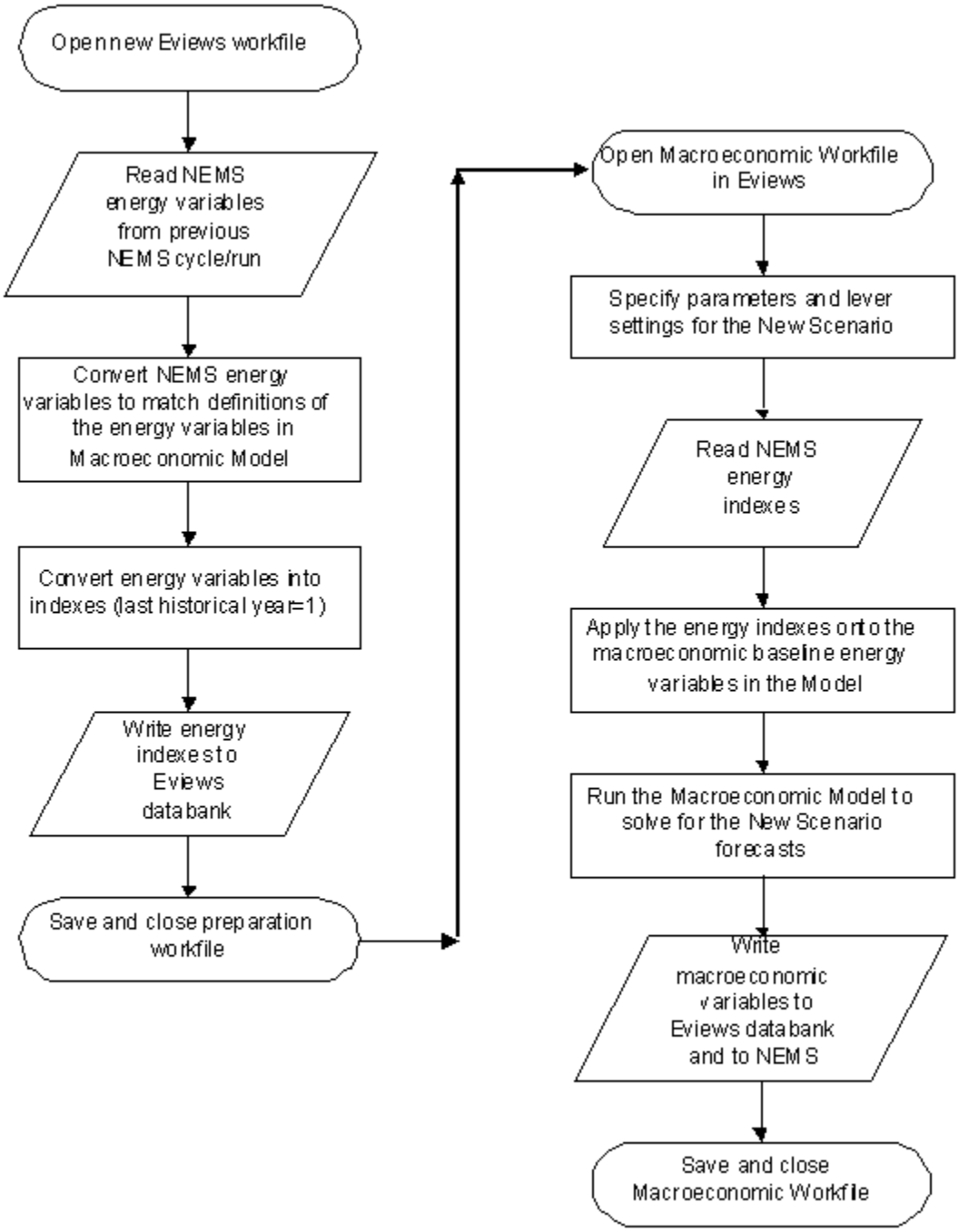
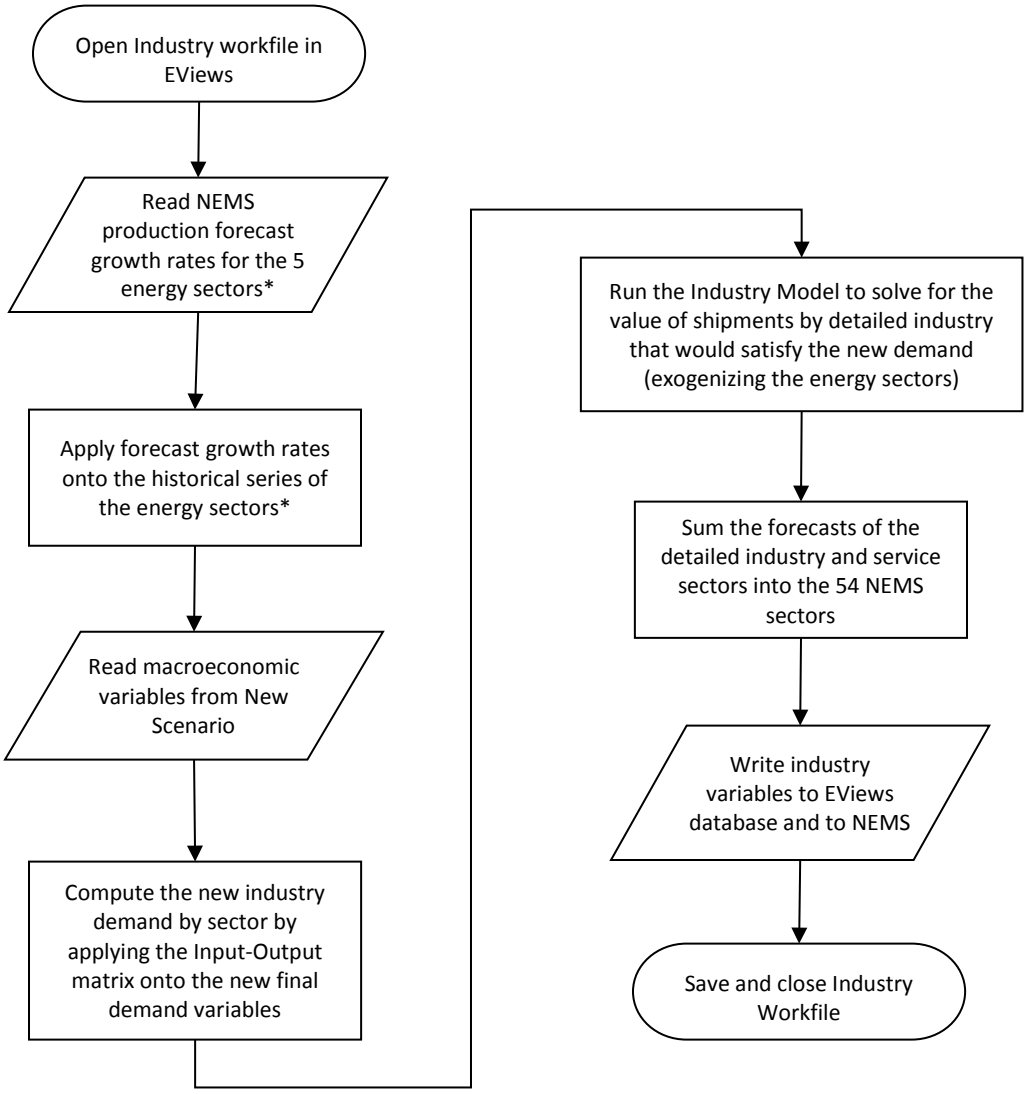
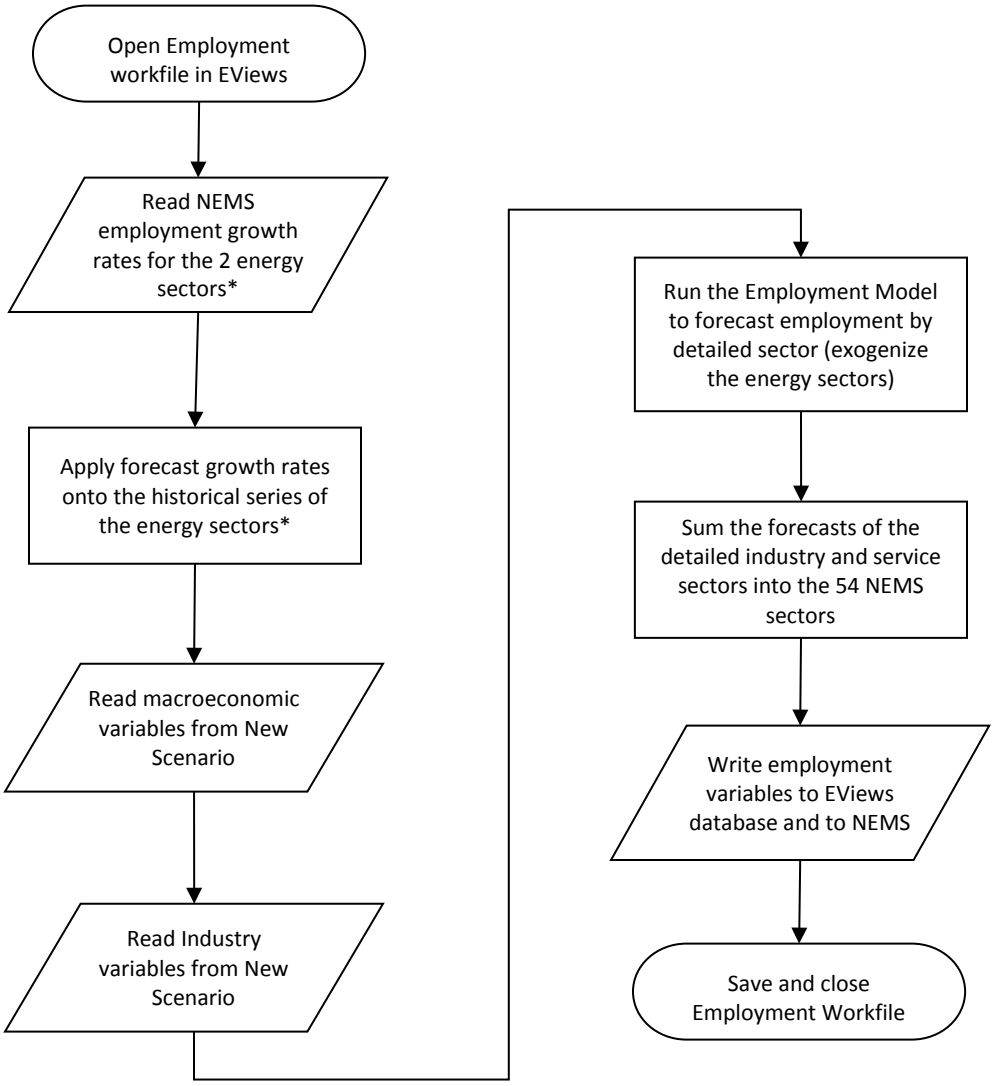


Figure 3. Industry Submodule – Industry Model



*Five energy sectors with NEMS production
Coal mining
Oil and gas extraction
Petroleum refining
Electric utilities
Gas utilities

Figure 4. Industry Submodule – Employment by Industry Model



*Two energy sectors with NEMS employment
Coal mining
Oil and gas extraction

Figure 5. Regional Submodule – Regional Macroeconomic Model

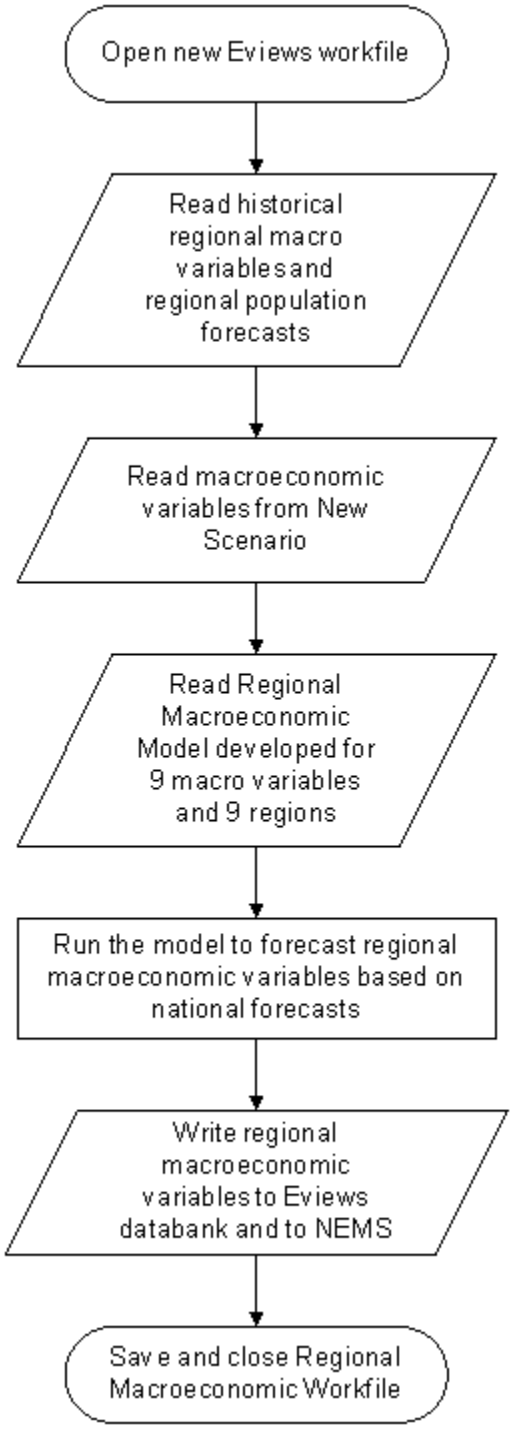


Figure 6. Regional Submodule –Regional Building Model

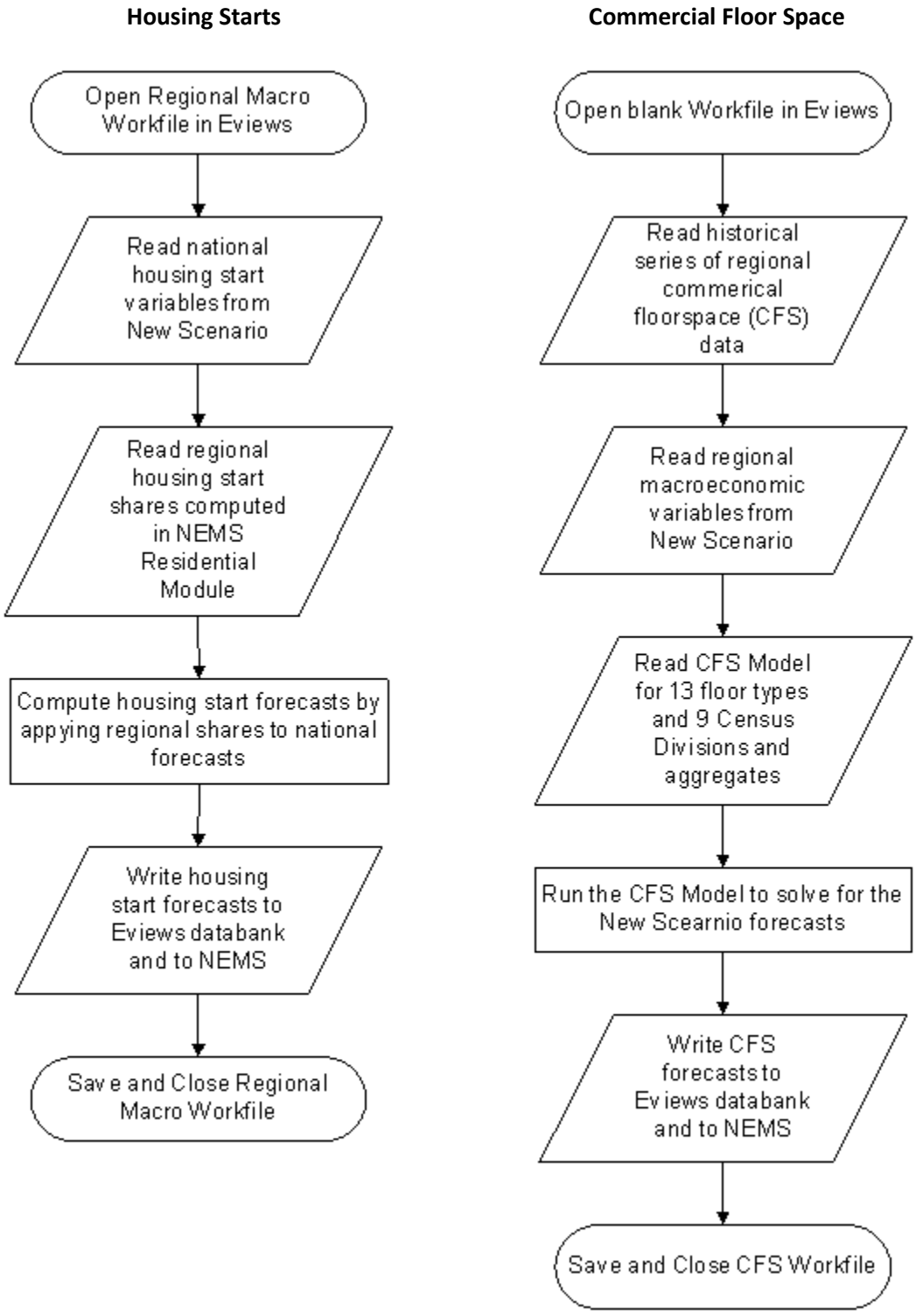
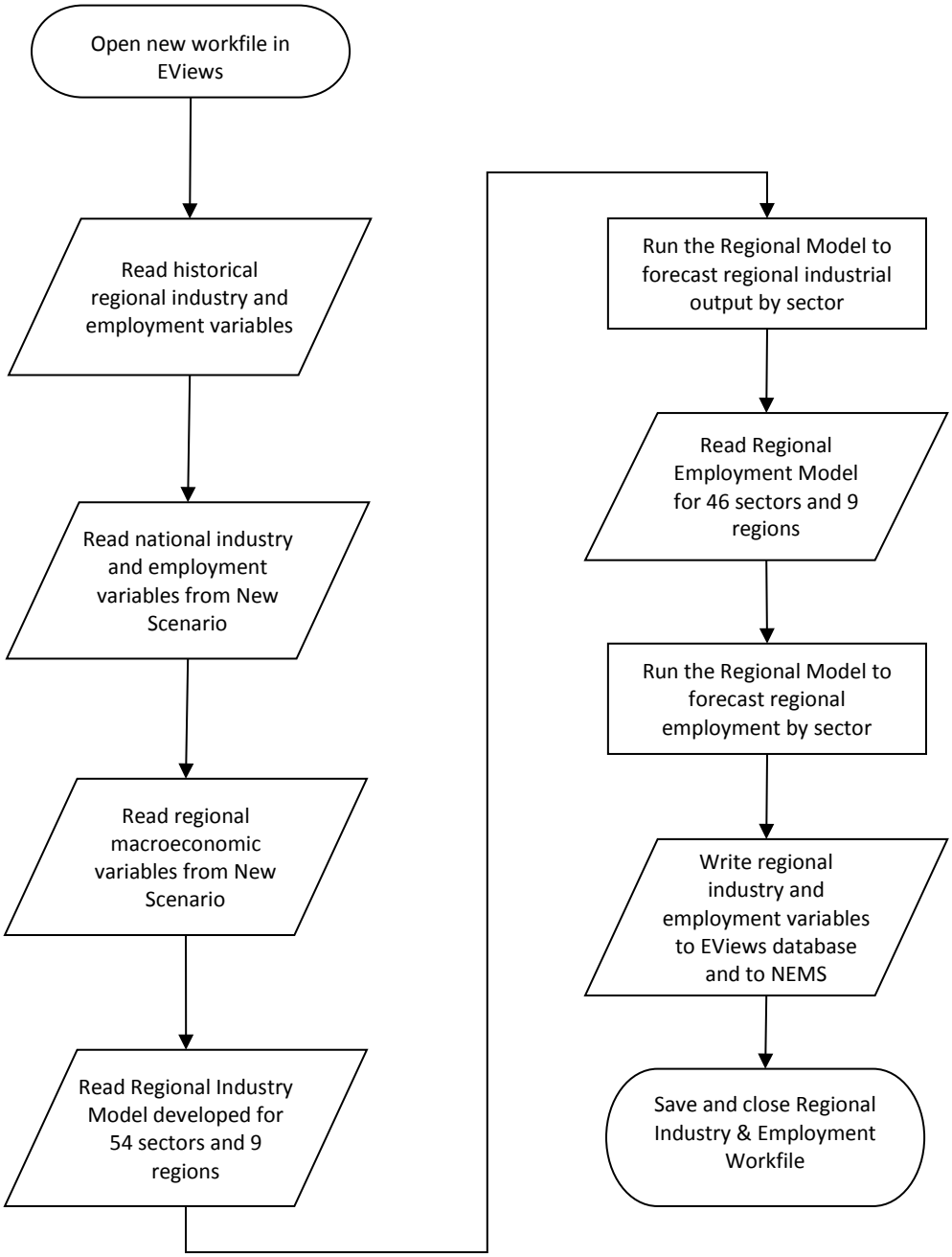


Figure 7. Regional Submodule – Regional Industry and Employment by Industry Model



6. Operation of MAM within NEMS

The Macroeconomic Activity Module (MAM) is one of a number of source files (also known as modules) that, after compiled and linked, compose the National Energy Modeling System (NEMS) executable. The MAM consists of nine subroutines used to read inputs, compute and apply shocks to the MAM models, run the model simulations, and write out the resulting projection. Figure 8 shows the flow of control within the MAM.

MAC subroutine

All of the activities in the MAM are directed by the MAC subroutine, the driver subroutine. In addition to making calls on the remaining eight subroutines in the MAM, the MAC subroutine has two tasks of its own. It writes the MC_ENERGY output [5] text file of the NEMS energy prices and quantities that are the exogenous assumptions to the models in the MAM. This text file includes aggregates and components used to compute the prices and quantities. The values of the NEMS energy prices and quantities contained in the text file, reported in 2009 dollars, are read from the global data structure. The MAC subroutine's second task is to write the MAM results to the global data structure for use by the remaining NEMS modules and the NEMS report writer. Once this is complete, the MAC subroutine returns program control to the NEMS.

READMAC subroutine

As mentioned above, the MAC subroutine functions as the driver within MAM and calls all the remaining subroutines. The first subroutine called is READMAC. Figure 9 shows the flow of control within READMAC. This subroutine is called just once per run in the first iteration of the first year of a NEMS run. The READMAC subroutine opens and reads the contents of one input file, a text file of the MAM parameter settings named MCPARMS (Table B2 in Appendix B on page 99).

DRTLINK subroutine

DRTLINK is the second subroutine called by the MAC and is responsible for executing the suite of IHS Markit's national and EIA's regional models. Like the READMAC subroutine, the DRTLINK subroutine executes only in the first iteration of the first year of a NEMS run. Figure 10 shows the flow of control within DRTLINK.

There are instances when the modeler does not want the estimation of the other NEMS modules affected by a change from the MAM's reference values. The presence of feedback is controlled with the NEMS parameter MACFDBK. When the feedback switch is set to zero, the DRTLINK subroutine is not called. The value of the MACFDBK parameter is set in the NEMS scenario descriptor file (Table B2 in Appendix B on page 99).

Much of what the DRTLINK subroutine does is preparation for executing the suite of IHS Markit's national and EIA's regional models within Quantitative Micro Software's EViews software. The programming in the subroutine begins by mapping the NEMS energy prices and quantities read from the global data input variables to comparable variables in IHS Markit's national model (Table B3 in Appendix B on page 101). It then builds an EViews output program file called DRIVERS. The DRIVERS program file contains instructions written in the EViews programming language. The commands in this program

5 Files that are "output" files reside in the NEMS simulation output directory. The NEMS directory names begin with the character "d" which is followed by a date key and a letter identifying the particular run done that day. Files that are "input" files reside within the input subdirectory of the NEMS output directory.

import exogenous assumptions, temporarily alter the model structure, simulate IHS Markit's and EIA's models and then export the results. Program control is temporarily transferred to EViews as it executes the commands in the DRIVERS program file. The resulting model estimates are written to the following six output text files:

1. EPMAC.CSV – level of national economic activity, industrial output, and employment
2. MC_COMMFLR.CSV – rates of growth of the stocks of commercial floor space by Census Division (Table B11 in Appendix B on page 122)
3. MC_DETAIL.CSV – level of energy detail used as assumptions in the MAM
4. MC_REGEMP.CSV – level of employment by Census Division (Table B12 in Appendix B on page 123)
5. MC_REGIO.CSV – level of industrial output by Census Division (Table B13 in Appendix B on page 125)
6. MC_REGMAC.CSV – level of economic activity by Census Division (Table B10 in Appendix B on page 121)
7. MC_VEHICLES.CSV – national level of light truck sales by sales class (Table B8 in Appendix B on page 116)
8. MC_XTABS.CSV – level of national economic activity in more detail

Once EViews completes execution of the DRIVERS program, control is returned to the DRTLINK subroutine. The DRTLINK subroutine reads the results contained in each of the above text files. Control is then returned to the MAC subroutine. The MAC subroutine then calls its third subroutine, INDUSTSUB.

INDUSTSUB subroutine

The INDUSTSUB subroutine operates in a manner similar to that described for the MAC subroutine. Figure 11 diagrams the flow of control within INDUSTSUB. Estimated levels coming from IHS Markit's model of industrial output are stored in the EPMAC text file. The resulting projection covers 48 categories of industrial output and ten categories of services. The results are written to the MC_INDUSTRIAL text file (Table B6 in Appendix B on page 112).

1. In the MAM, data for the five NEMS energy industries are overwritten by NEMS output:
    1. Petroleum refining
    2. Coal mining
    3. Oil and gas extraction
    4. Electric utilities and
    5. Gas utilities

The MAM computes annual growth rates using NEMS's projections of energy prices and quantities. Each of the growth rates is dynamically applied beginning with an initial historical value. The resulting time series becomes the industrial output projection for the five energy industries.

REGIONSUB subroutine

REGIONSUB, the fourth subroutine called by the MAC subroutine, copies and aggregates EIA's regional model results for export to the global data structure and writes to the MC_REGIONAL text file (Table B9

in Appendix B on page 117). Prior to the introduction to the MAM of EIA's regional models, the REGIONSUB subroutine allocated the national projection out to the nine Census Divisions.

EMPLOYMENT subroutine

The fifth subroutine called by the MAC subroutine is named EMPLOYMENT. This subroutine works just like the INDUSTSUB subroutine. Estimated levels coming from IHS Markit's model of employment by industry are written to the EPMAC output text file. The resulting projection is for 39 categories of industrial and eleven categories of service employment.

The NEMS supplies employment projections for the coal mining and oil and gas extraction industries (Table B4 in Appendix B on page 109). These results are estimated by the same method used to project shipments for the energy-related industries in the Industrial Output Model. The NEMS supplies the projections, and the MAM computes annual growth rates that are dynamically applied beginning with an initial historical value for each variable.

For the three remaining energy industries (petroleum refining, electric utilities, and gas utilities), employment projections are computed as for all the other employment variables. Since the Industrial Output Model executes before the Employment Model, the employment results for the remaining three energy sectors are affected by the NEMS industrial estimates.

COMFLR subroutine

Figure 14 shows the flow of control within COMFLR, the sixth subroutine called by the MAC subroutine. The COMFLR subroutine copies and aggregates the EViews model results in preparation for output to the global data structure and to the MC_REGIONAL text file (Table B9 in Appendix B on page 117). This subroutine once contained a FORTRAN model of commercial floor space, which has been moved to EViews.

TRANC subroutine

Figure 15 shows the flow of control within TRANC, the seventh subroutine called by the MAC subroutine. This subroutine copies light truck unit sales projections in preparation for output to the global data structure. Light trucks are vehicles with gross vehicle weight ratings of 14,000 pounds and less. Equations added to IHS Markit's model of the U.S. economy allocate total light truck sales, in thousands of vehicles, to the following size classes:

2. Unit Sales of Class 1 Light Trucks, 0 to 6000 lbs.
3. Unit Sales of Class 2 Light Trucks, 6001 to 10,000 lbs.
4. Unit Sales of Class 2a Light Trucks, 6001 to 8,500 lbs.
5. Unit Sales of Class 2b Light Trucks, 8,501 to 10,000 lbs.
6. Unit Sales of Class 3 Light Trucks, 10,001 to 14,000 lbs.

MACOUTPUT subroutine

After the TRANC subroutine executes, program control is returned to the MAC subroutine, which writes all of the MAM estimates to the global data structure for use by other modules in the NEMS, including the report writer. The MAC subroutine then calls the final MAM subroutine, MACOUTPUT. Figure 16

shows the flow of control within MACOUTPUT. The MACOUTPUT subroutine records the activities of the MAM for a NEMS run in the following five output text files:

1. MC_COMMON - Contains projected values of variables written to the global data structure from IHS Markit's U.S. and EIA's regional models. These include estimates of economic activity, industrial output, employment by industry and growth of stocks of commercial floor space. Table B14 in Appendix B on page 127 indicates the MAM variables used by other NEMS Modules.
2. MC_NATIONAL - Contains the projection of macroeconomic variables. The estimation is done using IHS Markit's model of the U.S. economy. Table B5 in Appendix B on page 110 lists the contents of the MC_NATIONAL text file.
3. MC_INDUSTRIAL - Contains the projection of industrial output for 42 manufacturing and non-manufacturing industries at the Census Division level as well as for the U.S. There is also a U.S. estimate for each of the ten services. Table B6 in Appendix B on page 112 lists the contents of the MC_INDUSTRIAL text file.
4. MC_EMPLOYMENT - Contains the employment projections from the Employment Model for the 44 manufacturing and service industries. Table B7 in Appendix B on page 114 lists the contents of the MC_EMPLOYMENT text file.
5. MC_REGIONAL - Contains the projected values of the regional variables by Census Division as well as for the U.S. EIA's regional models of economic activity, industrial output and employment by industry do the regional estimation. Table B9 in Appendix B on page 117 lists the contents of the MC_REGIONAL text file.

Once the last text file is written, program control is returned to the MAC subroutine, which in turn returns program control to the NEMS.

Figure 8. Flow of Control within MAM

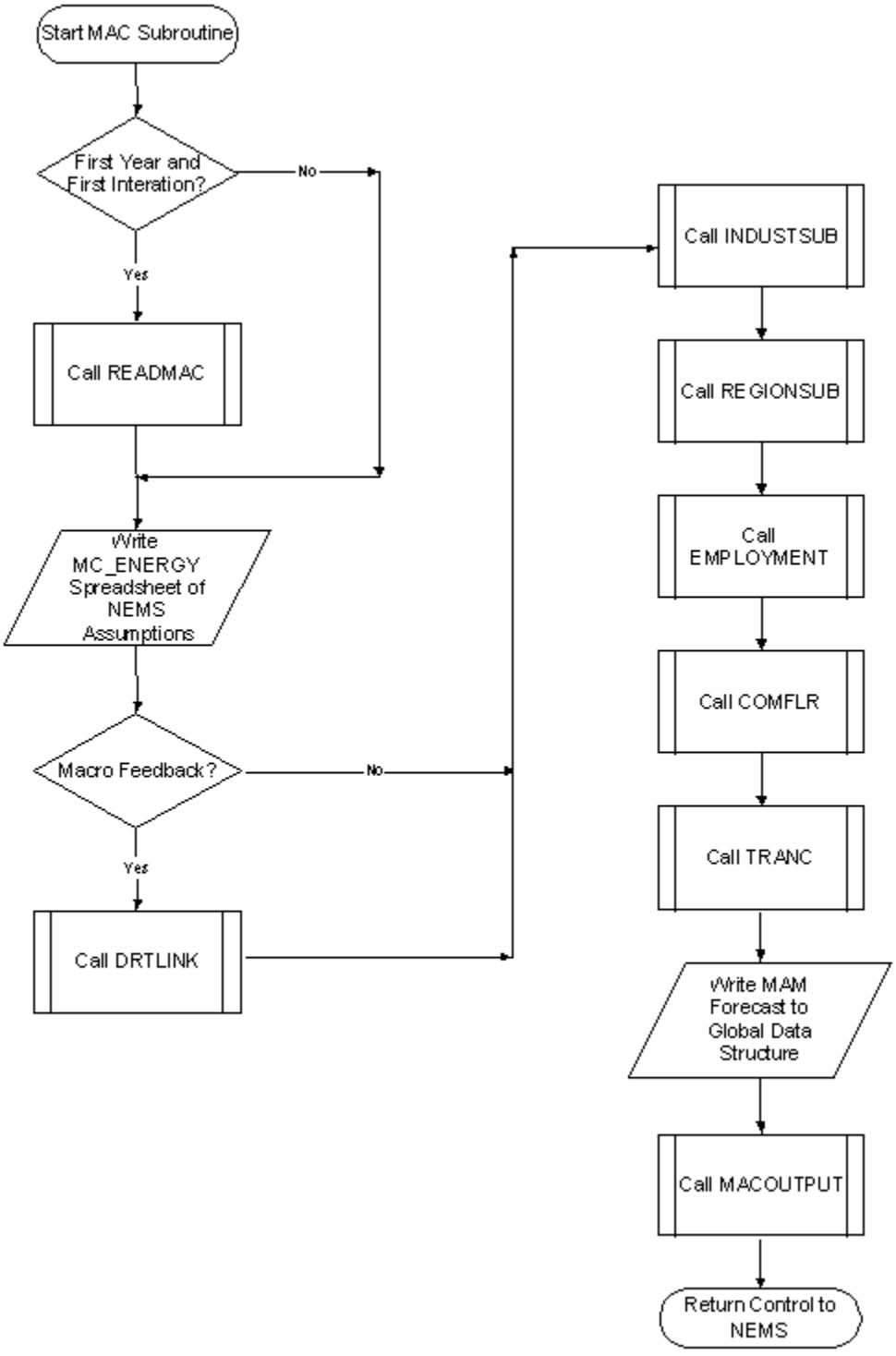


Figure 9. Subroutine READMAC

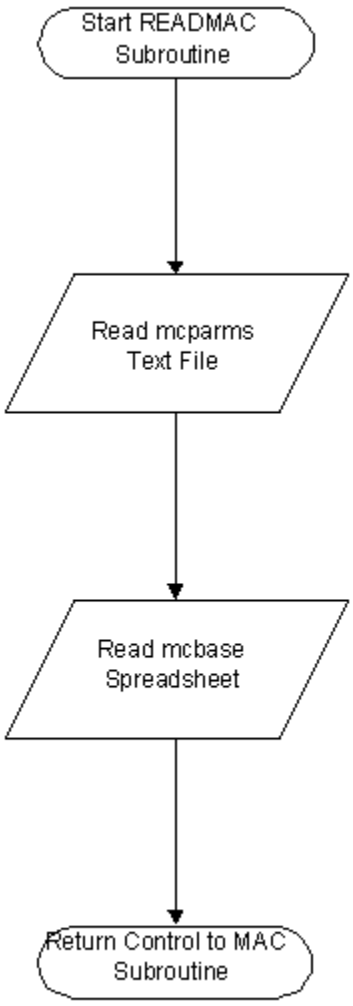


Figure 10. Subroutine DRTLINK

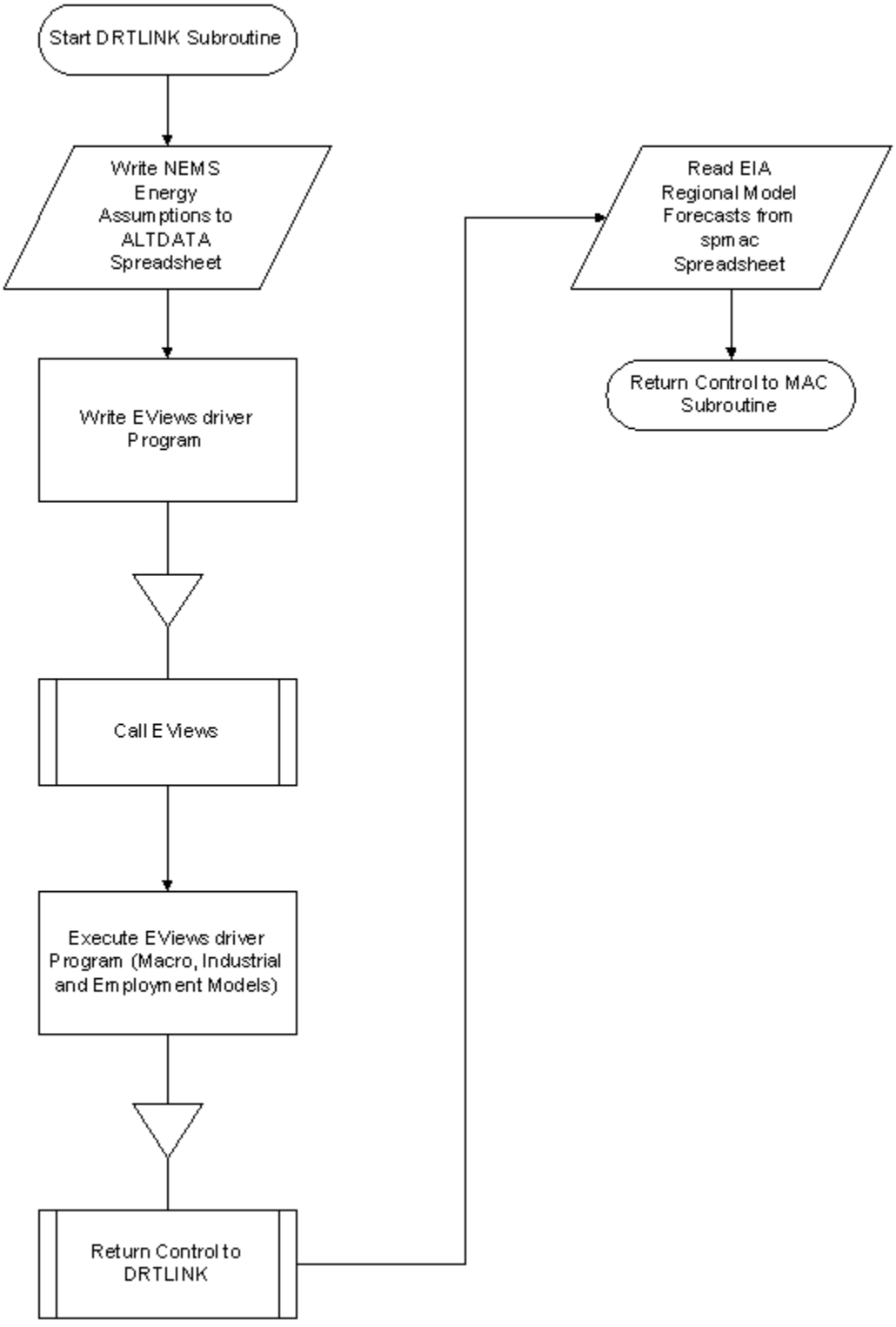


Figure 11. Subroutine INDUSTSUB

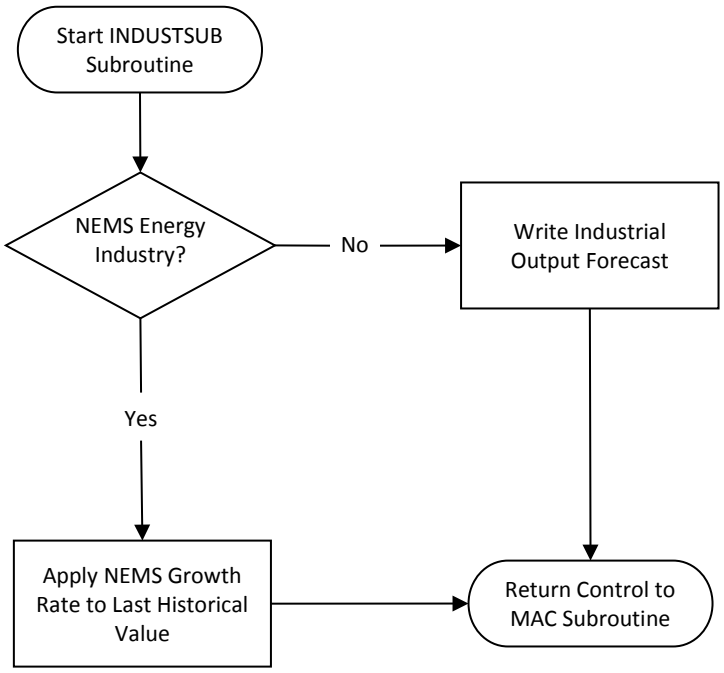


Figure 12. Subroutine REGIONSUB

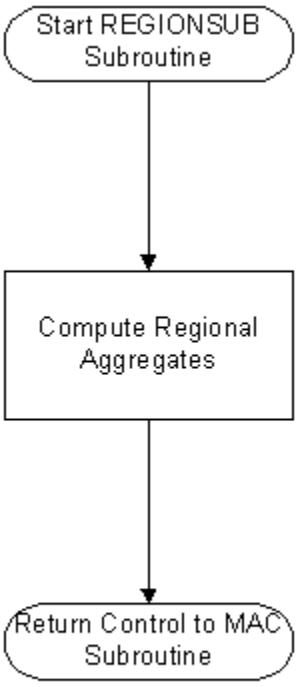


Figure 13. Subroutine EMPLOYMENT

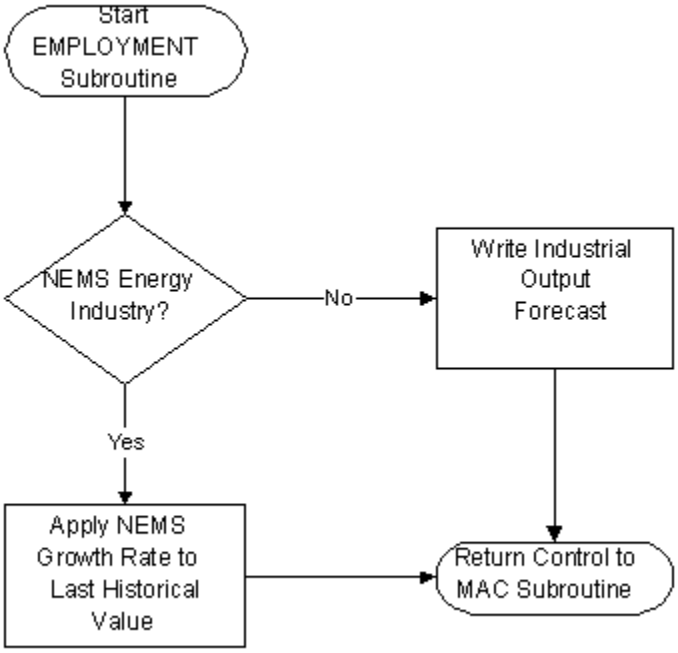


Figure 14. Subroutine COMFLR

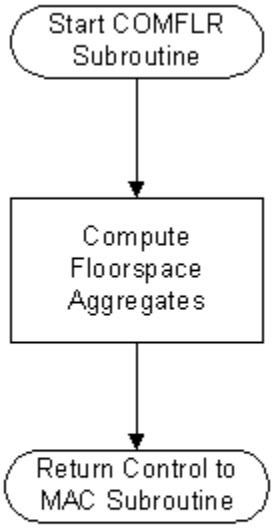


Figure 15. Subroutine TRANC

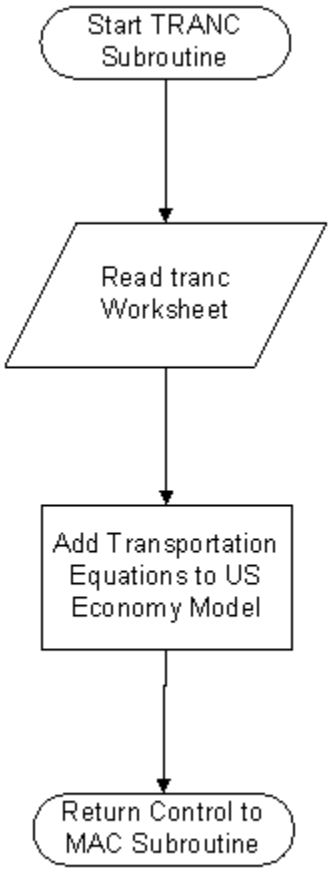
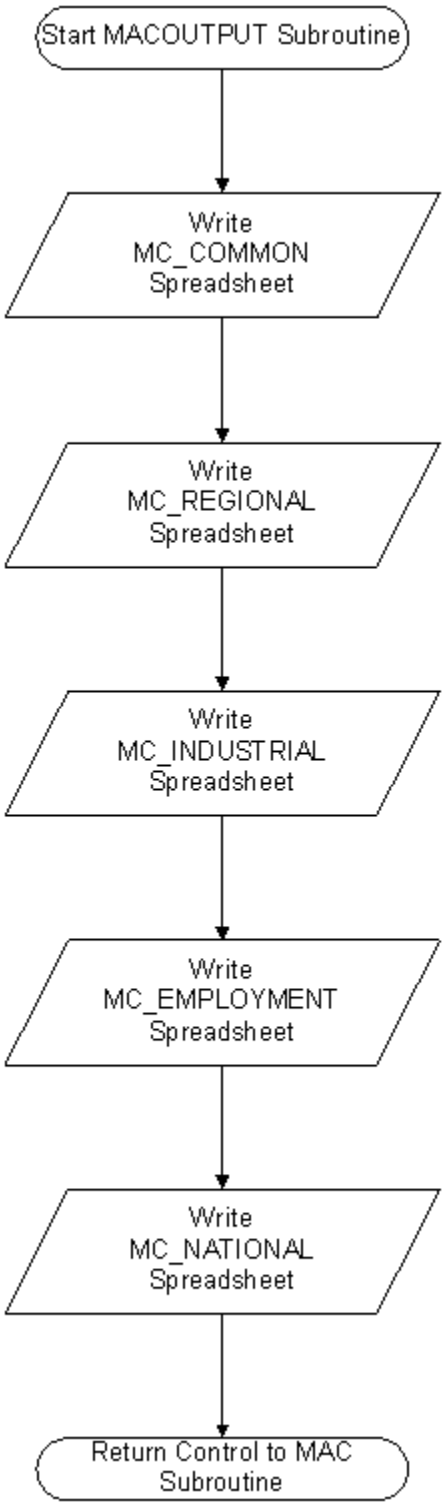


Figure 16. Subroutine MACOUTPUT



Appendix A: VARIABLES AND CLASSIFICATIONS IN MAM MODELS

Macroeconomic Model Detail

Table A1. Real personal consumption*

Personal consumption expenditures	**CONSR**
Durables	**CDR**
Motor vehicles & parts	**CDMVR**
Light vehicles	CDMVNR
Tires, tubes, accessories & parts	CDMVPAR
Used automobiles	CDMVPUNAR
Furniture and appliances	**CDFHER**
Computers and software	**CDRECIPR**
Computers	CDRECIPPCR
Software	CDRECIPCSR
Other durable goods	**CDOR**
Medical devises	CDOTAER
Other recreational goods	CDRECOR
All other (1)	CDOOR
Nondurables	**CNR**
Food	**CNFR**
Clothing & shoes	CNCSR
Gasoline & motor oil	CNEGAOR
Fuel oil & coal	CNEFAOR
Other nondurables	**CNOR**
Tobacco products	CNOTOBR
Prescription & over-the-counter drugs	CNOPMPR
All other (2)	CNOOR
Services	**CSVR**
Housing	CSVHR
Gas	CSVUGR
Electricity	CSVUER
Telecommunications	CSVOCTR
Water & sewer	CSVUWASR
Transportation	**CSVTSR**
Motor vehicle leases	CSVTSMVOLSR
Other user-operated transportation	CSVTSMVXLSR
Purchased local transportation	CSVTSPUBLR
Purchased intercity transportation	CSVTSPUBOR
Medical Care	CSVHCR
Recreation	CSVRECR
Accommodations	CSVACR
Food services	CSVFR
Personal business services	**CSVFAINSR**
Financial services furnished free	CSVFINFREER
Other personal business services	CSVOPXBFREER
Other services (4)	CSVOOR

* Variables denoted in bold are defined by identities.

Notes: (1) Sports equipment, jewelry, boats, books, etc.; (2) Toilet articles, semi durable house furnishings, cleaning stuff, toys, magazines, flowers, net foreign remittances, etc.; (3) Insurance, postage, etc.; (4) Education, personal care, net foreign travel, etc.

Table A2. Real business investment*

Real private fixed nonresidential investment	**IFNRER**
Investment in nonresidential equipment	**IFNREER**
Information equipment	**IFNREEIPR**
Computer equipment	IFNREEIPCCR
Communications equipment	IFNREEIPCTR
Other information equipment (1)	IFNREEIPOR
Industrial equipment	IFNREEINDR
Transportation equipment	**IFNREETR**
Light vehicles	IFNREETLVR
Aircraft	IFNREETACR
Other transportation equipment (2)	IFNREETOR
Other equipment (3)	IFNREEOR
Investment in nonresidential structures	**IFNRESR**
Structures excluding public utility & mines	**IFNRESBAOR**
Nonfarm buildings	**IFNRESXFR**
Industrial	IFNRESMFGR
Commercial	IFNRESCMLR
Other nonfarm buildings (4)	IFNRESBOTHR
Other buildings (5)	IFNRESOTHER
Mines & wells	IFNRESMIR
Public utilities	**IFNRESPUR**
Public utilities exc. Communications	IFNRESPUOR
Communications infrastructure	IFNRESPCR
Investment in intellectual property products	**IFNREIPR**
Software	IFNREIPSR
Research and development	IFNREIPRDR
Entertainment, literary, and artistic originals	IFNREIPELAR
Inventory investment (change in real stock of inventories)	**IIR**
Nonfarm inventories	**IINFR**
Manufacturing	IIMR
Wholesale trade	IIWR
Retail trade	**IIRTR**
Motor vehicles	IIRT44IR
All other	IIRTX44IR
Miscellaneous	**IIMISCR**
Construction, mining & utilities	IICMIUR
Other business	IIOR
Farm inventories	IIFR

* Variables denoted in bold are defined by identities.

Notes: (1) Copiers, instruments, office & accounting equipment; (2) Buses, railroad equipment, ships; (3) Furniture, farm equipment, electrical equipment, service industry machinery less sale of used stuff other than vehicles; (4) Religious, educational, medical; (5) Farm, brokers' commissions

Table A3. Real residential investment*

Housing starts including mobile homes	**HUS**
Housing starts	**HUSPS**
Single-family starts	HUSPS1
Multi-family starts	HUSPS2A
Mobile home shipments	HUSMFG
Housing sales	
New single-family homes sales	HUINSOLD
New single-family homes for sale	HUINFSALE
Sales of existing single-family home	HUIESOLD
Real private fixed residential investment	**IFRER**
Structures	**IFRESR**
Permanent site structures	**IFRESPER**
Single family houses	IFRESPESFR
Multi-family structures	IFRESPEMFR
Other residential structures	**IPRESOR**
Manufactured homes	IFRESOMFGR
Improvements	IFRESOIMPR
Other structures	**ICRESOOR**
Equipment	IFREER
Nominal Costs of housing	IFNRESBOTHR
Average price of existing single-family homes	IFNRESOTHER
Average price of constant-quality new home	IFNRESMIR
Average price of new single-family homes	**IFNRESPUR**
Median price of new single-family homes	IFNRESPUOR
30-year fixed mortgage rate	IFNRESPCR

* Variables denoted in bold are defined by identities.

Table A4. Key federal government expenditure*

Federal purchases of goods & services (real)	**GFR**
Defense	**GFMLR**
Consumption	**GFMLCR**
Personnel outlays	*GFMLWSSR*
Consumption of fixed capital	GFMLKER
Other	*GFMLCOR*
Gross investment	GFMLGIR
Nondefense	**GFOR**
Consumption	**GFOCR**
Personnel outlays	*GFOWSSR*
Consumption of fixed capital	GFOCKFR
CCC inventory change	*GFOCINTNCCR*
Other	*GFOCOR*
Gross investment	*GFOGIR*
Interest, dividends, transfer payments, subsidies and accruals:	**IFRER**
Federal net interest payments	INTNETGF
Federal transfer payments	**TRFGF**
Transfers to resident persons	**YPTRFGF**
Non-cyclical component	**YPTRFGFFE**
Medicare payments	*YPTRFGFSIHI*
Social security payments	YPTRFGFSISS
Other	YPTRFGFFEO
Cyclical component	YPTRFGFO
Federal social benefits to rest of the world	*TRFGFSIRW*
Other federal transfer payments	**TRFGFO**
Grants-in-aid to state & local governments	**GFAIDSL**
Medicaid grants	**GFAIDSLSSMED**
Other	**GFAIDSLO**
Transfers to rest of the world	TRFGFORW
Subsidies	**SUBGF**
Agricultural programs	*SUBGFAG*
Housing subsidies	*SUBGFHSNG*
Other federal subsidies	*SUBGFOTH*
Wage accruals less disbursements (1)	*WALDGF*

* Variables denoted in bold are defined by identities; variables denoted in italics are exogenous.

Notes:

(1) Negative expenditure.

Table A5. Key State & local government expenditure variables*

State & local purchases of goods & services (real)	**GSLR**
Consumption	**GSLCR**
Personnel outlays	GSLCWSSR
Consumption of fixed capital	GSLCKFR
All else	GSLCOR
Gross investment	**GSLGIR**
Equipment	GSLGIER
Construction	GSLGISR
Interest, dividends, transfer payments, subsidies and accruals:	
Net interest payments	INTNETGSL
Transfers to individuals	**YPTRFGSL**
Medical	YPTRFGSLPAM
Non-medical	YPTRFGSLPAAO
Subsidies less current surplus	*SUBLSURPGSL*
Wage accruals less disbursements (1)	*WALDGSL*
Dividends received	*YGSLADIV*

* Variables denoted in bold are defined by identities.

Notes:

(1) Negative expenditure.

Table A6. Components of nominal national income*

GNP = YPCOMPWSD + TXIM + CKFCORP + CKFNCORP + CKFG + YRENTADJ + YPPROPADJNF + YPPROPADJF + ZB + INTNETBUS + YPCOMPSUPPAI + TXSIEC – SUBLSSURPG + TRFBUS + CKFADJCORP + IVACORP + WALD + STAT

Gross National Product	**GNP**
Wage and salary disbursements	**YPCOMPWSD**
Private sector	**YPCOMPWSDP**
Government	**YPCOMPWSDG**
Excise tax receipts	**TXIM**
Federal	**TXIMGF**
State & local	**TXSIGSL**
Capital consumption allowances w/adjustment	**CKF**
Private	**CKFP**
Corporate	CKFCORP
Non-corporate	CKFNCORP
Government	**CKFG**
Rental income	YRENTADJ
Proprietors' income	
Nonfarm	YPPROPADJNF
Farm	YPPROPADJF
Corporate Profits	**ZB**
Business interest payments	**INTNETBUS**
Other labor income	YPCOMPSUPPAI
Health insurance	YPCOMPSUPPAIHI
Other benefits	YPCOMPSUPPAIO
Employer-paid payroll taxes	**TXSIEC**
Federal	**TXSIECGF**
State & Local	**TXSIECGSL**
Subsidies less current surplus	***SUBLSSURPG***
Federal enterprises	***SUBLSURPGF***
State & local government enterprises	***SUBLSURPGSL***
Transfer payments by business	TRFBUS
Adjustment for capital consumption allowance	CKFADJCORP
Corporate inventory valuation adjustment	IVACORP
Wage accruals less disbursements	***WALD***
Federal government	*WALDGF*
State & Local government	*WALDGSL*
Private sector	*WALDPRI*
Statistical discrepancy	*STAT*

* Variables denoted in bold are defined by identities; variables denoted in italics are exogenous.

Table A7. Components of nominal personal income*

YP = YCOMPWSD + YPCOMPSUPPAI + YPADIV + YPTRFGF + YPTRFGSL + YPAINT + YPTREFBUS + YPRENTADJ + YPPROPADJNF + YPPROPADJF –TXSIWC

Personal income	**YP**
Wage and salary disbursements	**YPCOMPWSD**
Private sector	**YPCOMPWSDP**
Government	**YPCOMPWSDG**
Other labor income	**YPCOMPSUPPAI**
Health insurance	YPCOMPSUPPAIHI
Other benefits	YPCOMPSUPPAIO
Dividend payments to individuals	**YPADIV**
Transfer payments to residents	
Federal	**YPTRFGF**
Social Security	YPTRFGFSISS
Medicare	*YPTRFGFSIHI*
Other full-employment	YPTRFGFFEO
Remaining cyclical component	**YPTRFGFO**
State and Local	**YPTRFGSL**
Medical	YPTRFGSLPAM
All other	**YPTRFGSLPAO**
Personal interest income	**YPAINT**
Business transfers to individuals	YPTRFBUS
Rental income	YPRENTADJ
Proprietors' income	
Nonfarm	**YPPROPADJNF**
Farm	**YPPROPADJF**
Social insurance tax receipts from individuals	**TXSIWC**

* Variables denoted in bold are defined by identities.

Table A8. Key variables in the tax sector*

Federal tax receipts	**TXGF**
Personal	**TXPGF**
Corporate	**TXCORPGF**
Production and imports	**TXIMGF**
VAT	**TXIMGFVAT**
Other	TXIMGFOTH
From rest of the world	*TXRWGF*
State & local tax receipts	**TXGSL**
Personal	**TXPGSL**
Corporate	**TXCORPGSL**
Excise	TRIMGSL
Federal average tax rates	
Personal	
Effective	RTXPGF
Marginal	***RTXPMARGF***
Corporate	
Statutory rate	*RTXCGFS*
Investment tax credits (marginal rates)	*RITC*
Payroll	*RTXSIGF*
State & Local average tax rates	
Personal	***RTXPGSL***
Corporate	***RTXCGSL***
Payroll	***RTXSIGSL***

* Variables denoted in bold are defined by identities; variables denoted in italics are exogenous.

Table A9. Key variables in the trade sector*

Real exports	
Goods	**XGR**
Foods, feeds and beverages	**XGFFBR**
Industrial materials and supplies	**XGINR**
Capital goods except motor vehicles	**XGKR**
Aircraft	XGKCAEPR
Computer equipment	XGKCPPR
Other capital equipment	**XGKOR**
Motor vehicles & parts	**XGAUTOR**
Consumer goods except motor vehicles	XGCR
Miscellaneous goods	**XGOR**
Services	**XSVTOTR**
Real Imports	
Goods	**MGR**
Foods, feeds and beverages	MGFFBR
Industrial materials and supplies	**MGINAPETR**
Petroleum and products	**MGPETR**
Other	MGINR
Capital goods except motor vehicles	**MGKR**
Aircraft	MGKCAEPR
Computer equipment	MGKCPPR
Other capital equipment	MGKOR
Motor vehicles & parts	**MGAUTOR**
Consumer goods except motor vehicles	**MGCR**
Miscellaneous goods	**MGOR**
Services	**MSVTOTR**
Trade-weighted exchange rates	
With major trading partners	**JEXCHMTP**
With other important trading partners	**JEXCHOITP**
Prices	
Industrial countries	**WPIWMTP**
Developing countries	**WPIWOITP**
Lever controlling relative price impacts	***TRADEPLEV***
Lever controlling US price feedthroughs	***WPIWLEV***
Output	
Real trade-weighted GDP in other industrial countries	***JGDPMTPR***
Real trade-weighted GDP in developing countries	***JGDPOITPR***
Long-term government bond yield – major trading partners	***RMGBLMTP***

* Variables denoted in bold are defined by identities; variables denoted in italics are exogenous.

Table A10. Key variables in the financial sector*

Interest rates	
Federal funds rate	**RMFF**
Supply of reserve as instrument	**RMFFRES**
Reaction function as instrument	**RMFFRCT**
Treasury yield	
3-month bill rate	RMTB3M
6-month bill rate	RMTB6M
1-year note yield	**RMTCM1Y**
2-year note yield	**RMTCM2Y**
5-year note yield	RMTCM5Y
10-year note yield	RMTCM10Y
Long-term bond yield	RMTCM25AY
Other	
Prime Rate	**RMPRIME**
3-month CDs, secondary market	RMCD3SEC
3-month commercial paper	RMCMLP3M
3-month Eurodollar deposits	**RMEUROD3M**
Rate on commercial bank loans for new light vehicles	**RMCBLV**
New York Fed discount rate	RMDWPRIME
11th district cost of funds	RMCOF11D
30-year mortgage rate	RMMTG30CON
Rate on existing-home mortgages	RMMTGEXIST
Yield on Aaa corporate bonds	RMCORPAAA
Yield on Baa corporate bonds	**RMCORPBAA**
Rate on Aa-rated public utility bonds	**RMCORPUAA**
Rate on Aaa-rated municipal bonds	**RUMMUNIAA**
Municipal bond buyer 20-bond index	**RUMMUNIBB20**
Other Financial Variables	
M1 money supply	**M1**
Currency and travelers' checks	**M1CURATC**
Checkable deposits	**M1DCHK**
M2 money supply	**M2**
M3 money supply	**M3**
Household net worth	**HHNETW**
Real estate & other nonfinancial assets	**HHAP**
Financial assets	**HHAF**
Equities	**HHAFEQ**
Money	**HHAFM**
Other	**HHAFO**
Household liabilities	**HHLB**
Home mortgages outstanding	**MTGHO**
Non-mortgage consumer credit	**LCNMTGO**
Business loans at commercial banks	**LCBCAI**
S&P 500 stock index	***SP500***
Wilshire 5000 stock index	***WL5000***

* Variables denoted in bold are defined by identities; variables denoted in italics are exogenous.

Table A11. Macroeconomic expenditure categories driving the Industrial Output Model

Variable	Description
Personal Consumption Expenditures	
CDRECIPR	Real consumer spending on computers & software
CDFHER	Real consumer spending on furniture and appliances
CDMVR	Real consumer spending on light vehicles
CDMVPAR	Real consumer spending on motor vehicle parts
CDOR	Real consumer spending on other durables plus medical devices
CDRECOR	Real consumer spending on other recreational goods and vehicles
CNCSR	Real consumer spending on clothing & shoes
CNEFAOR	Real consumer spending on fuel oil & coal
CNEGAOR	Real consumer spending on gasoline & motor oil
CNFR	Real consumer spending on off-site food and beverage
CNOPMPR	Real consumer spending on prescription & over-the-counter drugs
CNOTOBR	Real consumer spending on tobacco products
CNOOR	Real consumer spending on other nondurable goods
CSVUR	Real consumer spending on utilities
CSVFAACR	Real consumer spending on food services & accommodations
CSVHR	Real consumer spending on housing
CSVHCR	Real consumer spending on medical services
CSVFINR	Real consumer spending on financial services
CSVRECR	Real consumer spending on recreation services
CSVTSPUBR	Real consumer spending on public transportation
CSVTSMVXLSR	Real consumer spending on other user-operated transportation
CSVTSMVOLSR	Real consumer spending on motor vehicle leases
CSVOOR	Real consumer spending on other services
Investment and Inventories	
IFMVATLR	Real gross investment purchases of light vehicles
IFNREEINDR	Real gross nonresidential investment in industrial equipment
IFNREEIPCCR	Real gross nonresidential investment in computer equipment
IFNREIPSR	Real gross nonresidential investment in software
IFNREEIPCTR	Real gross nonresidential investment in communications equipment
IFNREEIPOR	Real gross nonresidential investment in other information processing equipment
IFNREETACR	Real gross nonresidential investment in aircraft
IFNREETOR	Real gross nonresidential investment in other transportation equipment
IFNREEOR	Real gross nonresidential investment in other transportation equipment
IFSR	Real gross investment in all structures
IIR	Real change in stock of business inventories

Table A11. Macroeconomic expenditure categories driving the Industrial Output Model (cont.)

Variable	Description
Government Spending	
GFMLGIR	Real federal defense gross investment
GFMLR	Real federal defense purchases of goods & services
GFOGIR	Real federal non-defense gross investment
GFOR	Real federal non-defense purchases of goods & services
GSLGIR	Real state & local gross investment
GSLR	Real state & local purchases of goods & services
Exports	
XGAUTOR	Real exports of motor vehicles & parts
XGCR	Real exports of non-automotive consumer goods
XGFFBR	Real exports of foods, feeds & beverages
XGINR	Real exports of industrial materials & supplies
XGKCAEPR	Real exports of aircraft
XGKCPPR	Real exports of computer equipment
XGKOR	Real exports of other capital equipment
XGOR	Real exports of other goods
XSVTOTR	Real exports of services
Imports	
MGAUTOR	Real imports of motor vehicles & parts
MGCR	Real imports of non-automotive consumer goods
MGFFBR	Real imports of foods, feeds & beverages
MGINR	Real imports of industrial supplies excl. petroleum
MGKCAEPR	Real imports of aircraft
MGKCPPR	Real imports of computer equipment
MGKOR	Real imports of other capital equipment
MGPETR	Real imports of petroleum & products
MGOR	Real imports of other goods
MSVTOTR	Real imports of services

In the IHS Markit model, output value series has "R" as prefix, and real value series has "R" as suffix (for example, R111R); employment series has "E" as prefix (for example, E111). The MAM variable names for output values are prefixed with REV (for example, REVIND1) and those for employment are prefixed with EMP (for example, EMPIND1). They are placed into three NEMS variables - MC_REVIND (output of industrial sectors), MC_REVSER (output of services sectors) and MC_EMPNA (employment).

Table A12. Detailed sector classification for industry and employment models

GI Code	Description	NAICS (2012) codes	NEMS Sector (Emp./IO)
Nonmanufacturing industries			
Agriculture, forestry, fishing and hunting			
111	Crop production	111	IND20/42
112	Animal production	112	IND21/43
113	Forestry and logging	113	IND21/44
11O	Agriculture, other	114, 115	IND21/44
Mining			
211	Oil and gas extraction	211	IND23/46
2121	Coal mining	2121	IND22/45
2122	Metal ore mining	2122	IND24/47
2123	Nonmetallic mineral mining	2123	IND24/47
213	Support activities for mining	213	IND23/46
Construction			
23	Construction	23	INDX/48
236	Construction of Buildings	236	IND25/X
237	Heavy and Civil Engineering Construction	237	IND26/X
238	Specialty Trade Contractors	238	IND27/X
Manufacturing industries			
311	Food products	311	IND1
3112	Grain and oilseed milling	3112	IND1/2
3115	Dairy products	3115	IND1/3
3116T7	Animal slaughtering and seafood products	3116-7	IND1/4
311O	Remaining food products codes	3111,3-4,8-9	IND1/5
312	Beverage and tobacco products	312	IND2/6
313T316	Textile mills and products, apparel, and leather products	313-6	IND3/7
321	Wood products	321	IND4/8
322	Pulp and paper products	322	IND6/10
3221	Pulp, paper, and paperboard mills	3221	IND6/11
32221	Paperboard container manufacturing	32221	IND6/12
322O	Other paper manufacturing	32222 - 32229	IND6/13
323	Printing	323	IND7/14
32411	Petroleum refineries	32411	IND10/25

324O	Other petroleum and coal products manufacturing	32412, 32419	IND10/26
32511A9	Basic organic chemicals	32511, 32519	IND8/16

Table A12. Detailed sector classification for industry and employment models (cont.)

GI Code	Description	NAICS (2012) codes	NEMS Sector (Emp./IO)
Manufacturing Industries (cont.)			
325193	Ethanol	321593	IND8/17
32511A9O	Other organic chemicals	32511, 32519 less 325193	IND8/17
32512T8	Basic inorganic chemicals	32512 - 32518	IND8/15
3252	Resins, synthetic rubber and synthetic fibers	3252	IND8/18
3253	Pesticide, fertilizer and other agricultural chemicals	3253	IND8/19
3254T9	Other chemical products	3254 - 3259	IND9/20
3254	Pharmaceuticals and medicines	3254	IND9/21
3255	Paints, coatings, and adhesives	3255	IND9/22
3256	Soaps and cleaning products	3256	IND9/23
325O	Other chemicals	3259	IND9/24
326	Plastics and rubber products	326	IND11/27
3272	Glass and glass products	3272	IND12/28
327211	Flat glass manufacturing	327211	IND12/29
32731	Cement	32731	IND12/30
3274	Lime and gypsum	3274	IND12/31
327O	Other non-metallic mineral products	3271, 32732 - 32739, 3279	IND12/32
3311A2	Iron and steel mills and ferroalloy and steel products	3311, 3312	IND13/33
3313	Alumina and aluminum products	3313	IND13/34
3314A5X1	Other primary metals	3314, 33152	IND13/35
33151	Ferrous metal foundries	33151	IND13/33
332	Fabricated metal products	332	IND14/36
333	Machinery	333	IND15/37
3341	Computer and peripheral equipment	3341	IND16/38
334413	Semiconductor and related devices	334413	IND16/38
334511	Search and navigation instrument manufacturing	334511	IND16/38
3345X11	Electro medical, measuring, and control instruments	3345 less 334511	IND16/38
334A5O	Other electronic and electrical equipment, appliance and components	3342 - 3344, 3346	IND16/38
335	Electric equipment and appliances	335	IND17/40
336	Transportation equipment	336	IND18/39
337	Furniture and related products	337	IND5/9
339	Miscellaneous durable products	339	IND19/41

Table A12. Detailed sector classification for industry and employment models (cont.)

GI Code	Description	NAICS (2012) codes	NEMS Sector (Emp./IO)
Services			
Utilities			
2211	Power generation and supply	2211	SER1/3
2212	Natural gas distribution	2212	SER2/4
2213	Water, sewage and related systems	2213	SER3/5
Wholesale and Retail Trade			
42	Wholesale trade	42	SER4/6
44A5	Retail trade	44, 45	SER5/7
Transportation			
48A9	Transportation and warehousing	48, 49	SER6/1
Other services			
5111	Newspaper, periodicals, book, and directory publishers	5111	SER7/9
515	Broadcasting (except internet)	515	SER8/2
517	Telecommunications	517	SER9/2
52	Finance and insurance	52	SER10/8
53	Real estate and rental and leasing	53	SER11/8
SERV	Other private services	5112, 512, 514, 54 - 81	SER12/9
921	Federal government[1]	921	SER12/10
922A3	State and local government	922, 923	SER12/10

Regional Model Detail

Table A13. Regional economic variables

Name	Description
CPI	Consumer Price Index, All Urban, 1982-84 = 1.0
GSPR	Real Gross State Product, billions of chained 2009 dollars
RWM	Average Annual Manufacturing Wages, thousands of nominal $
RWNM	Average Annual Non-Manufacturing Wages, thousands of nominal $
YP	Personal Income, billions of nominal dollars
YPCOMPWSD	Wage & Salary Disbursements, billions of nominal dollars
YPCOMPWSDG	Wage & Salary Disbursements, Government, billions of nominal $
YPCOMPWSDP	Wage & Salary Disbursements, Private, billions of nominal dollars
YPD	Personal Disposable Income, billions of dollars
YPDR	Real Disposable Personal Income, billions of chained 2009 dollars
YPDRZNP	Real per Capita Personal Disposable Income, billions of 2009 dollars
YPOTH	Other Personal Income, billions of dollars
NP	Total Population, Including Armed Forces Overseas, millions
HUSPS1	Single-Family Housing Starts, millions of units
HUSPS2A	Multi-Family Housing Starts, millions of units
HUSMFG	Shipments of Mobile Homes, millions of units
KHUPS1	Stock of Single-Family Housing, millions of units
KHUPS2A	Stock of Multi-Family Housing, millions of units
KHUMFG	Stock of Mobile Homes, millions of units

Table A14. Regional industry output and employment

NEMS Sector (Emp./IO)	Description	NAICS (2012) codes
Manufacturing Industries:		
IND1	Food products	311
IND1/2	Grain & oilseed milling	3112
IND1/3	Dairy products	3115
IND1/4	Animal slaughter and seafood products	3116-7
IND1/5	Other food products	3111, 3-4, 8-9
IND2/6	Beverage and tobacco products	312
IND3/7	Textile mills and products, apparel, and leather products	313-316
IND4/8	Wood products	321
IND5/9	Furniture and related products	337
IND6/10	Paper products	322
IND6/11	Pulp & paper mills	3221
IND6/12	Paperboard container manufacturing	32221
IND6/13	Other paper products	32222-9
IND7/14	Printing	323
IND8/15	Basic inorganic chemicals	32512 - 32518
IND8/16	Basic organic chemicals	32511, 32519
IND8/17	Ethanol	325193
IND8/18	Plastic and synthetic rubber materials	3252
IND8/19	Agricultural chemicals	3253
IND9/20	Other chemical products	3254 - 3259
IND9/21	Pharmaceuticals and medicines	3254
IND9/22	Paints and coatings	3255
IND9/23	Soaps and cleaning products	3256
IND9/24	Other chemicals	3259
IND10/25	Petroleum refineries	32411
IND10/26	Other petroleum and coal products	32412, 32419
IND11/27	Plastics and rubber products	326
IND12/28	Glass and glass products	3272
IND12/29	Flat glass	327211
IND12/30	Cement manufacturing	32731
IND12/31	Lime and gypsum	3274
IND12/32	Other non-metallic mineral products	327 less 3272, 3274, & 32731
IND13/33	Iron and steel mills, ferroalloy and steel products	3311, 3312
IND13/34	Alumina and aluminum products	3313
IND13/35	Other primary metals	3314, 3315
IND14/36	Fabricated metal products	332
IND15/37	Machinery	333

Table A14. Regional industry output and employment (cont.)

NEMS sector (Emp./IO)	Description	NAICS (2012) codes
Manufacturing Industries (cont.):		
IND16/38	Electronic and electric products	334
IND17/39	Transportation equipment	336
IND18/40	Electric equipment and appliances	335
IND19/41	Miscellaneous manufacturing	339
Nonmanufacturing Industries:		
IND20/42	Crop production	111
IND21/43	Animal production	112
IND21/44	Other agriculture, forestry, fishing and hunting	113 - 115
IND22/45	Coal mining	2121
IND23/46	Oil and gas extraction and support activities	211, 213
IND24/47	Other mining and quarrying	2122, 2123
INDX/48	Construction	23
IND25/X	Construction of Buildings	236
IND26/X	Heavy and Civil Engineering Construction	237
IND27/X	Specialty Trade Contractors	238
Services:		
SER6/1	Transportation and warehousing	48, 49
SERX/2	Broadcasting and telecommunications	515, 517
SER7/X	Publishing Industries (except internet)	511
SER8/X	Broadcasting(except internet)	515
SER9/X	Telecommunications	517
SER1/3	Electric power generation and distribution	2211
SER2/4	Natural gas distribution	2212
SER3/5	Water, sewage and related systems	2213
SER4/6	Wholesale trade	42
SER5/7	Retail trade	44, 45
SERX/8	Finance and insurance, real estate	52, 53
SER10/X	Finance & insurance	52
SER11/X	Real estate and rental/leasing	53
SER12/9	Other services	51, 54 - 81
SER12/10	Public administration	921, 922, 923
	Federal (employment only)	921
	State and local (employment only)	922, 923

Table A15. Commercial floor space types

Code	Description
STORES	Stores and restaurants
WARE	Manufacturing and wholesale trade, public and federally-owned warehouses
OFFICE	Private, federal, and state and local offices
AUTO	Auto service and parking garages
MFG	Manufacturing
EDUC	Primary, secondary and higher education
HEALTH	Health - hospitals and nursing homes
PUB	Federal and state and local government
REL	Religious
AMUSE	Amusement
MISCNR	Miscellaneous, non-residential - transportation related and all other not elsewhere classified
HOTEL	Hotels and motels
DORM	Dormitories, educational and federally-owned (primarily military)

Appendix B: MAM Inputs and Outputs

Introduction

Appendix B describes the inputs, parameters, and files required for execution of the Direct Link, Industrial Output, Employment, Regional, Commercial Floor Space, and Transportation submodules of the Macroeconomic Activity Module (MAM). This appendix also presents the primary outputs generated by MAM for the benefit of NEMS and of the MAM output files. As described in the main text of this volume, the Direct Link submodule of MAM uses IHS Markit's U.S. Macroeconomic Activity, Industrial Output, and Employment models. The EIA staff and contract support developed the remaining models of the MAM. These include models of regional economic activity, industrial output and employment, growth of regional stocks of commercial floor space, and unit sales of light trucks. Unlike IHS Markit's models, the EIA models are not proprietary. Table B1 identifies the files that are used and are created by the MAM during the execution of the NEMS. It also indicates whether each file is an input or an output file and describes its contents.

Inputs

Table B2 describes the MAM parameters and controls specified at the start of a NEMS run. They include user-specified modeling switches and array dimensions used in MAM's FORTRAN source code. The user-specified switches enable the modeler to choose among alternative assumptions for the scenario.

Inputs from NEMS

Before the MAM executes IHS Markit's U.S. model in EViews, 52 energy prices and quantities are computed using inputs from the NEMS. These are energy assumptions exogenous to IHS Markit's models. Table B3 lists and defines these energy assumptions. For each, the IHS Markit model mnemonic is given along with its definition. The final column of Table B3 lists the NEMS variables used to calculate the corresponding IHS Markit variable.

The MAM also calculates industrial gross output growth rates for the energy sectors (petroleum refining, coal mining, oil and gas extraction, electric utilities, and gas utilities) based upon physical activity for the appropriate NEMS supply or conversion modules, and then applies them to the historical output series in the Industrial Output Model. In the Employment Model, employment estimates for two energy sectors (coal mining and oil and gas extraction) are computed using growth rates extracted from the appropriate NEMS modules. Table B4 describes the NEMS variables used to calculate the growth rates for each sector.

Outputs

Table B5 lists the U.S. macroeconomic variable outputs returned to the MAM from EViews. Annual data beginning in 1990 and estimated through 2050 are recorded in the spreadsheet named MC_NATIONAL.

Table B6 defines industrial gross output variables contained within the Industrial Output Model of the MAM. Projected growth rates of the five energy industry sectors are replaced by the NEMS results. MC_INDUSTRIAL is a spreadsheet that presents the history and projections of industrial output by sector for the nine Census Divisions and for the United States.

Table B7 defines the employment variables contained in the Employment Model of the MAM. Projected growth rates of two energy sectors are replaced by the NEMS results. Historical and estimated values for the detailed industrial sectors and aggregates are shown in the MC_EMPLOYMENT spreadsheet.

Table B8 defines the light truck variables contained in the TRANC Submodule of the MAM. Annual data beginning in 1990 and estimated through 2050 are recorded in the spreadsheet named MC_VEHICLES.

Regional data and commercial floor space data produced by the Regional Model and the Commercial Floor Space Model of the MAM are presented in the MC_REGIONAL spreadsheet. Table B9 describes the regions and variables contained in that spreadsheet. The same regional projections for economic activity, commercial floor space, employment and industrial output contained in the MC_REGIONAL spreadsheet are also found in the MC_REGMAC, MC_COMMFLR, MC_REGEMP, and MC_REGIO spreadsheets, respectively. Table B10 describes the regions and variables contained in the output spreadsheet MC_REGMAC for EIA's Regional Economic Activity Model. Table B11 describes the regions and variables contained in the output spreadsheet MC_COMMFLR for EIA's Regional Commercial Floor Space Model. Table B12 describes the regions and variables contained in the output spreadsheet MC_REGEMP for EIA's Regional Employment Model. Table B13 describes the regions and variables contained in the output spreadsheet MC_REGIO for EIA's Regional Industrial Output Model.

Table B14 lists the MACOUT common block variables referenced by other NEMS modules. The final column lists the referencing NEMS modules and submodules. A description of the module and submodule abbreviations follows Table B14.

Table B1. MAM input and output files

Filename	Content	Input or Output
ALTDATA.CSV	NEMS energy price and quantity data used as MAM drivers	Input
COMFLOOR.XLS	Data for EIA's Regional, Industrial Output and Employment Models	Input
DRIVERS.PRG	Run-specific EViews program file	Input
DRVDATA.WF1	EViews workfile of annual frequency	Input
EPMAC.CSV	Projection of Macroeconomic, Industrial Output and Employment Models in levels	Input
EVIEWSDB.EDB	Intermediary database for workfiles of annual and quarterly frequency	Input
MC_COMMFLR.CSV	Regional Commercial Floor Space Model solution	Output
MC_COMMON.CSV	MAM projections written to Global Data Structure.	Output
MC_DETAIL.CSV	Detailed US Macroeconomic Model solution	Output
MC_EMPLOYMENT.CSV	US Employment Model solution and base	Output
MC_ENERGY.CSV	NEMS energy variables read from IHS Global Data Structure	Output
MC_INDUSTRIAL.CSV	US Industrial Output Model solution and base	Output
MC_NATIONAL.CSV	US Macroeconomic Model solution, base and percent change from base	Output
MC_REGEMP.CSV	Regional Employment Model solution	Output
MC_REGIO.CSV	Regional Industrial Output Model solution	Output
MC_REGIONAL.CSV	Regional Model solution and base	Output
MC_REGMAC.CSV	Regional Economic Model solution and base	Output
MC_VEHICLES.CSV	Light truck Unit Sales Model solution	Output
MCEVCODE.TXT	Generic EViews program file used to create run-specific drivers program file	Input
MCEVEPMD.WF1	US Employment Model	Input/Output
MCEVIOMD.WF1	US Industrial Output Model	Input/Output
MCEVRGMD.WF1	Regional Economic Model	Input/Output
MCEVSUBS.PRG	EViews subroutines	Input
MCEVWORK.WF1	US Macroeconomic Model	Input/Output
MCHIGHLO.XLS	High and low economic activity model factors and transportation model size class data	Input
MCPARMS.TXT	Parameters	Input
MCREGIND.WF1	Regional Industrial Output and Employment Models	Output
MC_XTABS.CSV	Detailed projection of US economic activity	Output

File Extension Key:

File Extension	File Type
EDB	EViews database
PRG	EViews program file
TXT	Text file
WF1	EViews workfile
CSV	Comma Separated text file
XLS	Microsoft Excel file

Table B2. MAM input controls and parameters

Parameter Name	Input Type (filename)	Input Description
CAFE	User-defined parameter (SCEDES)	Unit cost of automobiles under new CAFE standards, 0=No change from baseline, 1=factor cost determined by NEMS TRAN results
CFDIAGX=0	MAM parameter (MCPARMS)	Commercial floor space growth rate tables switch: 1=ON 0=OFF
CONTROLTARGET=1	MAM parameter (MCPARMS)	Commercial floor space add factor switch 1=ON 0=OFF
EVVERS	Run-time option (SCEDES)	Version of EViews used in simulation; 6 = v.6, 5 = v.5
EXM	Run-time option (SCEDES)	MAM Module Switch, 1 = on, 0 = off
GISWITCH=-1	MAM parameter (MCPARMS)	Global Insight Scenario Switch: ”1:”FF; ”="_0”; 1=”_pes”; 2=”_opt”; 3="_cyc"
MACFDBK	Run-time option (SCEDES)	Macroeconomic feedback lever, 1 = on, 0 = off
MACTAX	User-defined parameter (SCEDES)	Distribution of energy tax, 0=No distribution, other parameter values defined according to requirements of study
MCNMFLTYPE=9	MAM parameter (MCPARMS)	Number of commercial floor space types, including total
MCNMIND=48	MAM parameter (MCPARMS)	Number of regionalized industry output variables
MCNMMAC=75	MAM parameter (MCPARMS)	Number of non-regionalized macroeconomic variables
MCNMMACREG=73	MAM parameter (MCPARMS)	Number of regionalized macroeconomic variables
MCNMNATREG=14	MAM parameter (MCPARMS)	Number of regionalized macroeconomic variables
MCNMSERV=10	MAM parameter (MCPARMS)	Number of non-regionalized service output variables
MCNUMMNF=41	MAM parameter (MCPARMS)	Number of manufacturing industry variables
MCNUMREGS=11	MAM parameter (MCPARMS)	The nine Census Divisions, a placeholder for California (currently not in use), and the national total of all Census Divisions

Table B2. MAM input controls and parameters (cont.)

Parameter Name	Input Type (filename)	Input Description
MMAC	Run-time option (SCEDES)	Macroeconomic growth scenario: 1 = Low, 2 = Reference, 3 = High
NEMSENERGYNUM=360	MAM parameter (MCPARMS)	Number of exogenous variables (aggregates and components) from NEMS
NUMEMPL=39	MAM parameter (MCPARMS)	Number of industrial employment categories
NUMEPMAC=186	MAM parameter (MCPARMS)	Number of solution variables returned to MAM from EViews
NUMGIXTAB=206	MAM parameter (MCPARMS)	Number of variables for extra Global Insight tables
NUMXTABS=158	MAM parameter (MCPARMS)	Number of solution variables returned to NEMS for extra macro tables
RMFFLEV=0.90	MAM parameter (MCPARMS)	Federal fund rate lever, 0=Rate determined by balance of reserve, 1=Rate determined in response to changes in inflation and unemployment
SCENNUM=163	MAM parameter (MCPARMS)	Number of driver variables passed to EViews models from MAM
TTECH	User-defined parameter (SCEDES)	Technology scenario: 1 = Low, 2 = Reference, 3 = High

Table B3. NEMS input variables for MAM national submodule

MAM Variable Name	Definition	NEMS Variable Name and Source
CNEFAOR	Consumption of household fuel oil	QBLK common block: QTPRS-Total petroleum, residential
CNEGAOR	Consumption of consumer gasoline and oil	QBLK common block: QDSTR-Distillate, transportation QETTR-Ethanol, transportation QMGTR-Motor gasoline, transportation
CSVUER	Consumption of household electricity	QBLK common block: QELRS-Electricity, residential
CSVUGR	Consumption of household natural gas	QBLK common block: QNGRS-Natural gas, residential
DALLFUELSBIO	Total demand for biofuels	CONVFACT Common Block: CFBIOBUTE–Biobutanol CFBIOD–Biodiesel CFBTLLIQ–Liquids from biomass CFCORN–Corn CFPET–Pure ethanol CFVEGGIE–Biodiesel to vegetable oil LFMMOUT Common Block: CORNCD–Corn consumption RFBIOBUTECD–Production of biobutanol PMMOUT Common Block: BTLFRAC–BTL liquid component produced CBTLFRAC–Liquids produced from coal/biomass combo plant CFCBTLLIQ–Liquids from coal and biomass QBMRFBTL–Quantity of biomass for BTL UBAVOL–Upgraded bio-oil A7 PMMRPT Common Block: BIMQTYCD–Quantity biodiesel produced CLLETHCD–Ethanol produced from cellulose CRNETHCD–Ethanol produced from corn OTHETHCD–Advanced ethanol QBLK Common Block: QBMAS–Biomass, all sectors QBMRF–Biomass, refinery
DALLFUELSCOAL	Total demand for coal	CONVFACT Common Block: CFNGC–Natural gas consumption NGTDMREP Common Block: OGSUPGAS–Supplemental natural gas supplies

MAM Variable Name	Definition	NEMS Variable Name and Source
		QBLK Common Block: QCIIN–Net coal coke imports, industrial QCLAS–Coal, all sectors QMCIN–Metallurgical coal, industrial
DALLFUELSNG	Total demand for natural gas	CONVFACT Common Block: CFGTLLIQ–Liquids from gas CFNGN–Natural gas, non-utility consumption QBLK Common Block: QGPTR–Natural gas, pipeline QHYTR –Liquid hydrogen, transportation QLPIN–Natural gas, lease and plant fuel QNGAS–Natural gas, all sectors QNGLQ–Natural gas used for liquefaction
DALLFUELSOO	Total demand for other fuels	QBLK Common Block: QBMAS–Biomass, all sectors QEIEL–Electricity imports QETTR–Ethanol, transportation QGERS–Geothermal, residential QHOAS–Hydropower, all sectors QHYTR–Liquid hydrogen, transportation QPVCM–Photovoltaic, commercial QPVRS–Photovoltaic, residential QSTCM–Solar thermal, commercial QSTRS–Solar thermal, residential QTRAS–Total renewables, all sectors QUREL–Uranium, electricity WNCMSEL Common Block: WNCMSEL–Util MSW non-bio consumption
DALLFUELSPET	Total demand for petroleum	QBLK Common Block: QETTR–Ethanol, transportation QMETR–Methanol, transportation QTPAS–Total petroleum, all sectors
DENDUBIO	End-use demand for biofuels	CONVFACT Common Block CFBIOBUTE-Biobutanol CFBIOD–Biodiesel CFCORN-Corn, bushels to Btu CFGTLLIQ–Liquids from gas CFNGC–Natural gas consumption CFNGN–Natural gas, non-utility consumption CFPET–Pure ethanol CFVEGGIE-Biodiesel to vegetable oil

MAM Variable Name	Definition	NEMS Variable Name and Source
		LFMMOUT Common Block CORNCD-Corn Consumption RFBIOBUTECD–Production of biobutanol NGTDMREP Common Block: OGSUPGAS–Supplemental natural gas supplies PMMOUT Common Block: BTLFRAC–BTL liquid component produced CBTLFRAC–Liquids produced from coal/biomass combo plant CFCBTLLIQ–Liquids from coal and biomass QBMRFBTL–Quantity of biomass for BTL UBAVOL–Upgraded bio-oil A7 PMMRPT Common Block: BIMQTYCD-Quantity of biodiesel produced by type CLLETHCD–Ethanol produced from cellulose CRNETHCD–Ethanol produced from corn OTHETHCD–Advanced ethanol QBLK Common Block: QBMAS-Biomass, All Sectors QBMAS-Biomass, All Sectors QBMRF-Biomass, Refinery QCIIN–Net coal coke imports, industrial QCLAS–Coal, all sectors QETTR–Ethanol, transportation QGERS-Geothermal, Residential QGPTR–Natural gas, pipeline QHOAS–Hydropower, all sectors QHYTR –Liquid hydrogen, transportation QLPIN–Natural gas, lease and plant fuel QMCIN–Metallurgical coal, industrial QMETR–Methanol, transportation QNGAS–Natural gas, all sectors QNGLQ–Natural gas used for liquefaction QPVCM-Photovoltaic, Commercial QPVRS-Photovoltaic, Residential QSTCM-Solar Thermal, Commercial QSTRS-Solar Thermal, Residential QTPAS–Total petroleum, all sectors QTRAS-Total Renewables, All Sectors QUREL-Uranium, electricity

MAM Variable Name	Definition	NEMS Variable Name and Source
		WRENEW Common Block: WNCMSEL-Util, MSW Non-Bio Consumption
DENDUCOAL	End-use demand for coal	QBLK common block: QCIIN-Net coal coke imports, industrial QCLAS-Coal, all sectors QCLEL-Coal, electricity generation QMCIN-Metallurgical coal, industrial
DENDUELC	Electricity sales to ultimate consumers	QBLK common block: QELAS-Purchased electricity, all sectors
DENDUNG	End-use demand for natural gas	QBLK common block: QGPTR-Natural gas, pipeline, transportation QLPIN-Lease and plant fuel, industrial QNGAS-Natural gas, all sectors QNGEL-Natural gas, electricity
DENDUPET	End-use demand for petroleum	QBLK common block: QASIN-Asphalt and road oil, industrial QDSAS-Distillate, all sectors QDSEL-Distillate, electricity QJFTR-Jet fuel, transportation QKSAS-Kerosene, all sectors QLGAS-Liquefied petroleum gases, all sectors QMGAS-Motor gasoline, all sectors QOTAS-Other petroleum, all sectors QPCIN-Petroleum coke, industrial QPFIN-Petrochemical feedstocks, industrial QRSAS-Residual fuel, all sectors QRSEL-Residual fuel, electricity QSGIN-Still gas, industrial
ENDUSEPCCOAL	Steam coal share in electrical generation	QBLK common block: QCLEL -Coal, electricity generation QEIEL-Net electricity imports QTSEL-Total energy consumption-electric power
ENDUSEPCNG	Natural gas share in electrical generation	QBLK common block: QEIEL-Net electricity imports QNGEL-Electricity, natural gas QTSEL-Total energy consumption-electric power
ENDUSEPCPET	Distillate and residual fuel oil share in electrical generation	QBLK common block: QDSEL-Distillate, electricity

MAM Variable Name	Definition	NEMS Variable Name and Source
		QEIEL-Net electricity imports QRSEL -Residual fuel, electricity QTSEL-Total energy consumption-electric power
ENGDOMBIO	Domestic production of energy from biomass	CONVFACT Common Block CFCORN-Corn, bushels to Btu CFVEGGIE-Biodiesel to vegetable oil LFMMOUT Common Block CORNCD-Corn Consumption PMMFTAB Common Block: SBO2GDTPD-Soy Bean Oil to Green Diesel WGR2GDTPD-White Grease to Green Diesel YGR2GDTPD-Yellow Grease to Green Diesel PMMOUT Common Block: QBMRFBTL-Biomass for BTL PMMRPT Common Block: BIMQTYCD-Quantity of biodiesel produced by type QBLK Common Block: QBMAS-Biomass, All Sectors QBMRF-Biomass, Refinery
ENGDOMCOAL	Domestic production of energy from coal	COALREP COMMON BLOCK: CQSBB-COAL PRODUCTION WC_PROD_BTU-WC DISTRIBUTION INCLUDING EXPORTS
ENGDOMNG	Domestic production of energy from natural gas	CONVFACT Common Block: CFNGL-Natural gas liquids PMMOUT Common Block: RFPQNGL-Price and quantity of NGL
ENGDOMOO	Domestic production of energy from other fuels	CONVFACT Common Block: CFCRDDOM-Domestic Crude Production CFMEQT-Methanol CFRSQ-Residual Fuel CFVEGGIE-Convert Biodiesel Output to Vegetable Oil Input PMMFTAB Common Block: RFHCXH2IN-Hydrogen from Natural Gas Input to Refinery RFMETM85-Production of M85 SBO2GDTPD-Soy Bean Oil to Green Diesel WGR2GDTPD-White Grease to Green Diesel YGR2GDTPD-Yellow Grease to Green Diesel

MAM Variable Name	Definition	NEMS Variable Name and Source
		QBLK Common Block: QBMAS-Biomass, All Sectors QETTR-Ethanol, Transportation QGERS-Geothermal, Residential QHOAS-Hydropower, All Sectors QPVCM-Photovoltaic, Commercial QPVRS-Photovoltaic, Residential QSTCM-Solar Thermal, Commercial QSTRS-Solar Thermal, Residential QTRAS-Total Renewables, All Sectors QUREL-Uranium, Electricity WRENEW Common Block: WNCMSEL-Util, MSW Non-Bio Consumption
ENGDOMPET	Domestic production of energy from petroleum	CONVFACT Common Block: CFCRDDOM-Domestic crude production PMMOUT Common Block: RFQTDCRD-Production of crude oil
ENGEXPBIO	Exports of biofuels	CONVFACT Common Block: CFBIOBUTE–Biobutanol CFBIOD–Biodiesel CFPET–Pure ethanol LFMMOUT Common Block: BIOBUTEEXP–Exports of biobutanol PMMRPT Common Block: BIODEXP–Biodiesel exports ETHEXP–Ethanol exports
ENGEXPCOAL	Exports of coal	COALOUT Common Block: CQDBFB–Imports, exports and stock changes
ENGEXPNG	Exports of natural gas	CONVFACT Common Block: CFNGE–Natural gas exports NGTDMREP Common Block: NGEXPVOL–Total export volumes
ENGEXPOO	Exports of other fuels	COALOUT Common Block: CQDBFB–Imports, exports and stock changes CONVFACT Common Block: CFBIOBUTE–Biobutanol CFBIOD–Biodiesel CFCRDEXP–Crude oil exports CFEXPRD–Refined petroleum product exports CFNGE–Natural gas exports CFPET–Pure ethanol

MAM Variable Name	Definition	NEMS Variable Name and Source
		LFMMOUT Common Block: BIOBUTEEXP–Exports of biobutanol NGEXPVOL–Total export volumes PMMRPT Common Block: BIODEXP–Biodiesel exports ETHEXP–Ethanol exports RFQEXCRD–Crude exported RFQEXPRDT–Crude exported
ENGEXPPET	Exports of petroleum	CONVFACT Common Block: CFCRDEXP–Crude oil exports CFEXPRD–Refined petroleum product exports PMMRPT Common Block: RFQEXCRD–Crude exported RFQEXPRDT–Crude exported
ENGIMPBIO	Exports of biofuels	CONVFACT Common Block: CFBIOBUTE–Biobutanol CFBIOD–Biodiesel CFPET–Pure ethanol LFMMOUT Common Block: BIOBUTEIMP–Imports of biobutanol PMMRPT Common Block: BIODIMP–Biodiesel imports ETHIMP–Ethanol imports
ENGIMPCOAL	Imports of coal	COALOUT Common Block: CQDBFB–Imports, exports and stock changes
ENGIMPNG	Imports of natural gas	CONVFACT Common Blocks: CFNGI–Natural gas imports NGTDMREP Common Block: NGIMPVOL–Total import volumes
ENGIMPOO	Imports of other fuels	QBLK Common Block: QCIIN–Net coal coke imports, industrial QEIEL–Electricity imports
ENGIMPPET	Imports of petroleum	CONVFACT Common Block: CFCBOB –Conventional gasoline before oxygenate blending CFCRDIMP –Crude oil imports CFIMPRD –Petroleum product imports CFIMUO –Unfinished oil imports CFRBOB –Reformulated gasoline before oxygenate blending

MAM Variable Name	Definition	NEMS Variable Name and Source
		LFMMOUT Common Block: RFIPQCBOB –Imports, CBOB RFIPQRBOB –Imports, RBOB PMMOUT Common Block: RFSPRIM –SPR imports PMMRPT Common Block: RFMTBI –Imported MTBE RFPQIPRDT –Total imported product RFPQUFC –Total imports of unfinished RFQICRD –Imported total crude
ENGRESIDUAL	Inventory change and statistical discrepancy for all fuels	COALOUT Common Block: CQDBFB–Imports, exports and stock changes COALREP Common Block: CQSBB-Coal production WC_PROD_BTU-WC distribution including exports CONVFACT Common Block: CFBIOBUTE–Biobutanol CFBIOD–Biodiesel CFBTLLIQ–Liquids from biomass CFCBOB –Conventional gasoline before oxygenate blending CFCORN-Corn, bushels to Btu CFCRDDOM-Domestic crude production CFCRDEXP–Crude oil exports CFCRDIMP –Crude oil imports CFEXPRD–Refined petroleum product exports CFGTLLIQ–Liquids from gas CFIMPRD –Petroleum product imports CFIMUO –Unfinished oil imports CFMEQT-Methanol CFNGC–Natural gas consumption CFNGE–Natural gas exports CFNGI–Natural gas imports CFNGN–Natural gas, non-utility consumption CFPET–Pure ethanol CFRBOB –Reformulated gasoline before oxygenate blending CFRSQ-Residual Fuel CFVEGGIE-Convert Biodiesel Output to Vegetable Oil Input

MAM Variable Name	Definition	NEMS Variable Name and Source
		LFMMOUT Common Block: BIOBUTEEXP–Exports of biobutanol BIOBUTEIMP–Imports of biobutanol CORNCD-Corn Consumption NGEXPVOL–Total export volumes RFBIOBUTECD–Production of biobutanol RFIPQCBOB –Imports, CBOB RFIPQRBOB –Imports, RBOB NGTDMREP Common Block: OGSUPGAS–Supplemental natural gas supplies NGEXPVOL–Total export volumes NGIMPVOL–Total import volumes PMMFTAB Common Block: RFHCXH2IN-Hydrogen from Natural Gas Input to Refinery RFMETM85-Production of M85 SBO2GDTPD-Soy Bean Oil to Green Diesel SBO2GDTPD-Soy Bean Oil to Green Diesel WGR2GDTPD-White Grease to Green Diesel WGR2GDTPD-White Grease to Green Diesel YGR2GDTPD-Yellow Grease to Green Diesel YGR2GDTPD-Yellow Grease to Green Diesel PMMOUT Common Block: BTLFRAC–BTL liquid component produced CBTLFRAC–Liquids produced from coal/biomass combo plant CFCBTLLIQ–Liquids from coal and biomass QBMRFBTL-Biomass for BTL RFPQNGL-Price and quantity of NGL RFQTDCRD-Production of crude oil RFSPRIM –SPR imports UBAVOL–Upgraded bio-oil A7 PMMRPT Common Block: BIMQTYCD-Quantity of biodiesel produced by type BIODEXP–Biodiesel exports BIODIMP–Biodiesel imports CLLETHCD–Ethanol produced from cellulose CRNETHCD–Ethanol produced from corn ETHEXP–Ethanol exports ETHIMP–Ethanol imports OTHETHCD–Advanced ethanol

MAM Variable Name	Definition	NEMS Variable Name and Source
		RFMTBI –Imported MTBE RFPQIPRDT –Total imported product RFPQUFC –Total imports of unfinished RFQEXCRD–Crude exported RFQEXPRDT–Crude exported RFQICRD –Imported total crude QBLK Common Block: QBMAS-Biomass, All Sectors QBMRF-Biomass, Refinery QCIIN–Net coal coke imports, industrial QCLAS–Coal, all sectors QEIEL–Electricity imports QETTR-Ethanol, Transportation QGERS-Geothermal, Residential QGPTR–Natural gas, pipeline QHOAS-Hydropower, All Sectors QHYTR –Liquid hydrogen, transportation QLPIN–Natural gas, lease and plant fuel QMCIN–Metallurgical coal, industrial QMETR–Methanol, transportation QNGAS–Natural gas, all sectors QNGLQ–Natural gas used for liquefaction QPVCM-Photovoltaic, Commercial QPVRS-Photovoltaic, Residential QSTCM-Solar Thermal, Commercial QSTRS-Solar Thermal, Residential QTPAS–Total petroleum, all sectors QUREL-Uranium, Electricity WRENEW Common Block: WNCMSEL-Util, MSW Non-Bio Consumption
IPSG211A3	Industrial production index, oil and gas extraction	CONVFACT common block: CFNGC-Nat. gas consumption and production NGTDMREP common block: OGPRDNG-Production of dry natural gas PMMOUT common block: RFPQNGL-Production of natural gas liquids RFQTDCRD-Production of crude oil
IPSN2121	Industrial production index, coal mining	COALOUT common block: CQSBB-Coal production (East, West Miss)
JPCNEFAO	Personal consumption deflator, household fuel oil	MPBLK common block: PTPRS-Residential total petroleum price

MAM Variable Name	Definition	NEMS Variable Name and Source
JPCNEGAO	Personal consumption deflator, consumer gasoline and oil	AMPBLK common block: PDSTR-Transportation distillate price PETTR-Transportation, ethanol price PMGTR-Transportation motor gasoline price QBLK common block: QDSTR-Distillate, transportation QETTR-Ethanol, transportation QMGTR-Motor gasoline, transportation
JPCSVUE	Personal consumption deflator, household electricity	AMPBLK common block: PELRS-Residential purchased electricity price
JPCSVUG	Personal consumption deflator, household natural gas	AMPBLK common block: PNGRS-Residential natural gas price
PNGHH	Henry Hub cash market price of natural gas	NGTDMREP common block: OGHHPRNG-Price of natural gas at Henry Hub
POILIMP	Weighted average price of imported crude	INTOUT common block: IT_WOP-World oil price
POILWTI	Price of West Texas Intermediate crude	PMMRPT common block: RFTPQCLL-Price of West Texas Intermediate crude
QGASASF	Highway consumption of gasoline and special fuels	QBLK common block: QDSTR-Distillate, transportation QETTR-Ethanol, transportation QMGTR-Motor gasoline, transportation
WPI051	Producer price index -coal	AMPBLK common block: PCLIN-Industrial purchased coal price
WPI053	Producer price index-gas fuels	NGTDMREP Common Block: OGWPRNG –Natural gas wellhead price
WPI054	Producer price index -electric power	AMPBLK common block: PELCM-Commercial purchased electricity price PELIN-Industrial purchased electricity price PELRS-Residential purchased electricity price PELTR-Transportation purchased electricity price QBLK common block: QELCM-Commercial purchased electricity QELIN-Industrial purchased electricity QELRS-Residential purchased electricity QELTR-Transportation purchased electricity
WPI055	Producer price index -utility natural gas	AMPBLK common block: PNGCM-Commercial natural gas price PNGEL-Natural gas price to electric generators

MAM Variable Name	Definition	NEMS Variable Name and Source
		PNGIN-Industrial natural gas price PNGRS-Residential natural gas price PNGTR-Transportation natural gas price QBLK common block: QNGCM-Commercial purchased natural gas QNGEL-Electricity, natural gas QNGIN -Industrial purchased natural gas QNGRS-Residential purchased natural gas QNGTR-Transportation purchased natural gas-
WPI0561	Producer price index -crude petroleum	INTOUT common block: IT_WOP-World oil price
WPI057	Producer price index -refined petroleum product	AMPBLK common block: PDSCM-Commercial distillate price PDSIN-Industrial distillate price PDSTR-Transportation distillate price PJFTR-Transportation jet fuel price PMGTR-Transportation motor gasoline price PRSCM-Commercial residual fuel price PRSIN-Industrial residual fuel price PRSTR-Transportation residual fuel price PTPRS-Residential total petroleum price QBLK common block: QDSCM-Commercial distillate QDSIN-Industrial distillate QDSTR-Transportation distillate QJFTR-Transportation jet fuel QMGTR-Transportation motor gasoline QRSCM-Commercial residual fuel QRSIN-Industrial residual fuel QRSTR-Transportation residual fuel QTPRS-Residential total petroleum
WPI0574	Producer price index-residual petroleum fuels	AMPBLK Common Block: PRSIN –Residual fuel, industrial MPBLK Common Block: PRSCM –Residual fuel, commercial PRSTR –Residual fuel, transportation QBLK Common Block: QRSCM –Residual fuel, commercial QRSIN –Residual fuel, industrial

MAM Variable Name	Definition	NEMS Variable Name and Source
		QRSTR –Residual fuel, transportation

Table B4. Energy industry and employment growth determined by NEMS results

MACOUT Common Block Name	Industry Sector Definition	NEMS Variable Name and Source
mc_empna(22)	Employment, coal mining	COALOUT common block: TOTMINERS – Number of coal miners
mc_empna(23)	Employment, oil and gas extraction	OGSMOUT common block: OGJOBS – Number of jobs in oil and gas supply sector
MC_REVIND(25)	Output, petroleum refining	PMMOUT common block: RFQPRDT – Total petroleum product supplied PMMRPT common block: RFPQIPRDT – Total imported petroleum products
MC_REVIND(45)	Output, coal mining	COALOUT common block: CQSBB – Total coal production
MC_REVIND(46)	Output, oil and gas extraction	PMMOUT common block: RFQTDCRD – Total crude oil production RFPQNGL – Total natural gas plant liquids production OGPRDNG – Total dry natural gas production OGPRSUP – Supplemental natural gas production
MC_REVSER(3)	Output, electric utilities	UEFDOUT common block: UGNTLNR – Total electricity generation
MC_REVSER(4)	Output, gas utilities	PMMOUT common block: OGPRDNG – Total dry natural gas production

Table B5. MC_NATIONAL output variables

MACOUT Common Block Name	Description
MC_GDPR	Gross Domestic Product, billions of chained 2009$
MC_GDPFER	Gross Domestic Product at full employment, billions of chained 2009$
MC_CONSR	Consumer Spending on all Goods & Services, billions of chained 2009$
MC_IRC	Gross Private Domestic Investment, billions of chained 2009$
MC_XR	Exports of Goods & Services, billions of chained 2009$
MC_MR	Imports of Goods & Services, billions of chained 2009$
MC_GR	Government Purchases of Goods & Services, billions of chained 2009$
MC_CDR	Consumer Spending on Durable Goods, billions of chained 2009$
MC_CNR	Consumer Spending on Nondurable Goods, billions of chained 2009$
MC_CSVR	Consumer Spending on Services, billions of chained 2009$
MC_IFNRESR	Gross Nonresidential Investment in Structures, billions of chained 2009$
MC_IFRESR	Gross Residential Investment, billions of chained 2009$
MC_IFNREER	Gross Nonresidential Investment in Equipment, billions of chained 2009$
MC_IFREER	Gross Residential Investment in Equipment, billions of chained 2009$
MC_IFXR	Gross Private Fixed Investment, billions of chained 2009$
MC_IFNRER	Gross Private Fixed Nonresidential Investment, billions of chained 2009$
MC_IFRER	Gross Private Fixed Residential Investment, billions of chained 2009$
MC_XGFFBR	Exports, Foods, Feeds, & Beverages, billions of chained 2009$
MC_XGINR	Exports, Industrial Supplies & Materials, billions of chained 2009$
MC_XGKR	Exports, Capital Goods exc autos, billions of chained 2009$
MC_XGAUTOR	Exports, Automotive Vehicles, Engines & Parts, billions of chained 2009$
MC_XGCR	Exports, Consumer Goods except Automotive, billions of chained 2009$
MC_XGR	Exports, Goods, billions of chained 2009$
MC_XSVTOTR	Exports, Services, billions of chained 2009$
MC_MGFFBR	Imports, Foods, Feeds, and Beverages, billions of chained 2009$
MC_MGINAPETR	Imports, Industrial Supplies & Materials, billions of chained 2009$
MC_MGKR	Imports, Capital Goods excl. Motor Vehicles, billions of chained 2009$
MC_MGAUTOR	Imports, Motor Vehicles & Parts, billions of chained 2009$
MC_MGCR	Imports, Non-automotive Consumer Goods, billions of chained 2009$
MC_MSVTOTR	Imports, Services, billions of chained 2009$

Table B5. MC_NATIONAL output variables (cont.)

MACOUT Common Block Name	Description
MC_IIR	Change in Real Stock of Business Inventories, billions of chained 2009$
MC_GFMLR	Federal Defense Purchases of Goods and Services, billions of chained 2009$
MC_GDP	Gross Domestic Product, billions of nominal $
MC_CONS	Consumer Spending on all Goods & Services, billions of nominal $
MC_I	Gross Private Domestic Investment, billions of nominal $
MC_GNPR	Gross National Product, billions of chained 2009$
MC_JPGDP	Chain-Type Price Index, GDP, 2009 = 1.0 (1987 = 1.0 in MC_COMMON)
MC_RMTB3M	Discount Rate on 3-Month U.S. Treasury Bills
MC_RMMTG30CON	Conventional 30-Year Mortgage Commitment Rate
MC_RMCORPPUAA	Yield on AA Utility Bonds
MC_RMGBLUSREAL	Real Average Yield on U.S. Treasury Long-term Bonds
MC_JECIWSP	Employment Cost Index, Wages & Salaries, Private Sector, June 1989 = 1.0
MC_SUVA	Unit Sales of Automobiles, Total, millions of units
MC_SUVLV	Unit Sales of Light Duty Vehicles, Domestic, millions of units
MC_SUVTL	Unit Sales of New Light Trucks, millions of units
MC_SUVTHAM	Unit Sales of Heavy and Medium Trucks, millions of units
MC_RUC	Unemployment Rate, All Civilian Workers
MC_WPI	Producer Price Index, All Commodities, 1982 = 1.0
MC_WPI11	Producer Price Index, Machinery & Equipment, 1982 = 1.0
MC_WPI14	Producer Price Index, Transportation Equipment, 1982 = 1.0
MC_NLFC	Civilian Labor Force as Measured by the Household Survey, millions of persons
MC_RMFF	Effective Rate on Federal Funds
MC_WPI05	Producer Price Index, Fuels, Related Products & Power, 1982 = 1.0
MC_RMTCM10Y	Yield on 10-year Treasury Notes
MC_RMCORPBAA	Yield on Baa-Rated Corporate Bonds
MC_CPIE	Consumer Price Index for Energy
MC_NP65A	Population Aged 65 and Over
MC_JQPCMHNF	Index of Output per Hour in Nonfarm Business
MC_WPISOP3200	Producer Price Index – Finished Producer Goods
MC_WPI10	Producer Price Index – Metals and Metal Products
MC_RLRMCORPPUAA	Real Yield on Baa-Rated Corporate Bonds

Table B6. MC_INDUSTRIAL output variables (variables by region)

Regions:

Census Division	Description
NENG	New England
MATL	Middle Atlantic
ENC	East North Central
WNC	West North Central
SATL	South Atlantic
ESC	East South Central
WSC	West South Central
MTN	Mountain
PAC	Pacific
US	United States

Variables:

MACOUT Common Block Name	Description
MC_REVIND(1)	Production, food products (billions of fixed 2009 dollars)
MC_REVIND(2)	Production, grain and oilseed milling (billions of fixed 2009 dollars)
MC_REVIND(3)	Production, dairy products (billions of fixed 2009 dollars)
MC_REVIND(4)	Production, animal slaughter and seafood products (billions of fixed 2009 dollars)
MC_REVIND(5)	Production, other food products (billions of fixed 2009 dollars)
MC_REVIND(6)	Production, beverage and tobacco products (billions of fixed 2009 dollars)
MC_REVIND(7)	Production, textile mills and products, apparel, and leather (billions of fixed 2009 dollars)
MC_REVIND(8)	Production, wood products (billions of fixed 2009 dollars)
MC_REVIND(9)	Production, furniture and related products (billions of fixed 2009 dollars)
MC_REVIND(10)	Production, pulp and paper products (billions of fixed 2009 dollars)
MC_REVIND(11)	Production, pulp and paper mills (billions of fixed 2009 dollars)
MC_REVIND(12)	Production, paperboard containers (billions of fixed 2009 dollars)
MC_REVIND(13)	Production, other paper products (billions of fixed 2009 dollars)
MC_REVIND(14)	Production, printing (billions of fixed 2009 dollars)
MC_REVIND(15)	Production, basic inorganic chemicals (billions of fixed 2009 dollars)
MC_REVIND(16)	Production, basic organic chemicals (billions of fixed 2009 dollars)
MC_REVIND(17)	Production, ethanol (billions of fixed 2009 dollars)
MC_REVIND(18)	Production, plastic and synthetic rubber materials (billions of fixed 2009 dollars)
MC_REVIND(19)	Production, agricultural chemicals (billions of fixed 2009 dollars)
MC_REVIND(20)	Production, other chemical products (billions of fixed 2009 dollars)
MC_REVIND(21)	Production, pharmaceuticals and medicines (billions of fixed 2009 dollars)
MC_REVIND(22)	Production, paints, coatings, and adhesives (billions of fixed 2009 dollars)

MACOUT Common Block	Description
MC_REVIND(23)	Production, soaps and cleaning products (billions of fixed 2009 dollars)
MC_REVIND(24)	Production, other chemical products (billions of fixed 2009 dollars)
MC_REVIND(25)	Production, petroleum refineries (billions of fixed 2009 dollars)
MC_REVIND(26)	Production, other petroleum and coal products (billions of fixed 2009 dollars)
MC_REVIND(27)	Production, plastics and rubber products (billions of fixed 2009 dollars)
MC_REVIND(28)	Production, glass and glass products (billions of fixed 2009 dollars)
MC_REVIND(29)	Production, flat glass (billions of fixed 2009 dollars)
MC_REVIND(30)	Production, cement manufacturing (billions of fixed 2009 dollars)
MC_REVIND(31)	Production, lime and gypsum (billions of fixed 2009 dollars)
MC_REVIND(32)	Production, other non-metallic mineral products (billions of fixed 2009 dollars)
MC_REVIND(33)	Production, iron and steel mills, ferroalloy and steel products (billions of fixed 2009 dollars)
MC_REVIND(34)	Production, alumina and aluminum products (billions of fixed 2009 dollars)
MC_REVIND(35)	Production, other primary metals (billions of fixed 2009 dollars)
MC_REVIND(36)	Production, fabricated metal products (billions of fixed 2009 dollars)
MC_REVIND(37)	Production, machinery (billions of fixed 2009 dollars)
MC_REVIND(38)	Production, other electronic and electric products (billions of fixed 2009 dollars)
MC_REVIND(39)	Production, transportation equipment (billions of fixed 2009 dollars)
MC_REVIND(40)	Production, measuring and control instruments (billions of fixed 2009 dollars)
MC_REVIND(41)	Production, miscellaneous manufacturing (billions of fixed 2009 dollars)
MC_REVIND(42)	Production, crop production (billions of fixed 2009 dollars)
MC_REVIND(43)	Production, animal production (billions of fixed 2009 dollars)
MC_REVIND(44)	Production, other agriculture, forestry, and fishing and hunting (billions of fixed 2009 dollars)
MC_REVIND(45)	Production, coal mining (billions of fixed 2009 dollars)
MC_REVIND(46)	Production, oil and gas extraction and support activities (billions of fixed 2009 dollars)
MC_REVIND(47)	Production, other mining and quarrying (billions of fixed 2009 dollars)
MC_REVIND(48)	Production, construction (billions of fixed 2009 dollars)
MC_REVIND(49)	Production, sum of all chemicals (billions of fixed 2009 dollars)
MC_REVIND(50)	Production, sum of all petroleum products (billions of fixed 2009 dollars)
MC_REVIND(51)	Production, sum of all non-metallic mineral products (billions of fixed 2009 dollars)
MC_REVIND(52)	Production, sum of all primary metals (billions of fixed 2009 dollars)
(Aggregate)	Production, total manufacturing output (billions of fixed 2009 dollars)
(Aggregate)	Production, total industrial output (billions of fixed 2009 dollars)

Table B7. MC_EMPLOYMENT output variables

Employment	
Variable Name	**Description**
EMPIND1	Food products (millions of employees)
EMPIND2	Beverage and tobacco products (millions of employees)
EMPIND3	Textile mills and products, apparel, and leather (millions of employees)
EMPIND4	Wood products (millions of employees)
EMPIND5	Furniture and related products (millions of employees)
EMPIND6	Paper products (millions of employees)
EMPIND7	Printing (millions of employees)
EMPIND8	Bulk chemicals (millions of employees)
EMPIND9	Other chemical products (millions of employees)
EMPIND10	Petroleum and coal products (millions of employees)
EMPIND11	Plastics and rubber products (millions of employees)
EMPIND12	Non-metallic mineral products (millions of employees)
EMPIND13	Primary metals (millions of employees)
EMPIND14	Fabricated metal products (millions of employees)
EMPIND15	Machinery (millions of employees)
EMPIND16	Computers and electronics (millions of employees)
EMPIND17	Transportation equipment (millions of employees)
EMPIND18	Electrical equipment and appliances (millions of employees)
EMPIND19	Miscellaneous manufacturing (millions of employees)

Table B7. MC_EMPLOYMENT output variables (cont.)

Employment	
Variable Name	**Description**
EMPIND20	Crop production (millions of employees)
EMPIND21	Other agriculture, forestry, fishing and hunting (millions of employees)
EMPIND22	Coal mining (millions of employees)
EMPIND23	Oil and gas extraction and support activities (millions of employees)
EMPIND24	Other mining and quarrying (millions of employees)
EMPIND25	Construction of Buildings (millions of employees)
EMPIND26	Heavy and Civil Engineering Construction (millions of employees)
EMPIND27	Specialty Trade Contractors (millions of employees)
EMPSER6	Transportation and warehousing (millions of employees)
EMPSER7	Publishing except internet (millions of employees)
EMPSER8	Broadcasting except internet (millions of employees)
EMPSER9	Telecommunications (millions of employees)
EMPSER1	Electric power generation and distribution (millions of employees)
EMPSER2	Natural gas distribution (millions of employees)
EMPSER3	Water, sewage and related systems (millions of employees)
EMPSER4	Wholesale trade (millions of employees)
EMPSER5	Retail trade (millions of employees)
EMPSER10	Finance and insurance (millions of employees)
EMPSER11	Real estate and rental/leasing(millions of employees)
EMPSER12	Other services (millions of employees)
(Aggregate)	Total manufacturing (millions of employees)
(Aggregate)	Total non-manufacturing (millions of employees)
(Aggregate)	Total services (millions of employees)
(Aggregate)	Total nonfarm (millions of employees)

Table B8. MC_VEHICLES output variables

MACOUT Common Block

Name	Description
MC_VEHICLES(1)	Unit Sales of Class 1 Light Trucks, 0 to 6000 lbs., Wards Communication, Thousands of Vehicles
MC_VEHICLES(2)	Unit Sales of Class 2 Light Trucks, 6001 to 10,000 lbs., Wards Communication, Thousands of Vehicles
MC_VEHICLES(3)	Unit Sales of Class 2a Light Trucks, 6001 to 8,500 lbs., ORNL, Thousands of Vehicles
MC_VEHICLES(4)	Unit Sales of Class 2b Light Trucks, 8,500 to 10,000 lbs., ORNL, Thousands of Vehicles
MC_VEHICLES(5)	Unit Sales of Class 3 Light Trucks, 10,000 to 14,000 lbs., Wards Communication, Thousands of Vehicles
(Aggregate)	Unit Sales of Classes 1, 2 and 3 Light Trucks, 0 to 14,000 lbs., Sum, Thousands of Vehicles.

Table B9. MC_REGIONAL output variables

Regions:

Census Division	Description
NENG	New England
MATL	Middle Atlantic
ENC	East North Central
WNC	West North Central
SATL	South Atlantic
ESC	East South Central
WSC	West South Central
MTN	Mountain
PAC	Pacific
US	United States

Variables:

MACOUT Common Block Name	Description
MC_CPI	Consumer Price Index (all urban) - all items (1982-84 = 1.0)
MC_YPDR	Disposable personal income (billions of chained 2009$)
MC_YPCOMPWSD	Wage and salary disbursements (billions of nominal $)
MC_YP	Personal income (billions of nominal $)
MC_HUSMFG	Mobile homes shipments (millions of units)
MC_HUSPS1	Single-family housing starts, private including farm (millions of units)
MC_HUSPS2A	Multi-family housing starts, private including farm (millions of units)
MC_KHUMFG	Stock of mobile homes (millions of units)
MC_KHUPS1	Stock of single-family housing (millions of units)
MC_KHUPS2A	Stock of multi-family housing (millions of units)
MC_NP	Population including armed forces overseas (millions of persons)
MC_NP16A	Population aged 16 and over (millions of persons)
MC_RWM	Average annual manufacturing wages (thousands of nominal $)
MC_RWNM	Average annual non-manufacturing wages (thousands of nominal $)
MC_COMMFLSP(1); AMUSE_REL	Commercial floor space, amusement (billion square feet)

MACOUT Common Block Name	Description
MC_COMMFLSP(2); EDUC	Commercial floor space, automotive (billion square feet)
MC_COMMFLSP(3); HEALTH	Commercial floor space, dormitories (billion square feet)
MC_COMMFLSP(4); HOTEL_DORM	Commercial floor space, education (billion square feet)
MC_COMMFLSP(5); OFFICE	Commercial floor space, health (billion square feet)
MC_COMMFLSP(6); AUTO	Commercial floor space, hotels and motels (billion square feet)
MC_COMMFLSP(7); STORES	Commercial floor space, manufacturing (billion square feet)
MC_COMMFLSP(8); WARE	Commercial floor space, miscellaneous non-residential (billion square feet)
MC_COMMFLSP(9); PUB_MISCNR	Commercial floor space, offices (billion square feet)
MC_EMPNA(1); EEA	Employment, total nonfarm (millions of persons)
MC_EMPNA(2); EMPIND25T27	Employment, construction (millions of persons)
MC_EMPNA(3); EMPSER12	Employment, federal government (millions of persons)
MC_EMPNA(4); EMPSER10T11	Employment, financial, insurance, real estate (millions of persons)
MC_EMPNA(5); EMPIND22T24	Employment, mining (millions of persons)
MC_EMPNA(6); EMPSER12	Employment, other services (millions of persons)
MC_EMPNA(7); EMPSER12	Employment, state and local government (millions of persons)
MC_EMPNA(8); EMPSER1T3A6T9	Employment, transportation, communications and public utilities (millions of persons)
MC_EMPNA(9); EMPSER5	Employment, retail trade (millions of persons)
MC_EMPNA(10); EMPSER4	Employment, wholesale trade (millions of persons)
MC_EMPNA(11); EMPIND4	Employment, wood products (millions of persons)
MC_EMPNA(12); EMPIND5	Employment, furniture and related products (millions of persons)
MC_EMPNA(13); EMPIND12	Employment, non-metallic mineral products (millions of persons)
MC_EMPNA(14); EMPIND13	Employment, primary metal industries (millions of persons)
MC_EMPNA(15); EMPIND14	Employment, fabricated metal products (millions of persons)
MC_EMPNA(16); EMPIND15	Employment, machinery (millions of persons)
MC_EMPNA(17); EMPIND16	Employment, computers and electronics (millions of persons)

MACOUT Common Block Name	Description
MC_EMPNA(18); EMPIND17	Employment, transportation equipment (millions of persons)
MC_EMPNA(19); EMPIND18	Employment, electrical equip. and appliances (millions of persons)
MC_EMPNA(20); EMPIND19	Employment, miscellaneous manufacturing (millions of persons)
MC_EMPNA(21); EMPIND1	Employment, food products (millions of persons)
MC_EMPNA(22); EMPIND2	Employment, beverage and tobacco products (millions of persons)
MC_EMPNA(23); EMPIND3	Employment, textile mills and products, apparel, and leather (millions of persons)
MC_EMPNA(24); EMPIND6	Employment, paper products (millions of persons)
MC_EMPNA(25); EMPIND7	Employment, printing (millions of persons)
MC_EMPNA(26); EMPIND8T9	Employment, chemicals (millions of persons)
MC_EMPNA(27); EMPIND10	Employment, petroleum products (millions of persons)
MC_EMPNA(28); EMPIND11	Employment, plastics and rubber products (millions of persons)
MC_EMPNA(29); EMPIND20T21	Employment, agriculture, forestry, fishing and hunting (millions of persons)
MC_REVIND(1)	Production, food products (billions of fixed 2009 dollars)
MC_REVIND(2)	Production, grain and oilseed milling (billions of fixed 2009 dollars)
MC_REVIND(3)	Production, dairy products (billions of fixed 2009 dollars)
MC_REVIND(4)	Production, animal slaughter and seafood products (billions of fixed 2009 dollars)
MC_REVIND(5)	Production, other food products (billions of fixed 2009 dollars)
MC_REVIND(6)	Production, beverage and tobacco products (billions of fixed 2009 dollars)
MC_REVIND(7)	Production, textile mills and products, apparel, and leather (billions of fixed 2009 dollars)
MC_REVIND(8)	Production, wood products (billions of fixed 2009 dollars)
MC_REVIND(9)	Production, furniture and related products (billions of fixed 2009 dollars)
MC_REVIND(10)	Production, paper products (billions of fixed 2009 dollars)
MC_REVIND(11)	Production, pulp and paper mills (billions of fixed 2009 dollars)
MC_REVIND(12)	Production, paperboard containers (billions of fixed 2009 dollars)
MC_REVIND(13)	Production, other paper products (billions of fixed 2009 dollars)
MC_REVIND(14)	Production, printing (billions of fixed 2009 dollars)
MC_REVIND(15)	Production, basic inorganic chemicals (billions of fixed 2009 dollars)
MC_REVIND(16)	Production, basic organic chemicals (billions of fixed 2009 dollars)
MC_REVIND(17)	Production, ethanol (billions of fixed 2009 dollars)
MC_REVIND(18)	Production, plastic and synthetic rubber materials (billions of fixed 2009 dollars)
MC_REVIND(19)	Production, agricultural chemicals (billions of fixed 2009 dollars)
MC_REVIND(20)	Production, other chemical products (billions of fixed 2009 dollars)
MC_REVIND(21)	Production, pharmaceuticals and medicines (billions of fixed 2009 dollars)
MC_REVIND(22)	Production, paints, coatings, and adhesives (billions of fixed 2009 dollars)
MC_REVIND(23)	Production, soaps and cleaning products (billions of fixed 2009 dollars)

MACOUT Common Block Name	Description
MC_REVIND(24)	Production, other chemical products (billions of fixed 2009 dollars)
MC_REVIND(25)	Production, petroleum refineries (billions of fixed 2009 dollars)
MC_REVIND(26)	Production, other petroleum and coal products (billions of fixed 2009 dollars)
MC_REVIND(27)	Production, plastics and rubber products (billions of fixed 2009 dollars)
MC_REVIND(28)	Production, glass and glass products (billions of fixed 2009 dollars)
MC_REVIND(29)	Production, flat glass (billions of fixed 2009 dollars)
MC_REVIND(30)	Production, cement manufacturing (billions of fixed 2009 dollars)
MC_REVIND(31)	Production, lime and gypsum (billions of fixed 2009 dollars)
MC_REVIND(32)	Production, other non-metallic mineral products (billions of fixed 2009 dollars)
MC_REVIND(33)	Production, iron and steel mills, ferroalloy and steel products (billions of fixed 2009 dollars)
MC_REVIND(34)	Production, alumina and aluminum products (billions of fixed 2009 dollars)
MC_REVIND(35)	Production, other primary metals (billions of fixed 2009 dollars)
MC_REVIND(36)	Production, fabricated metal products (billions of fixed 2009 dollars)
MC_REVIND(37)	Production, machinery (billions of fixed 2009 dollars)
MC_REVIND(38)	Production, other electronic and electric products (billions of fixed 2009 dollars)
MC_REVIND(39)	Production, transportation equipment (billions of fixed 2009 dollars)
MC_REVIND(40)	Production, measuring and control instruments (billions of fixed 2009 dollars)
MC_REVIND(41)	Production, miscellaneous manufacturing (billions of fixed 2009 dollars)
MC_REVIND(42)	Production, crop production (billions of fixed 2009 dollars)
MC_REVIND(43)	Production, animal production (billions of fixed 2009 dollars)
MC_REVIND(44)	Production, other agriculture, forestry, fishing and hunting (billions of fixed 2009 dollars)
MC_REVIND(45)	Production, coal mining (billions of fixed 2009 dollars)
MC_REVIND(46)	Production, oil and gas extraction and support activities (billions of fixed 2009 dollars)
MC_REVIND(47)	Production, other mining and quarrying (billions of fixed 2009 dollars)
MC_REVIND(48)	Production, construction (billions of fixed 2009 dollars)

Table B10. MC_REGMAC output variables (variables by region)

Regions:

Census Division	Description
NENG	New England
MATL	Middle Atlantic
ENC	East North Central
WNC	West North Central
SATL	South Atlantic
ESC	East South Central
WSC	West South Central
MTN	Mountain
PAC	Pacific
US	United States

Variables:

Economic Activity Variable Name	Description
CPI	Consumer Price Index (all urban) - all items (1982-84 = 1.0)
YPDR	Disposable personal income (billions of chained 2009 dollars)
YPCOMPWSD	Wage and salary disbursements (billions of nominal dollars)
YP	Personal income (billions of nominal dollars)
HUSMFG	Mobile homes shipments (millions of units)
HUSPS1	Single-family housing starts, private including farm (millions of units)
HUSPS2A	Multi-family housing starts, private including farm (millions of units)
KHUMFG	Stock of mobile homes (millions of units)
KHUPS1	Stock of single-family housing (millions of units)
KHUPS2A	Stock of multi-family housing (millions of units)
NP	Population including armed forces overseas (millions of persons)
NP16A	Population aged 16 and over (millions of persons)
RWM	Average annual manufacturing wages (thousands of nominal dollars)
RWNM	Average annual non-manufacturing wages (thousands of nominal dollars)

Table B11. MC_COMMFLR output variables (variables by region)

Regions:

Census Division	Description
ENC	East North Central
ESC	East South Central
MATL	Middle Atlantic
MTN	Mountain
NENG	New England
PAC	Pacific
SATL	South Atlantic
WNC	West North Central
WSC	West South Central
SUM	United States

Variables:

Commercial Floor Space

Variable Name	Description
AMUSE	Commercial floor space, amusement (rate of growth)
AUTO	Commercial floor space, auto service and parking garages (rate of growth)
DORM	Commercial floor space, educational and federally-owned (primarily military) (rate of growth)
EDUC	Commercial floor space, primary/secondary and higher education (rate of growth)
HEALTH	Commercial floor space, hospitals and nursing homes (rate of growth)
HOTEL	Commercial floor space, hotels and motels (rate of growth)
MFG	Commercial floor space, manufacturing (rate of growth)
MISCNR	Commercial floor space, miscellaneous, non-residential - transportation related and all other nec (rate of growth)
OFFICE	Commercial floor space, private, federal, and state and local offices (rate of growth)
PUB	Commercial floor space, federal and state and local (rate of growth)
REL	Commercial floor space, religious (rate of growth)
STORES	Commercial floor space, stores and restaurants (rate of growth)
WARE	Commercial floor space, manufacturing and wholesale trade, public and federally-owned warehouses (rate of growth)

Table B12. MC_REGEMP output variables (variables by region)

Regions:

Census Division	Description
NENG	New England
MATL	Middle Atlantic
ENC	East North Central
WNC	West North Central
SATL	South Atlantic
ESC	East South Central
WSC	West South Central
MTN	Mountain
PAC	Pacific
US	United States

Variables:

Employment Variable Name	Description
EEA	Employment, total nonfarm (millions of persons)
EMPIND25T27	Employment, construction (millions of persons)
EMPSER12	Employment, federal government (millions of persons)
EMPSER10T11	Employment, financial, insurance, real estate (millions of persons)
EMPIND22T24	Employment, mining (millions of persons)
EMPSER12	Employment, other services (millions of persons)
EMPSER12	Employment, state and local government (millions of persons)
EMPSER1T3A6T9	Employment, transportation, communications and public utilities (millions of persons)
EMPSER5	Employment, retail trade (millions of persons)
EMPSER4	Employment, wholesale trade (millions of persons)
EMPIND4	Employment, wood products (millions of persons)
EMPIND5	Employment, furniture and related products (millions of persons)
EMPIND12	Employment, non-metallic mineral products (millions of persons)
EMPIND13	Employment, primary metal industries (millions of persons)

Employment Variable Name	Description
EMPIND14	Employment, fabricated metal products (millions of persons)
EMPIND15	Employment, machinery (millions of persons)
EMPIND16	Employment, computers and electronics (millions of persons)
EMPIND17	Employment, transportation equipment (millions of persons)
EMPIND18	Employment, electrical equip. and appliances (millions of persons)
EMPIND19	Employment, miscellaneous manufacturing (millions of persons)
EMPIND1	Employment, food products (millions of persons)
EMPIND2	Employment, beverage and tobacco products (millions of persons)
EMPIND3	Employment, textile mills and products, apparel, and leather (millions of persons)
EMPIND6	Employment, paper products (millions of persons)
EMPIND7	Employment, printing (millions of persons)
EMPIND8T9	Employment, chemicals (millions of persons)
EMPIND10	Employment, petroleum products (millions of persons)
EMPIND11	Employment, plastics and rubber products (millions of persons)
EMPIND20T21	Employment, agriculture, forestry, fishing and hunting (millions of persons)

Table B13. MC_REGIO output variables (variables by region)

Regions:

Census Division	Description
NENG	New England
MATL	Middle Atlantic
ENC	East North Central
WNC	West North Central
SATL	South Atlantic
ESC	East South Central
WSC	West South Central
MTN	Mountain
PAC	Pacific
US	United States

Variables:

Industrial Output Variable Name	Description
REVIND1	Production, food products (billions of fixed 2009 dollars)
REVIND2	Production, grain and oilseed milling (billions of fixed 2009 dollars)
REVIND3	Production, dairy products (billions of fixed 2009 dollars)
REVIND4	Production, animal slaughter and seafood products (billions of fixed 2009 dollars)
REVIND5	Production, other food products (billions of fixed 2009 dollars)
REVIND6	Production, beverage and tobacco products (billions of fixed 2009 dollars)
REVIND7	Production, textile mills and products, apparel, and leather (billions of fixed 2009 dollars)
REVIND8	Production, wood products (billions of fixed 2009 dollars)
REVIND9	Production, furniture and related products (billions of fixed 2009 dollars)
REVIND10	Production, paper products (billions of fixed 2009 dollars)
REVIND11	Production, pulp & paper mills (billions of fixed 2009 dollars)
REVIND12	Production, paperboard container (billions of fixed 2009 dollars)
REVIND13	Production, other paper products (billions of fixed 2009 dollars)
REVIND14	Production, printing (billions of fixed 2009 dollars)
REVIND15	Production, basic inorganic chemicals (billions of fixed 2009 dollars)
REVIND16	Production, basic organic chemicals (billions of fixed 2009 dollars)
REVIND17	Production, ethanol (billions of fixed 2009 dollars)
REVIND18	Production, plastic and synthetic rubber materials (billions of fixed 2009 dollars)
REVIND19	Production, agricultural chemicals (billions of fixed 2009 dollars)
REVIND20	Production, other chemical products (billions of fixed 2009 dollars)
REVIND21	Production, pharmaceuticals and medicines (billions of fixed 2009 dollars)
REVIND22	Production, paints, coatings, and adhesives (billions of fixed 2009 dollars)
REVIND23	Production, soaps and cleaning products (billions of fixed 2009 dollars)

Industrial Output Variable Name	Description
REVIND24	Production, other chemical products (billions of fixed 2009 dollars)
REVIND25	Production, petroleum refineries (billions of fixed 2009 dollars)
REVIND26	Production, other petroleum and coal products (billions of fixed 2009 dollars)
REVIND27	Production, plastics and rubber products (billions of fixed 2009 dollars)
REVIND28	Production, glass and glass products (billions of fixed 2009 dollars)
REVIND29	Production, glass and glass products (billions of fixed 2009 dollars)
REVIND30	Production, cement manufacturing (billions of fixed 2009 dollars)
REVIND31	Production, lime and gypsum(billions of fixed 2009 dollars)
REVIND32	Production, other non-metallic mineral products (billions of fixed 2009 dollars)
REVIND33	Production, iron and steel mills, ferroalloy and steel products (billions of fixed 2009 dollars)
REVIND34	Production, alumina and aluminum products (billions of fixed 2009 dollars)
REVIND35	Production, other primary metals (billions of fixed 2009 dollars)
REVIND36	Production, fabricated metal products (billions of fixed 2009 dollars)
REVIND37	Production, machinery (billions of fixed 2009 dollars)
REVIND38	Production, other electronic and electric products (billions of fixed 2009 dollars)
REVIND39	Production, transportation equipment (billions of fixed 2009 dollars)
REVIND40	Production, measuring and control instruments (billions of fixed 2009 dollars)
REVIND41	Production, miscellaneous manufacturing (billions of fixed 2009 dollars)
REVIND42	Production, crop production (billions of fixed 2009 dollars)
REVIND43	Production, animal production (billions of fixed 2009 dollars)
REVIND44	Production, other agriculture, forestry, fishing and hunting (billions of fixed 2009 dollars)
REVIND45	Production, coal mining (billions of fixed 2009 dollars)
REVIND46	Production, oil and gas extraction and support activities (billions of fixed 2009 dollars)
REVIND47	Production, other mining and quarrying (billions of fixed 2009 dollars)
REVIND48	Production, construction (billions of fixed 2009 dollars)

Table B14. MAM variables used by other NEMS modules

MACOUT Common Block Name	Macroeconomic Variable Description	Referencing NEMS Module or Submodules
MC_COMMFLSP	Commercial floor space by type of building (rate of growth)	COMM
MC_CPI	Consumer Price Index (all urban) - all items (1982-84 = 1.0)	NGTDM TRAN
MC_EMPNA	Employment by industrial sector (millions of employees)	IND
MC_GDPR	Gross Domestic Product (billions of chained 2009$)	INTERCV MAIN RENEW TRAN
MC_GFMLR	Federal defense purchases of goods & services (billions of chained 2009$)	TRAN
MC_GNPR	Gross National Product (billions of chained 2009$)	TRAN
MC_HUSMFG	Mobile homes shipments (millions of units)	RESD
MC_HUSPS1	Single-family housing starts (millions of units)	RESD
MC_HUSPS2A	Multi-family housing starts (millions of units)	RESD
MC_JECIWSP	Employment cost index, wages & salaries, private sector (June 1989 = 1.0)	NGTDM UEFP

Table B14. MAM variables used by other NEMS modules (cont.)

MACOUT Common Block Name	Macroeconomic Variable Description	Referencing NEMS Module or Submodules
MC_JPGDP	Chained Price Index, GDP (2009 = 100.0, 1987 = 1.0 in MACOUT)	COALCDS
		COALCPS
		COMM
		EPM
		IND
		NGHIST
		NGPTM
		NGTDM
		REFETH
		REFINE
		REFRPT
		RENEW
		RESD
		TRAN
		TRANFRT
		UDAT
		UECP
		EUEFD
		UEFP
		ULDSM
		WELLAK
		WELLCOST
		WELLEXP
		WELLIMP
		WELLLNG
		WELLOFF
		WELLOGS
		WELLUGR
MC_MR	Imports of goods & services (billions of chained 2009$)	TRAN
MC_NP	Population including armed forces overseas (millions of persons)	COMM
		RENEW
		TRAN

Table B14. MAM variables used by other NEMS modules (cont.)

MACOUT Common Block Name	Macroeconomic Variable Description	Referencing NEMS Module or Submodules
MC_NP16A	Population aged 16 and over (millions of persons)	RESD
		TRAN
MC_ REVIND	Gross output by industrial sector (billions of fixed 2009$)	IND
		TRAN
		TRANFRT
MC_REVSER	Gross output by service sector (billions of fixed 2009$)	TRAN
		TRANFRT
MC_RLRMCORPPUAA	Real yield on AA Utility Bonds (= Nominal Yield - inflation)	COALCPS
		WELLOGS
MC_RMCORPBAA	Yield on Baa Rated Corporate Bonds	NGLNG
		NGTDM
		REFINE
		UTIL
MC_RMCORPPUAA	Yield on AA Utility Bonds	COALCDS
		NGPTM
		NGTDM
		UEFP
MC_RMGBLUSREAL	Real average yield on U.S. Treasury Long-term Bonds	COMM
		NGTDM
MC_RMMTG30CON	Commitment rate on conventional 30-year mortgage	RESD
MC_RMTB3M	Discount rate on 3-month U.S. Treasury Bills	UEFP
MC_RMTCM10Y	Yield on 10-year Treasury Notes	UEFP
MC_SUVA	Unit sales of automobiles, total (millions of units)	TRAN
MC_SUVTHAM	Unit sales of new heavy and medium trucks	TRANFRT
MC_VEHICLES	Unit sales of light trucks by size class	TRAN
		TRANFRT
MC_WPI10	Producer Price Index – metals and metal products (index 1982 = 1.0)	COALCPS
		UDAT

Table B14. MAM variables used by other NEMS modules (cont.)

MACOUT Common Block Name	Macroeconomic Variable Description	Referencing NEMS Module or Submodules
MC_WPI11	Producer Price Index - machinery and equipment (1982 = 1.0)	UEFP
MC_WPI14	Producer Price Index - transportation equipment (1982 = 1.0)	COALCDS
		COALCPS
MC_WPISOP3200	Producer Price Index – finished producer goods (1982 = 1.0)	REFINE
MC_XGR	Exports, goods (billions of chained 2009$)	TRAN
MC_XR	Exports of goods & services (billions of chained 2009$)	TRAN
MC_YPDR	Disposable personal income (billions of chained 2009$)	COMM
		RESD
		TRAN

NEMS module/submodule descriptions:

COALCDS	Coal Market Module, Coal Distribution Submodule
COALCPS	Coal Market Module, Coal Production Submodule
COMM	Commercial Demand Module
EPM	Future Emission Policy Module
IND	Industrial Demand Module
INTERCV	Integrating Module, Inter-cycle
MAIN	Integrating Module, Main
NGHIST	Natural Gas Transmission & Distribution Module, Historical Processing Code
NGPTM	Natural Gas Transmission & Distribution Module, Pipeline Tariff Submodule
NGTDM	Natural Gas Transmission & Distribution Module, Main Module
REFETH	Petroleum Market Module, Refinery, Ethanol Supply Submodule
REFINE	Petroleum Market Module, Refinery Processes
REFRPT	Petroleum Market Module, Refinery Report Writer
RENEW	Renewable Fuels Module
RESD	Residential Demand Module
TRAN	Transportation Demand Module
TRANFRT	Transportation Demand Module, Freight Transport Submodule
UDAT	Electricity Market Module, Electricity Data Processing
UECP	Electricity Market Module, Electricity Capacity Planning Submodule
UEFD	Electricity Market Module, Electricity Fuel Dispatch Submodule
UEFP	Electricity Market Module, Finance and Pricing Submodule
ULDSM	Electricity Market Module, Load and Demand-Side Management Submodule
WELLCOST	Oil & Gas Supply Module, Cost Submodule
WELLEXP	Oil & Gas Supply Module, Drilling Submodule
WELLIMP	Oil & Gas Supply Module, Foreign Supply Submodule
WELLLNG	Oil & Gas Supply Module, Liquid Natural Gas Submodule
WELLOFF	Oil & Gas Supply Module, Offshore Supply Submodule
WELLOGS	Oil & Gas Supply Module, Main Module
WELLUGR	Oil & Gas Supply Module, Unconventional Gas Recovery Supply Submodule

Appendix C: Equations in Regional Submodule

Appendix C1: Regional Macroeconomic Model

Endogenous variables:

CPI_{R}	Consumer Price Index, all urban, 1982-84=1.0, regional
GSPR_{R}	Real Gross State Product, billions of 2009 dollars, regional
GSPRZNP_{R}	Real Per Capita Gross State Product, billions of 2009 dollars per person, regional
RWM_{R}	Average Annual Manufacturing Wages, thousands of dollars, regional
RWNM_{R}	Average Annual Non-Manufacturing Wages, thousands of dollars, regional
YP_{R}	Personal Income, billions of dollars, regional
YPCOMPWSD_{R}	Wage and Salary Disbursements, billions of dollars, regional
YPCOMPWSDG_{R}	Wage and Salary Disbursements by Government, billions of dollars, regional
YPCOMPWSDP_{R}	Wage and Salary Disbursements by Private Sector, billions of dollars, regional
YPD_{R}	Personal Disposable Income, billions of dollars, regional
YPDR_{R}	Real Personal Disposable Income, billions of 2009 dollars, regional
YPDRZNP_{R}	Real Per Capita Personal Disposable Income, billions of 2009 dollars, regional
YPOTH_{R}	Other Personal Income, billions of dollars, regional

Model description is in Chapter 7. Codes and descriptions of the regions are in Table B9.

Exogenous variables:

CPI	Consumer Price Index, all urban, 1982-84=1.0, national
CPIZ_{R}	Regional Consumer Price Index Relative Share to National, regional
GDPR	Real Gross Domestic Product, billions of 2009 dollars, national
JECIWSP	Employment Cost Index, private-sector wages and salaries, Dec. 2005 = 1.0, national

Exogenous variables (cont.):

NP	Population, millions, national
NP_{R}	Population, millions, regional
YP	Personal Income, billions of dollars, national
YPCOMPWSD	Wage and Salary Disbursements, billions of dollars, national
YPCOMPWSDG	Wage and Salary Disbursements by Government, billions of dollars, national
YPD	Personal Disposable Income, billions of dollars, national
YPDR	Real Personal Disposable Income, billions of 2009 dollars, national

Equations:

CPI – Consumer Price Index

Eqn 1: CPI_{R} = (CPI_{R} / CPI_{R}_AVE) * CPI

GSPR – Real Gross State Product

Eqn 2: GSPR_{R} = (GSPR_{R} /GSPR_{R}_SUM) * GDPR

GSPRZNP – Real Per Capita Gross State Product

Eqn 3: LOG(GSPRZNP_ENC/GDPRZN) = 1.0052571064*LOG(GSPRZNP_ENC(-1)/GDPRZN(-1))

Eqn 4: LOG(GSPRZNP_ESC/GDPRZN) = 1.52764027005*LOG(GSPRZNP_ESC(-1)/GDPRZN(-1)) - 0.527988488415*@MOVAV(LOG(GSPRZNP_ESC(-1)/GDPRZN(-1)),3)

Eqn 5: LOG(GSPRZNP_MATL/GDPRZN) = 1.00151550108*LOG(GSPRZNP_MATL(-1)/GDPRZN(-1))

Eqn 6: LOG(GSPRZNP_MTN/GDPRZN) = 0.988401613154*LOG(GSPRZNP_MTN(-1)/GDPRZN(-1))

Eqn 7: LOG(GSPRZNP_NENG/GDPRZN) = 1.00466139868*LOG(GSPRZNP_NENG(-1)/GDPRZN(-1))

Eqn 8: LOG(GSPRZNP_PAC/GDPRZN) = 1.56853212181*LOG(GSPRZNP_PAC(-1)/GDPRZN(-1)) - 0.569412166976*@MOVAV(LOG(GSPRZNP_PAC(-1)/GDPRZN(-1)),3)

Eqn 9: LOG(GSPRZNP_SATL/GDPRZN) = 1.00824323784*LOG(GSPRZNP_SATL(-1)/GDPRZN(-1))

Eqn 10 LOG(GSPRZNP_WNC/GDPRZN) = 0.97375055948*LOG(GSPRZNP_WNC(-1)/GDPRZN(-1))

Eqn 11: LOG(GSPRZNP_WSC/GDPRZN) = 0.971762462463*LOG(GSPRZNP_WSC(-1)/GDPRZN(-1))

RWM - Average annual manufacturing wages

Eqn 12: DLOG(RWM_ENC) = 1.01869328702*DLOG(JECIWSP)

Eqn 13: DLOG(RWM_ESC) = 1.22880757647*DLOG(JECIWSP)

Eqn 14: DLOG(RWM_MATL) = 1.10548610918*DLOG(JECIWSP)

Eqn 15: DLOG(RWM_MTN) = 1.31783386031*DLOG(JECIWSP)

Eqn 16: DLOG(RWM_NENG) = 1.26005568167*DLOG(JECIWSP)

Eqn 17: DLOG(RWM_PAC) = 1.24283633836*DLOG(JECIWSP)

Eqn 18: DLOG(RWM_SATL) = 1.2974640807*DLOG(JECIWSP)

Eqn 19: DLOG(RWM_WNC) = 1.07970967608*DLOG(JECIWSP)

Eqn 20: DLOG(RWM_WSC) = 1.23818579934*DLOG(JECIWSP)

RWNM - Average annual non-manufacturing wages

Eqn 21: DLOG(RWNM_ENC) = 1.15089697853*DLOG(JECIWSP)

Eqn 22: DLOG(RWNM_ESC) = 1.15731093606*DLOG(JECIWSP)

Eqn 23: DLOG(RWNM_MATL) = 1.25045110248*DLOG(JECIWSP)

Eqn 24: DLOG(RWNM_MTN) = 1.23471573654*DLOG(JECIWSP)

Eqn 25: DLOG(RWNM_NENG) = 1.3239634903*DLOG(JECIWSP)

Eqn 26: DLOG(RWNM_PAC) = 1.19362030775*DLOG(JECIWSP)

Eqn 27: DLOG(RWNM_SATL) = 1.19460013116*DLOG(JECIWSP)

Eqn 28: DLOG(RWNM_WNC) = 1.22186061807*DLOG(JECIWSP)

Eqn 29: DLOG(RWNM_WSC) = 1.24941541178*DLOG(JECIWSP)

YP – Personal income

Eqn 30: YP_{R} = YP * (YP_{R} / YP_{R}_SUM)

YPCOMPWSD - Wage and salary disbursements

Eqn 31: YPCOMPWSD_{R} = YPCOMPWSD * (YPCOMPWSD_{R} / YPCOMPWSD_{R}_SUM)

YPCOMPWSDG - Wage and salary disbursements by government

Eqn 32: YPCOMPWSDG_{R} = YPCOMPWSDG * (YPCOMPWSDG_{R} / YPCOMPWSDG_{R}_SUM)

YPCOMPWSDP - Wage and salary disbursements by private sector

Eqn 33: YPCOMPWSDP_{R} = YPCOMPWSDP * (YPCOMPWSDP_{R} / YPCOMPWSDP_{R}_SUM)

YPD – Personal disposable income

Eqn 34: YPD_{R} = YPD * (YPD_{R} / YPD_{R}_SUM)

YPDR – Real personal disposable income

Eqn 35: YPDR_{R} = YPDR * (YPDR_{R} / YPDR_{R}_SUM)

YPDRZNP – Real per capita personal disposable income

Eqn 36: YPDRZNP_{R} = YPDR_{R} / NP_{R}

YPOTH – Other Personal Income

Eqn 37: YPOTH_{R} = YP_{R} - YPCOMPWSD_{R}

Appendix C2: Regional Commercial Floor Space Model

Endogenous variables:

$Comflr_{ij}$ Commercial floor space j, rate of growth, Census Division i

The 13 commercial floor space types, j, are:

1. Stores - stores and restaurants
2. Warehouse - manufacturing and wholesale trade, public and federally-owned warehouses
3. Office - private, federal, and state and local offices
4. Automotive - auto service and parking garages
5. Manufacturing
6. Education - primary/secondary and higher education
7. Health - hospitals and nursing homes
8. Public - federal and state and local
9. Religious
10. Amusement
11. Miscellaneous, non-residential - transportation related and all other nec
12. Hotel - hotels and motels
13. Dormitories - educational and federally-owned (primarily military)

The nine Census Divisions, i, are:

14. New England
15. Middle Atlantic
16. South Atlantic

17. East North Central
18. East South Central
19. West North Central
20. West South Central
21. Mountain
22. Pacific

Model description is in Chapter 6.

Exogenous variables:

$COMFLRSTK_i(t)$ stock of commercial floor space type i for quarter *t*; in thousands of square feet, national

$COMFLRSTKTREND_i(t)$ long-term trend of stock of commercial floor space type i for quarter *t*; in thousands of square feet, national

$CONSR(t)$ real consumer spending on all goods and services for quarter *t*, in billions of chained 2009 dollars, national

$GDPR(t)$ real gross domestic product for quarter *t*, in billions of chained 2009 dollars, national

$IFNRER(t)$ private fixed nonresidential investment for quarter *t*, in billions of dollars, national

$JQPCMHFE(t)$ full-employment productivity in nonfarm business for quarter *t*, index - 2009 = 100, national

$NP16A(t)$ population aged 16 and over for quarter *t*, millions of persons, national

$RMCORPAAA(t)$ yield on Aaa-rated corporate bonds for quarter t; in percent per annum, national

$YPDR(t)$ disposable income for quarter t, in billions of chained 2009 dollars, national

Equations:

AMUSE Amusement

Eqn 1: D(ENC_AMUSE_DLBSD) = -0.000832072762079 - 0.0720745117198*D(ENC_AMUSE_DLBSD(-1)) + 0.0387720579392*DLOG(GDPR/NP16A) + 0.123709747517*(DLOG(ENC_AMUSE_FTREND(-1))-ENC_AMUSE_DLBSD(-1))

Eqn 2: D(ESC_AMUSE_DLBSD) = -0.00373081894175 - 0.335401842634*D(ESC_AMUSE_DLBSD(-1)) + 0.196077546232*DLOG(JQPCMHFE) - 0.00215116224691*DLOG(RLRMCORPAAA) + 0.239116058712*(DLOG(ESC_AMUSE_FTREND(-1))-ESC_AMUSE_DLBSD(-1))

Eqn 3: D(MA_AMUSE_DLBSD) = -0.000407103391862 - 0.453802866795*D(MA_AMUSE_DLBSD(-1)) + 0.0170573314379*DLOG(CONSR/NP16A) + 0.31894314048*(DLOG(MA_AMUSE_FTREND(-1))-MA_AMUSE_DLBSD(-1))

Eqn 4: D(MTN_AMUSE_DLBSD) = -0.00102948763286 - 0.461561895286*D(MTN_AMUSE_DLBSD(-1)) - 0.0270661122754*DLOG(NP16A) + 0.0777665300309*(DLOG(MTN_AMUSE_FTREND(-1))-MTN_AMUSE_DLBSD(-1))

Eqn 5: D(NENG_AMUSE_DLBSD) = -0.000439795525973 - 0.103738750214*D(NENG_AMUSE_DLBSD(-1)) + 0.0111085314729*DLOG(GDPR/NP16A) + 0.249976767744*(DLOG(NENG_AMUSE_FTREND(-1))-NENG_AMUSE_DLBSD(-1))

Eqn 6: D(PAC_AMUSE_DLBSD) = -0.000659284929041 - 0.165972843453*D(PAC_AMUSE_DLBSD(-1)) + 0.0181819094362*DLOG(GDPR/NP16A) + 0.249167884848*(DLOG(PAC_AMUSE_FTREND(-1))-PAC_AMUSE_DLBSD(-1))

Eqn 7: D(SATL_AMUSE_DLBSD) = -0.000600986186757 + 0.0789994738504*D(SATL_AMUSE_DLBSD(-1)) + 0.00413598294789*DLOG(IFNRER/NP16A) + 0.130913154656*(DLOG(SATL_AMUSE_FTREND(-1))-SATL_AMUSE_DLBSD(-1))

Eqn 8: D(WNC_AMUSE_DLBSD) = -0.000418727578021 - 0.457243752305*D(WNC_AMUSE_DLBSD(-1)) + 0.00106921945163*DLOG(IFNRER/NP16A) + 0.203881689504*(DLOG(WNC_AMUSE_FTREND(-1))-WNC_AMUSE_DLBSD(-1))

Eqn 9: D(WSC_AMUSE_DLBSD) = -0.000969474178273 - 0.339772488402*D(WSC_AMUSE_DLBSD(-1)) + 0.0247112564141*DLOG(GDPR/NP16A) + 0.151944370279*(DLOG(WSC_AMUSE_FTREND(-1))-WSC_AMUSE_DLBSD(-1))

Eqn 10: TOTAL_AMUSE_DLBSD = 0.175014381 * ENC_AMUSE_DLBSD + 0.063751448 * ESC_AMUSE_DLBSD + 0.141906182 * MA_AMUSE_DLBSD + 0.061541654 * MTN_AMUSE_DLBSD + 0.050935824 * NENG_AMUSE_DLBSD + 0.138725549 * PAC_AMUSE_DLBSD + 0.178501786 * SATL_AMUSE_DLBSD + 0.076720845 * WNC_AMUSE_DLBSD + 0.112902331 * WSC_AMUSE_DLBSD

AMUSE_REL Amusement and Religious

Eqn 11: ENC_AMUSE_REL_DLBSD = 0.441821 * ENC_AMUSE_DLBSD + 0.558179 * ENC_REL_DLBSD

Eqn 12: ESC_AMUSE_REL_DLBSD = 0.416758 * ESC_AMUSE_DLBSD + 0.583242 * ESC_REL_DLBSD

Eqn 13: MA_AMUSE_REL_DLBSD = 0.432946 * MA_AMUSE_DLBSD + 0.567054 * MA_REL_DLBSD

Eqn 14: MTN_AMUSE_REL_DLBSD = 0.485667 * MTN_AMUSE_DLBSD + 0.514333 * MTN_REL_DLBSD

Eqn 15: NENG_AMUSE_REL_DLBSD = 0.425248 * NENG_AMUSE_DLBSD + 0.574752 * NENG_REL_DLBSD

Eqn 16: PAC_AMUSE_REL_DLBSD = 0.545379 * PAC_AMUSE_DLBSD + 0.454621 * PAC_REL_DLBSD

Eqn 17: SATL_AMUSE_REL_DLBSD = 0.477301 * SATL_AMUSE_DLBSD + 0.522699 * SATL_REL_DLBSD

Eqn 18: WNC_AMUSE_REL_DLBSD = 0.418214 * WNC_AMUSE_DLBSD + 0.581786 * WNC_REL_DLBSD

Eqn 19: WSC_AMUSE_REL_DLBSD = 0.428857 * WSC_AMUSE_DLBSD + 0.571143 * WSC_REL_DLBSD

Eqn 20: TOTAL_AMUSE_REL_DLBSD = 0.174753352 * ENC_AMUSE_REL_DLBSD + 0.071649653 * ESC_AMUSE_REL_DLBSD + 0.130168272 * MA_AMUSE_REL_DLBSD + 0.064923786 * MTN_AMUSE_REL_DLBSD + 0.048771059 * NENG_AMUSE_REL_DLBSD + 0.116627761 * PAC_AMUSE_REL_DLBSD + 0.185364574 * SATL_AMUSE_REL_DLBSD + 0.08150079 * WNC_AMUSE_REL_DLBSD + 0.126240736 * WSC_AMUSE_REL_DLBSD

AUTO Automotive; auto service and parking garages

Eqn 21: D(ENC_AUTO_DLBSD) = -0.000698320914555 - 0.374414175583*D(ENC_AUTO_DLBSD(-1)) + 0.0319383662535*DLOG(GDPR/NP16A) + 0.157685868071*(DLOG(ENC_AUTO_FTREND(-1))-ENC_AUTO_DLBSD(-1))

Eqn 22: D(ESC_AUTO_DLBSD) = -0.00022970456735 - 0.463373708792*D(ESC_AUTO_DLBSD(-1)) + 0.0160571406109*DLOG(IFNRER/NP16A) + 0.11846994155*(DLOG(ESC_AUTO_FTREND(-1))-ESC_AUTO_DLBSD(-1))

Eqn 23: D(MA_AUTO_DLBSD) = -0.000113846304232 - 0.113325347023*D(MA_AUTO_DLBSD(-1)) + 0.0142624158465*DLOG(GDPR/NP16A) + 0.179638968358*(DLOG(MA_AUTO_FTREND(-1))-MA_AUTO_DLBSD(-1))

Eqn 24: D(MTN_AUTO_DLBSD) = -0.00110722935793 - 0.304747448767*D(MTN_AUTO_DLBSD(-1)) + 0.0727848103751*DLOG(GDPR/NP16A) + 0.0502079272969*(DLOG(MTN_AUTO_FTREND(-1))-MTN_AUTO_DLBSD(-1))

Eqn 25: D(NENG_AUTO_DLBSD) = -0.00147252453357 - 0.434501155681*D(NENG_AUTO_DLBSD(-1)) + 0.091031116583*DLOG(GDPR/NP16A) + 0.151761789883*(DLOG(NENG_AUTO_FTREND(-1))-NENG_AUTO_DLBSD(-1))

Eqn 26: D(PAC_AUTO_DLBSD) = -0.00108663879968 + 0.0688030098099*D(PAC_AUTO_DLBSD(-1)) + 0.0448925979779*DLOG(GDPR/NP16A) + 0.0701644274347*(DLOG(PAC_AUTO_FTREND(-1))-PAC_AUTO_DLBSD(-1))

Eqn 27: D(SATL_AUTO_DLBSD) = -0.00230849453045 + 0.0286760424046*D(SATL_AUTO_DLBSD(-1)) + 0.150207389855*DLOG(GDPR/NP16A) + 0.0400779035565*(DLOG(SATL_AUTO_FTREND(-1))-SATL_AUTO_DLBSD(-1))

Eqn 28: D(WNC_AUTO_DLBSD) = -0.000288537915879 - 0.255844155194*D(WNC_AUTO_DLBSD(-1)) + 0.0177332859535*DLOG(GDPR/NP16A) + 0.137366512501*(DLOG(WNC_AUTO_FTREND(-1))-WNC_AUTO_DLBSD(-1))

Eqn 29: D(WSC_AUTO_DLBSD) = -0.00105219311707 - 0.0144702257427*D(WSC_AUTO_DLBSD(-1)) + 0.0499751320672*DLOG(CONSR/NP16A) + 0.144777124583*(DLOG(WSC_AUTO_FTREND(-1))-WSC_AUTO_DLBSD(-1))

Eqn 30: TOTAL_AUTO_DLBSD = 0.165014789 * ENC_AUTO_DLBSD + 0.055705552 * ESC_AUTO_DLBSD + 0.117778519 * MA_AUTO_DLBSD + 0.064440837 * MTN_AUTO_DLBSD + 0.053263054 * NENG_AUTO_DLBSD + 0.162838531 * PAC_AUTO_DLBSD + 0.188263062 * SATL_AUTO_DLBSD + 0.077287587 * WNC_AUTO_DLBSD + 0.11540807 * WSC_AUTO_DLBSD

DORM Dormitories; educational and federally-owned (primarily military)

Eqn 31: D(ENC_DORM_DLBSD) = -0.000292728153498 - 0.275938017905*D(ENC_DORM_DLBSD(-1)) + 0.0362791354246*DLOG(GDPR/NP16A) + 0.0578273626442*(DLOG(ENC_DORM_FTREND(-1))-ENC_DORM_DLBSD(-1))

Eqn 32: D(ESC_DORM_DLBSD) = 7.99456168547e-05 - 0.103684576537*D(ESC_DORM_DLBSD(-1)) + 0.0120637101023*DLOG(GDPR/NP16A) + 0.219492265906*(DLOG(ESC_DORM_FTREND(-1))-ESC_DORM_DLBSD(-1))

Eqn 33: D(MA_DORM_DLBSD) = -0.000992916021542 - 0.370645109695*D(MA_DORM_DLBSD(-1)) + 0.0380549755945*DLOG(GDPR/NP16A) + 0.109670373509*(DLOG(MA_DORM_FTREND(-1))-MA_DORM_DLBSD(-1))

Eqn 34: D(MTN_DORM_DLBSD) = -0.000421958315899 - 0.422975687985*D(MTN_DORM_DLBSD(-1)) + 0.0224891639683*DLOG(YPDR/NP16A) + 0.301143116034*(DLOG(MTN_DORM_FTREND(-1))-MTN_DORM_DLBSD(-1))

Eqn 35: D(NENG_DORM_DLBSD) = -0.000418458394142 - 0.154081330667*D(NENG_DORM_DLBSD(-1)) + 0.00309472652408*DLOG(GDPR/NP16A) + 0.231106333618*(DLOG(NENG_DORM_FTREND(-1))-NENG_DORM_DLBSD(-1))

Eqn 36: D(PAC_DORM_DLBSD) = -0.0011832043442 - 0.180492422719*D(PAC_DORM_DLBSD(-1)) + 0.110036928562*DLOG(JQPCMHFE) - 0.00462373061046*DLOG(RLRMCORPAAA) + 0.0940563870735*(DLOG(PAC_DORM_FTREND(-1))-PAC_DORM_DLBSD(-1))

Eqn 37: D(SATL_DORM_DLBSD) = -0.000281949599764 - 0.155350061628*D(SATL_DORM_DLBSD(-1)) + 0.0267092450083*DLOG(GDPR/NP16A) + 0.113395130477*(DLOG(SATL_DORM_FTREND(-1))-SATL_DORM_DLBSD(-1))

Eqn 38: D(WNC_DORM_DLBSD) = -0.000448286326143 - 0.302672585009*D(WNC_DORM_DLBSD(-1)) + 0.0646786279621*DLOG(GDPR/NP16A) + 0.122998902284*(DLOG(WNC_DORM_FTREND(-1))-WNC_DORM_DLBSD(-1))

Eqn 39: D(WSC_DORM_DLBSD) = -0.00193917656251 - 0.533613521511*D(WSC_DORM_DLBSD(-1)) + 0.137776108107*DLOG(JQPCMHFE) - 8.39934202014e-05*DLOG(RLRMCORPAAA) + 0.0706630812566*(DLOG(WSC_DORM_FTREND(-1))-WSC_DORM_DLBSD(-1))

Eqn 40: TOTAL_DORM_DLBSD = 0.115461093 * ENC_DORM_DLBSD + 0.07786562 * ESC_DORM_DLBSD + 0.106164435 * MA_DORM_DLBSD + 0.0737696 * MTN_DORM_DLBSD + 0.057914076 * NENG_DORM_DLBSD + 0.174389063 * PAC_DORM_DLBSD + 0.20975663 * SATL_DORM_DLBSD + 0.06994049 * WNC_DORM_DLBSD + 0.114738993 * WSC_DORM_DLBSD

EDUC Education; primary/secondary and higher education

Eqn 41: D(ENC_EDUC_DLBSD) = -0.000558594601758 + 0.0710396091079*D(ENC_EDUC_DLBSD(-1)) + 0.00410089884199*DLOG(GDPR/NP16A) + 0.0929084163531*(DLOG(ENC_EDUC_FTREND(-1))-ENC_EDUC_DLBSD(-1))

Eqn 42: D(ESC_EDUC_DLBSD) = -0.000754900742091 + 0.0970685451146*D(ESC_EDUC_DLBSD(-1)) + 0.0171612978949*DLOG(GDPR/NP16A) + 0.126801057333*(DLOG(ESC_EDUC_FTREND(-1))-ESC_EDUC_DLBSD(-1))

Eqn 43: D(MA_EDUC_DLBSD) = -0.000337942779065 + 0.255389545402*D(MA_EDUC_DLBSD(-1)) + 0.00334876632934*DLOG(YPDR/NP16A) + 0.144054674232*(DLOG(MA_EDUC_FTREND(-1))-MA_EDUC_DLBSD(-1))

Eqn 44: D(MTN_EDUC_DLBSD) = -0.00119580858239 - 0.10103665862*D(MTN_EDUC_DLBSD(-1)) + 0.0243361847149*DLOG(CONSR/NP16A) + 0.146781026842*(DLOG(MTN_EDUC_FTREND(-1))-MTN_EDUC_DLBSD(-1))

Eqn 45: D(NENG_EDUC_DLBSD) = -0.00103725659202 + 0.209024369154*D(NENG_EDUC_DLBSD(-1)) + 0.0346133107283*DLOG(GDPR/NP16A) + 0.16783949575*(DLOG(NENG_EDUC_FTREND(-1))-NENG_EDUC_DLBSD(-1))

Eqn 46: D(PAC_EDUC_DLBSD) = -0.00102928788872 - 0.0148601606982*D(PAC_EDUC_DLBSD(-1)) + 0.0516099693653*DLOG(GDPR/NP16A) + 0.125890514881*(DLOG(PAC_EDUC_FTREND(-1))-PAC_EDUC_DLBSD(-1))

Eqn 47: D(SATL_EDUC_DLBSD) = -0.00398728660448 - 0.0181574030851*D(SATL_EDUC_DLBSD(-1)) + 0.211617259173*DLOG(JQPCMHFE) - 0.004504375038*DLOG(RLRMCORPAAA) + 0.0960453038904*(DLOG(SATL_EDUC_FTREND(-1))-SATL_EDUC_DLBSD(-1))

Eqn 48: D(WNC_EDUC_DLBSD) = -0.000871913406763 - 0.125738523085*D(WNC_EDUC_DLBSD(-1)) + 0.0311961521531*DLOG(GDPR/NP16A) + 0.0657743120893*(DLOG(WNC_EDUC_FTREND(-1))-WNC_EDUC_DLBSD(-1))

Eqn 49: D(WSC_EDUC_DLBSD) = -0.000320176005805 + 0.00209705688424*D(WSC_EDUC_DLBSD(-1)) + 0.0144603726048*DLOG(GDPR/NP16A) + 0.0409332059821*(DLOG(WSC_EDUC_FTREND(-1))-WSC_EDUC_DLBSD(-1))

Eqn 50: TOTAL_EDUC_DLBSD = 0.174086374 * ENC_EDUC_DLBSD + 0.063034543 * ESC_EDUC_DLBSD + 0.150215507 * MA_EDUC_DLBSD + 0.06158221 * MTN_EDUC_DLBSD + 0.059590026 *

NENG_EDUC_DLBSD + 0.126166958 * PAC_EDUC_DLBSD + 0.175296984 * SATL_EDUC_DLBSD + 0.074693572 * WNC_EDUC_DLBSD + 0.115333826 * WSC_EDUC_DLBSD

HEALTH Health; hospitals and nursing homes

Eqn 51: D(ENC_HEALTH_DLBSD) = -0.00163138555574 - 0.0750460795316*D(ENC_HEALTH_DLBSD(-1)) + 0.0649441486851*DLOG(GDPR/NP16A) + 0.150021021342*(DLOG(ENC_HEALTH_FTREND(-1))-ENC_HEALTH_DLBSD(-1))

Eqn 52: D(ESC_HEALTH_DLBSD) = -0.00157632834414 - 0.156655033622*D(ESC_HEALTH_DLBSD(-1)) + 0.0209906180303*DLOG(GDPR/NP16A) + 0.490037862535*(DLOG(ESC_HEALTH_FTREND(-1))-ESC_HEALTH_DLBSD(-1))

Eqn 53: D(MA_HEALTH_DLBSD) = -0.0013771989046 + 0.232300119039*D(MA_HEALTH_DLBSD(-1)) + 0.0781074937729*DLOG(GDPR/NP16A) + 0.313664646447*(DLOG(MA_HEALTH_FTREND(-1))-MA_HEALTH_DLBSD(-1))

Eqn 54: D(MTN_HEALTH_DLBSD) = -0.00182491328659 - 0.361819977701*D(MTN_HEALTH_DLBSD(-1)) + 0.0680175895917*DLOG(GDPR/NP16A) + 0.0285730449717*(DLOG(MTN_HEALTH_FTREND(-1))-MTN_HEALTH_DLBSD(-1))

Eqn 55: D(NENG_HEALTH_DLBSD) = -0.00139084621644 - 0.0847666009765*D(NENG_HEALTH_DLBSD(-1)) + 0.0066821981229*DLOG(GDPR/NP16A) + 0.721884451386*(DLOG(NENG_HEALTH_FTREND(-1))-NENG_HEALTH_DLBSD(-1))

Eqn 56: D(PAC_HEALTH_DLBSD) = -0.000961255664591 + 0.00515194415965*D(PAC_HEALTH_DLBSD(-1)) - 0.000976478986494*DLOG(IFNRER/NP16A) + 0.196816642353*(DLOG(PAC_HEALTH_FTREND(-1))-PAC_HEALTH_DLBSD(-1))

Eqn 57: D(SATL_HEALTH_DLBSD) = -0.00190425260659 + 0.0837854048057*D(SATL_HEALTH_DLBSD(-1)) + 0.0668024287851*DLOG(GDPR/NP16A) + 0.183853921581*(DLOG(SATL_HEALTH_FTREND(-1))-SATL_HEALTH_DLBSD(-1))

Eqn 58: D(WNC_HEALTH_DLBSD) = -0.000860938400014 - 0.19637502629*D(WNC_HEALTH_DLBSD(-1)) + 0.0221057118259*DLOG(GDPR/NP16A) + 0.265971185114*(DLOG(WNC_HEALTH_FTREND(-1))-WNC_HEALTH_DLBSD(-1))

Eqn 59: D(WSC_HEALTH_DLBSD) = -0.000804358776461 - 0.163246639743*D(WSC_HEALTH_DLBSD(-1)) + 0.00132498282258*DLOG(GDPR/NP16A) + 0.214120556607*(DLOG(WSC_HEALTH_FTREND(-1))-WSC_HEALTH_DLBSD(-1))

Eqn 60: TOTAL_HEALTH_DLBSD = 0.178028051 * ENC_HEALTH_DLBSD + 0.068358138 * ESC_HEALTH_DLBSD + 0.155416667 * MA_HEALTH_DLBSD + 0.048975149 * MTN_HEALTH_DLBSD + 0.05557712 * NENG_HEALTH_DLBSD + 0.118768226 * PAC_HEALTH_DLBSD + 0.176866835 * SATL_HEALTH_DLBSD + 0.086777387 * WNC_HEALTH_DLBSD + 0.111232426 * WSC_HEALTH_DLBSD

HOTEL Hotel; hotels and motels

Eqn 61: D(ENC_HOTEL_DLBSD) = -0.00390010031505 + 0.308969769427*D(ENC_HOTEL_DLBSD(-1)) + 0.240518249511*DLOG(GDPR/NP16A) + 0.430505428022*(DLOG(ENC_HOTEL_FTREND(-1))-ENC_HOTEL_DLBSD(-1))

Eqn 62: D(ESC_HOTEL_DLBSD) = -0.00584233911777 + 0.557665903721*D(ESC_HOTEL_DLBSD(-1)) + 0.245968190117*DLOG(GDPR/NP16A) + 0.583355039424*(DLOG(ESC_HOTEL_FTREND(-1))-ESC_HOTEL_DLBSD(-1))

Eqn 63: D(MA_HOTEL_DLBSD) = -0.000487113850181 + 0.0227542167443*D(MA_HOTEL_DLBSD(-1)) + 0.0428376306832*DLOG(GDPR/NP16A) + 0.384402879933*(DLOG(MA_HOTEL_FTREND(-1))-MA_HOTEL_DLBSD(-1))

Eqn 64: D(MTN_HOTEL_DLBSD) = -0.0138513001156 + 0.0644170965426*D(MTN_HOTEL_DLBSD(-1)) + 0.692593071865*DLOG(JQPCMHFE) - 0.00561768605936*DLOG(RLRMCORPAAA) + 0.804910984361*(DLOG(MTN_HOTEL_FTREND(-1))-MTN_HOTEL_DLBSD(-1))

Eqn 65: D(NENG_HOTEL_DLBSD) = -0.00372279220856 - 0.0698339628439*D(NENG_HOTEL_DLBSD(-1)) + 0.183530591689*DLOG(GDPR/NP16A) + 0.281323005398*(DLOG(NENG_HOTEL_FTREND(-1))-NENG_HOTEL_DLBSD(-1))

Eqn 66: D(PAC_HOTEL_DLBSD) = -0.00323885952561 - 0.0260348838575*D(PAC_HOTEL_DLBSD(-1)) + 0.0772551690523*DLOG(GDPR/NP16A) + 0.310051121876*(DLOG(PAC_HOTEL_FTREND(-1))-PAC_HOTEL_DLBSD(-1))

Eqn 67: D(SATL_HOTEL_DLBSD) = -0.0057829881281 + 0.589387935599*D(SATL_HOTEL_DLBSD(-1)) + 0.298830066867*DLOG(GDPR/NP16A) + 0.414626477111*(DLOG(SATL_HOTEL_FTREND(-1))-SATL_HOTEL_DLBSD(-1))

Eqn 68: D(WNC_HOTEL_DLBSD) = -0.00114736493743 + 0.00734398252579*D(WNC_HOTEL_DLBSD(-1)) + 0.0112742952825*DLOG(IFNRER/NP16A) + 0.668494206423*(DLOG(WNC_HOTEL_FTREND(-1))-WNC_HOTEL_DLBSD(-1))

Eqn 69: D(WSC_HOTEL_DLBSD) = -0.00261299275374 + 0.275326708188*D(WSC_HOTEL_DLBSD(-1)) + 0.0443283967817*DLOG(IFNRER/NP16A) + 0.266310206901*(DLOG(WSC_HOTEL_FTREND(-1))-WSC_HOTEL_DLBSD(-1))

Eqn 70: TOTAL_HOTEL_DLBSD = 0.120081877 * ENC_HOTEL_DLBSD + 0.053191674 * ESC_HOTEL_DLBSD + 0.110171724 * MA_HOTEL_DLBSD + 0.115250261 * MTN_HOTEL_DLBSD + 0.045175766 * NENG_HOTEL_DLBSD + 0.159318344 * PAC_HOTEL_DLBSD + 0.227140741 * SATL_HOTEL_DLBSD + 0.065568116 * WNC_HOTEL_DLBSD + 0.104101497 * WSC_HOTEL_DLBSD

HOTEL_DORM Hotel and Dormitories; Hotels and motels and educational and federally-owned dormitories (primarily military)

Eqn 71: ENC_HOTEL_DORM_DLBSD = 0.634201 * ENC_HOTEL_DLBSD + 0.365799 * ENC_DORM_DLBSD

Eqn 72: ESC_HOTEL_DORM_DLBSD = 0.529713 * ESC_HOTEL_DLBSD + 0.470287 * ESC_DORM_DLBSD

Eqn 73: MA_HOTEL_DORM_DLBSD = 0.646117 * MA_HOTEL_DLBSD + 0.353883 * MA_DORM_DLBSD

Eqn 74: MTN_HOTEL_DORM_DLBSD = 0.704116 * MTN_HOTEL_DLBSD + 0.295884 * MTN_DORM_DLBSD

Eqn 75: NENG_HOTEL_DORM_DLBSD = 0.574928 * NENG_HOTEL_DLBSD + 0.425072 * NENG_DORM_DLBSD

Eqn 76: PAC_HOTEL_DORM_DLBSD = 0.601099 * PAC_HOTEL_DLBSD + 0.398901 * PAC_DORM_DLBSD

Eqn 77: SATL_HOTEL_DORM_DLBSD = 0.637119 * SATL_HOTEL_DLBSD + 0.362881 * SATL_DORM_DLBSD

Eqn 78: WNC_HOTEL_DORM_DLBSD = 0.614984 * WNC_HOTEL_DLBSD + 0.385016 * WNC_DORM_DLBSD

Eqn 79: WSC_HOTEL_DORM_DLBSD = 0.593967 * WSC_HOTEL_DLBSD + 0.406033 * WSC_DORM_DLBSD

Eqn 80: TOTAL_HOTEL_DORM_DLBSD = 0.115629647 * ENC_HOTEL_DORM_DLBSD + 0.062403481 * ESC_HOTEL_DORM_DLBSD + 0.104072045 * MA_HOTEL_DORM_DLBSD + 0.108167117 * MTN_HOTEL_DORM_DLBSD + 0.047379489 * NENG_HOTEL_DORM_DLBSD + 0.156446106 * PAC_HOTEL_DORM_DLBSD + 0.228566007 * SATL_HOTEL_DORM_DLBSD + 0.063965981 * WNC_HOTEL_DORM_DLBSD + 0.113370068 * WSC_HOTEL_DORM_DLBSD

MFG Manufacturing

Eqn 81: D(ENC_MFG_DLBSD) = -0.000333905007165 + 0.163633899132*D(ENC_MFG_DLBSD(-1)) + 0.0166440882339*DLOG(GDPR/NP16A) + 0.308045689557*(DLOG(ENC_MFG_FTREND(-1))-ENC_MFG_DLBSD(-1))

Eqn 82: D(ESC_MFG_DLBSD) = -0.000129226665978 + 0.291373490412*D(ESC_MFG_DLBSD(-1)) + 0.00430334370186*DLOG(IFNRER/NP16A) + 0.572257153043*(DLOG(ESC_MFG_FTREND(-1))-ESC_MFG_DLBSD(-1))

Eqn 83: D(MA_MFG_DLBSD) = -0.00110476562161 - 0.00875641251539*D(MA_MFG_DLBSD(-1)) + 0.0766879841306*DLOG(NP16A) + 0.483525306038*(DLOG(MA_MFG_FTREND(-1))-MA_MFG_DLBSD(-1))

Eqn 84: D(MTN_MFG_DLBSD) = -0.000531767217707 - 0.00827810977787*D(MTN_MFG_DLBSD(-1)) + 0.010113339807*DLOG(IFNRER/NP16A) + 0.38319855609*(DLOG(MTN_MFG_FTREND(-1))-MTN_MFG_DLBSD(-1))

Eqn 85: D(NENG_MFG_DLBSD) = -0.000316932699958 - 0.33347564153*D(NENG_MFG_DLBSD(-1)) + 0.0072992366873*DLOG(IFNRER/NP16A) + 0.160851726405*(DLOG(NENG_MFG_FTREND(-1))-NENG_MFG_DLBSD(-1))

Eqn 86: D(PAC_MFG_DLBSD) = -0.000618436500209 + 0.12721790266*D(PAC_MFG_DLBSD(-1)) + 0.016289224671*DLOG(IFNRER/NP16A) + 0.119054024724*(DLOG(PAC_MFG_FTREND(-1))-PAC_MFG_DLBSD(-1))

Eqn 87: D(SATL_MFG_DLBSD) = -0.000392806701518 - 0.0329671520865*D(SATL_MFG_DLBSD(-1)) + 0.00681243974875*DLOG(IFNRER/NP16A) + 0.251008973262*(DLOG(SATL_MFG_FTREND(-1))-SATL_MFG_DLBSD(-1))

Eqn 88: D(WNC_MFG_DLBSD) = -0.00758123613289 + 0.277572255489*D(WNC_MFG_DLBSD(-1)) + 0.634422572755*DLOG(NP16A) + 0.690074623934*(DLOG(WNC_MFG_FTREND(-1))-WNC_MFG_DLBSD(-1))

Eqn 89: D(WSC_MFG_DLBSD) = -0.00684853126593 + 0.0327641633334*D(WSC_MFG_DLBSD(-1)) + 0.575534881784*DLOG(NP16A) + 0.480127403063*(DLOG(WSC_MFG_FTREND(-1))-WSC_MFG_DLBSD(-1))

Eqn 90: TOTAL_MFG_DLBSD = 0.247585636 * ENC_MFG_DLBSD + 0.07463863 * ESC_MFG_DLBSD + 0.155291314 * MA_MFG_DLBSD + 0.032496146 * MTN_MFG_DLBSD + 0.062536882 * NENG_MFG_DLBSD + 0.12067783 * PAC_MFG_DLBSD + 0.15447908 * SATL_MFG_DLBSD + 0.072405514 * WNC_MFG_DLBSD + 0.079888968 * WSC_MFG_DLBSD

MISCNR Miscellaneous, non-residential transportation related and all other nec

Eqn 91: D(ENC_MISCNR_DLBSD) = -0.00379344820353 - 0.0736723305717*D(ENC_MISCNR_DLBSD(-1)) + 0.0312785986514*DLOG(IFNRER/NP16A) + 0.278069308713*(DLOG(ENC_MISCNR_FTREND(-1))-ENC_MISCNR_DLBSD(-1))

Eqn 92: D(ESC_MISCNR_DLBSD) = -0.00488402387977 - 0.408919951653*D(ESC_MISCNR_DLBSD(-1)) + 0.0419046557703*DLOG(YPDR/NP16A) + 0.406272841895*(DLOG(ESC_MISCNR_FTREND(-1))-ESC_MISCNR_DLBSD(-1))

Eqn 93: D(MA_MISCNR_DLBSD) = -0.00398616081756 - 0.284304150651*D(MA_MISCNR_DLBSD(-1)) + 0.0550734390288*DLOG(CONSR/NP16A) + 0.606858730251*(DLOG(MA_MISCNR_FTREND(-1))-MA_MISCNR_DLBSD(-1))

Eqn 94: D(MTN_MISCNR_DLBSD) = -0.0405102506818 - 0.101572002526*D(MTN_MISCNR_DLBSD(-1)) + 3.47159152284*DLOG(NP16A) + 0.903694349967*(DLOG(MTN_MISCNR_FTREND(-1))-MTN_MISCNR_DLBSD(-1))

Eqn 95: D(NENG_MISCNR_DLBSD) = -0.00445021440183 - 0.43410423953*D(NENG_MISCNR_DLBSD(-1)) + 0.0389638480488*DLOG(YPDR/NP16A) + 0.620468684893*(DLOG(NENG_MISCNR_FTREND(-1))-NENG_MISCNR_DLBSD(-1))

Eqn 96: D(PAC_MISCNR_DLBSD) = -0.0298981082947 - 0.0316274323225*D(PAC_MISCNR_DLBSD(-1)) + 2.53143755986*DLOG(NP16A) + 0.460857095335*(DLOG(PAC_MISCNR_FTREND(-1))-PAC_MISCNR_DLBSD(-1))

Eqn 97: D(SATL_MISCNR_DLBSD) = -0.00469127745954 - 0.197902810379*D(SATL_MISCNR_DLBSD(-1)) + 0.103317535187*DLOG(JQPCMHFE) - 0.0120251664319*DLOG(RLRMCORPAAA) + 0.502765948213*(DLOG(SATL_MISCNR_FTREND(-1))-SATL_MISCNR_DLBSD(-1))

Eqn 98: D(WNC_MISCNR_DLBSD) = -0.00411999921005 - 0.221954474975*D(WNC_MISCNR_DLBSD(-1)) + 0.134581724789*DLOG(GDPR/NP16A) + 0.511139959796*(DLOG(WNC_MISCNR_FTREND(-1))-WNC_MISCNR_DLBSD(-1))

Eqn 99: D(WSC_MISCNR_DLBSD) = -0.0162463414029 - 0.37592021928*D(WSC_MISCNR_DLBSD(-1)) + 1.19041849843*DLOG(NP16A) + 0.58570130876*(DLOG(WSC_MISCNR_FTREND(-1))-WSC_MISCNR_DLBSD(-1))

Eqn 100: TOTAL_MISCNR_DLBSD = 0.163712298 * ENC_MISCNR_DLBSD + 0.054450626 * ESC_MISCNR_DLBSD + 0.110677479 * MA_MISCNR_DLBSD + 0.078805829 * MTN_MISCNR_DLBSD + 0.03496633 * NENG_MISCNR_DLBSD + 0.184376493 * PAC_MISCNR_DLBSD + 0.195534448 * SATL_MISCNR_DLBSD + 0.068779612 * WNC_MISCNR_DLBSD + 0.108696885 * WSC_MISCNR_DLBSD

OFFICE Office; private, federal, and state and local offices

Eqn 101: D(ENC_OFFICE_DLBSD) = -0.000951913191188 + 0.197249740653*D(ENC_OFFICE_DLBSD(-1)) + 0.0486560827483*DLOG(GDPR/NP16A) + 0.207106428571*(DLOG(ENC_OFFICE_FTREND(-1))-ENC_OFFICE_DLBSD(-1))

Eqn 102: D(ESC_OFFICE_DLBSD) = -0.000763558714832 + 0.0340286011465*D(ESC_OFFICE_DLBSD(-1)) + 0.0250398373684*DLOG(CONSR/NP16A) + 0.364337534711*(DLOG(ESC_OFFICE_FTREND(-1))-ESC_OFFICE_DLBSD(-1))

Eqn 103: D(MA_OFFICE_DLBSD) = -0.000955520250851 + 0.00327893227615*D(MA_OFFICE_DLBSD(-1)) + 0.0264966379646*DLOG(CONSR/NP16A) + 0.31621162572*(DLOG(MA_OFFICE_FTREND(-1))-MA_OFFICE_DLBSD(-1))

Eqn 104: D(MTN_OFFICE_DLBSD) = -0.000877903426897 + 0.265361108478*D(MTN_OFFICE_DLBSD(-1)) + 0.00901734785601*DLOG(IFNRER/NP16A) + 0.212714365331*(DLOG(MTN_OFFICE_FTREND(-1))-MTN_OFFICE_DLBSD(-1))

Eqn 105: D(NENG_OFFICE_DLBSD) = -0.000635465117865 + 0.153508954416*D(NENG_OFFICE_DLBSD(-1)) + 0.0322143949688*DLOG(GDPR/NP16A) + 0.216689649165*(DLOG(NENG_OFFICE_FTREND(-1))-NENG_OFFICE_DLBSD(-1))

Eqn 106: D(PAC_OFFICE_DLBSD) = -0.00291649396779 + 0.168666051048*D(PAC_OFFICE_DLBSD(-1)) + 0.137738458298*DLOG(JQPCMHFE) + 0.160331239312*(DLOG(PAC_OFFICE_FTREND(-1))-PAC_OFFICE_DLBSD(-1))

Eqn 107: D(SATL_OFFICE_DLBSD) = -0.000974701075741 + 0.556779578211*D(SATL_OFFICE_DLBSD(-1)) + 0.0287109655647*DLOG(GDPR/NP16A) + 0.183465017209*(DLOG(SATL_OFFICE_FTREND(-1))-SATL_OFFICE_DLBSD(-1))

Eqn 108: D(WNC_OFFICE_DLBSD) = -0.0048886570866 - 0.0083621030688*D(WNC_OFFICE_DLBSD(-1)) + 0.250266981835*DLOG(JQPCMHFE) + 0.434695877208*(DLOG(WNC_OFFICE_FTREND(-1))-WNC_OFFICE_DLBSD(-1))

Eqn 109: D(WSC_OFFICE_DLBSD) = -0.000161171156568 + 0.324192280354*D(WSC_OFFICE_DLBSD(-1)) + 0.0129128355666*DLOG(CONSR/NP16A) + 0.212745378149*(DLOG(WSC_OFFICE_FTREND(-1))-WSC_OFFICE_DLBSD(-1))

Eqn 110: TOTAL_OFFICE_DLBSD = 0.172554356 * ENC_OFFICE_DLBSD + 0.049705679 * ESC_OFFICE_DLBSD + 0.154375382 * MA_OFFICE_DLBSD + 0.054450379 * MTN_OFFICE_DLBSD + 0.060490839 * NENG_OFFICE_DLBSD + 0.15329798 * PAC_OFFICE_DLBSD + 0.175771552 * SATL_OFFICE_DLBSD + 0.070659464 * WNC_OFFICE_DLBSD + 0.108694369 * WSC_OFFICE_DLBSD

PUB Public; federal and state and local

Eqn 111: D(ENC_PUB_DLBSD) = -0.00202872038268 - 0.157413467288*D(ENC_PUB_DLBSD(-1)) + 0.0352666359765*DLOG(GDPR/NP16A) + 0.381161504289*(DLOG(ENC_PUB_FTREND(-1))-ENC_PUB_DLBSD(-1))

Eqn 112: D(ESC_PUB_DLBSD) = -0.0033565273559 - 0.195113186186*D(ESC_PUB_DLBSD(-1)) + 0.0531995927421*DLOG(GDPR/NP16A) + 0.314481857858*(DLOG(ESC_PUB_FTREND(-1))-ESC_PUB_DLBSD(-1))

Eqn 113: D(MA_PUB_DLBSD) = -0.00274605372893 - 0.277698959466*D(MA_PUB_DLBSD(-1)) + 0.0262474589365*DLOG(CONSR/NP16A) + 0.394345887389*(DLOG(MA_PUB_FTREND(-1))-MA_PUB_DLBSD(-1))

Eqn 114: D(MTN_PUB_DLBSD) = -0.00873453687294 - 0.207446726948*D(MTN_PUB_DLBSD(-1)) + 0.361133987789*DLOG(JQPCMHFE) - 0.00111571095577*DLOG(RLRMCORPAAA) + 0.215207598445*(DLOG(MTN_PUB_FTREND(-1))-MTN_PUB_DLBSD(-1))

Eqn 115: D(NENG_PUB_DLBSD) = -0.00530403265311 + 0.100849752098*D(NENG_PUB_DLBSD(-1)) + 0.230067459693*DLOG(JQPCMHFE) - 0.01205052641*DLOG(RLRMCORPAAA) + 0.5449744491*(DLOG(NENG_PUB_FTREND(-1))-NENG_PUB_DLBSD(-1))

Eqn 116: D(PAC_PUB_DLBSD) = -0.00518819375585 - 0.254841027218*D(PAC_PUB_DLBSD(-1)) + 0.178873906427*DLOG(JQPCMHFE) - 0.0104758905606*DLOG(RLRMCORPAAA) + 0.350879476885*(DLOG(PAC_PUB_FTREND(-1))-PAC_PUB_DLBSD(-1))

Eqn 117: D(SATL_PUB_DLBSD) = -0.0043630923957 + 0.0121116671341*D(SATL_PUB_DLBSD(-1)) + 0.143608936388*DLOG(JQPCMHFE) - 0.0127204658624*DLOG(RLRMCORPAAA) + 0.180479833659*(DLOG(SATL_PUB_FTREND(-1))-SATL_PUB_DLBSD(-1))

Eqn 118: D(WNC_PUB_DLBSD) = -0.00632715822636 - 0.145410885128*D(WNC_PUB_DLBSD(-1)) + 0.285597886817*DLOG(JQPCMHFE) - 0.0138975180198*DLOG(RLRMCORPAAA) + 0.282417579949*(DLOG(WNC_PUB_FTREND(-1))-WNC_PUB_DLBSD(-1))

Eqn 119: D(WSC_PUB_DLBSD) = -0.00584640695777 - 0.192497347638*D(WSC_PUB_DLBSD(-1)) + 0.213135128409*DLOG(JQPCMHFE) - 0.0202924418056*DLOG(RLRMCORPAAA) + 0.431142764144*(DLOG(WSC_PUB_FTREND(-1))-WSC_PUB_DLBSD(-1))

Eqn 120: TOTAL_PUB_DLBSD = 0.143986648 * ENC_PUB_DLBSD + 0.061913934 * ESC_PUB_DLBSD + 0.130546352 * MA_PUB_DLBSD + 0.073783279 * MTN_PUB_DLBSD + 0.052851353 * NENG_PUB_DLBSD + 0.145722989 * PAC_PUB_DLBSD + 0.206988869 * SATL_PUB_DLBSD + 0.074175339 * WNC_PUB_DLBSD + 0.110031238 * WSC_PUB_DLBSD

PUB_MISCNR Public and Miscellaneous; Federal and state and local and non-residential transportation related and all other nec

Eqn 121: ENC_PUB_MISCNR_DLBSD = 0.634201 * ENC_PUB_DLBSD + 0.365799 * ENC_MISCNR_DLBSD

Eqn 122: ESC_PUB_MISCNR_DLBSD = 0.529713 * ESC_PUB_DLBSD + 0.470287 * ESC_MISCNR_DLBSD

Eqn 123: MA_PUB_MISCNR_DLBSD = 0.646117 * MA_PUB_DLBSD + 0.353883 * MA_MISCNR_DLBSD

Eqn 124: MTN_PUB_MISCNR_DLBSD = 0.704116 * MTN_PUB_DLBSD + 0.295884 * MTN_MISCNR_DLBSD

Eqn 125: NENG_PUB_MISCNR_DLBSD = 0.574928 * NENG_PUB_DLBSD + 0.425072 * NENG_MISCNR_DLBSD

Eqn 126: PAC_PUB_MISCNR_DLBSD = 0.601099 * PAC_PUB_DLBSD + 0.398901 * PAC_MISCNR_DLBSD

Eqn 127: SATL_PUB_MISCNR_DLBSD = 0.637119 * SATL_PUB_DLBSD + 0.362881 * SATL_MISCNR_DLBSD

Eqn 128: WNC_PUB_MISCNR_DLBSD = 0.614984 * WNC_PUB_DLBSD + 0.385016 * WNC_MISCNR_DLBSD

Eqn 129: WSC_PUB_MISCNR_DLBSD = 0.593967 * WSC_PUB_DLBSD + 0.406033 * WSC_MISCNR_DLBSD

Eqn 130: TOTAL_PUB_MISCNR_DLBSD = 0.150531276 * ENC_PUB_MISCNR_DLBSD + 0.060838068 * ESC_PUB_MISCNR_DLBSD + 0.112763418 * MA_PUB_MISCNR_DLBSD + 0.081208022 *

MTN_PUB_MISCNR_DLBSD + 0.041693895 * NENG_PUB_MISCNR_DLBSD + 0.157117576 * PAC_PUB_MISCNR_DLBSD + 0.210853121 * SATL_PUB_MISCNR_DLBSD + 0.07031529 * WNC_PUB_MISCNR_DLBSD + 0.114679507 * WSC_PUB_MISCNR_DLBSD

REL Religious

Eqn 131: D(ENC_REL_DLBSD) = -0.000302105364115 + 0.139807158092*D(ENC_REL_DLBSD(-1)) + 0.0161676084845*DLOG(GDPR/NP16A) + 0.0563104479612*(DLOG(ENC_REL_FTREND(-1))-ENC_REL_DLBSD(-1))

Eqn 132: D(ESC_REL_DLBSD) = -0.000849892057999 - 0.106302991414*D(ESC_REL_DLBSD(-1)) + 0.0489400747061*DLOG(GDPR/NP16A) + 0.0647503848461*(DLOG(ESC_REL_FTREND(-1))-ESC_REL_DLBSD(-1))

Eqn 133: D(MA_REL_DLBSD) = -0.000171615531488 - 0.0178871793575*D(MA_REL_DLBSD(-1)) + 0.0109566710121*DLOG(GDPR/NP16A) + 0.0764561157549*(DLOG(MA_REL_FTREND(-1))-MA_REL_DLBSD(-1))

Eqn 134: D(MTN_REL_DLBSD) = -0.00049814270666 + 0.265807340294*D(MTN_REL_DLBSD(-1)) + 0.0186149772397*DLOG(GDPR/NP16A) + 0.228767202742*(DLOG(MTN_REL_FTREND(-1))-MTN_REL_DLBSD(-1))

Eqn 135: D(NENG_REL_DLBSD) = -0.000223363647947 - 0.292736202475*D(NENG_REL_DLBSD(-1)) + 0.0143305174562*DLOG(GDPR/NP16A) + 0.056958479794*(DLOG(NENG_REL_FTREND(-1))-NENG_REL_DLBSD(-1))

Eqn 136: D(PAC_REL_DLBSD) = -0.000299037727945 - 0.250896544896*D(PAC_REL_DLBSD(-1)) + 0.0097669960443*DLOG(GDPR/NP16A) + 0.100491036024*(DLOG(PAC_REL_FTREND(-1))-PAC_REL_DLBSD(-1))

Eqn 137: D(SATL_REL_DLBSD) = -0.000680980312971 + 0.156093423373*D(SATL_REL_DLBSD(-1)) + 0.0355990627798*DLOG(GDPR/NP16A) + 0.0591302872047*(DLOG(SATL_REL_FTREND(-1))-SATL_REL_DLBSD(-1))

Eqn 138: D(WNC_REL_DLBSD) = -0.000343836727568 - 0.3477460253*D(WNC_REL_DLBSD(-1)) + 0.0201261119133*DLOG(GDPR/NP16A) + 0.0871099986751*(DLOG(WNC_REL_FTREND(-1))-WNC_REL_DLBSD(-1))

Eqn 139: D(WSC_REL_DLBSD) = -0.00048782095432 + 0.0681392117221*D(WSC_REL_DLBSD(-1)) + 0.0287712401265*DLOG(GDPR/NP16A) + 0.106996512372*(DLOG(WSC_REL_FTREND(-1))-WSC_REL_DLBSD(-1))

Eqn 140: TOTAL_REL_DLBSD = 0.185862529 * ENC_REL_DLBSD + 0.074847563 * ESC_REL_DLBSD + 0.158734808 * MA_REL_DLBSD + 0.051589853 * MTN_REL_DLBSD + 0.058582307 * NENG_REL_DLBSD + 0.096202919 * EQN 141: PAC_REL_DLBSD + 0.161128962 * SATL_REL_DLBSD + 0.089198557 * WNC_REL_DLBSD + 0.123852501 * WSC_REL_DLBSD

STORES Stores; stores and restaurants

Eqn 141: D(ENC_STORES_DLBSD) = -0.00134902047812 + 0.535250222424*D(ENC_STORES_DLBSD(-1)) + 0.0795330948346*DLOG(GDPR/NP16A) + 0.117907009756*(DLOG(ENC_STORES_FTREND(-1))-ENC_STORES_DLBSD(-1))

Eqn 142: D(ESC_STORES_DLBSD) = -0.00155894456379 + 0.062141474489*D(ESC_STORES_DLBSD(-1)) + 0.0555656768924*DLOG(GDPR/NP16A) + 0.212563687886*(DLOG(ESC_STORES_FTREND(-1))-ESC_STORES_DLBSD(-1))

Eqn 143: D(MA_STORES_DLBSD) = -0.000503668172487 + 0.161089085467*D(MA_STORES_DLBSD(-1)) + 0.0178241277196*DLOG(GDPR/NP16A) + 0.17921237557*(DLOG(MA_STORES_FTREND(-1))-MA_STORES_DLBSD(-1))

Eqn 144: D(MTN_STORES_DLBSD) = -0.00191598085574 + 0.341885753865*D(MTN_STORES_DLBSD(-1)) + 0.0713342456853*DLOG(GDPR/NP16A) + 0.169326896651*(DLOG(MTN_STORES_FTREND(-1))-MTN_STORES_DLBSD(-1))

Eqn 145: D(NENG_STORES_DLBSD) = -0.000825860594111 + 0.0952437092274*D(NENG_STORES_DLBSD(-1)) + 0.0315739573324*DLOG(GDPR/NP16A) + 0.21683673051*(DLOG(NENG_STORES_FTREND(-1))-NENG_STORES_DLBSD(-1))

Eqn 146: D(PAC_STORES_DLBSD) = -0.000943362492963 + 0.395184021158*D(PAC_STORES_DLBSD(-1)) + 0.0339758841911*DLOG(GDPR/NP16A) + 0.228515525034*(DLOG(PAC_STORES_FTREND(-1))-PAC_STORES_DLBSD(-1))

Eqn 147: D(SATL_STORES_DLBSD) = -0.00257433445172 + 0.267701364441*D(SATL_STORES_DLBSD(-1)) + 0.120813655532*DLOG(GDPR/NP16A) + 0.137170239662*(DLOG(SATL_STORES_FTREND(-1))-SATL_STORES_DLBSD(-1))

Eqn 148: D(WNC_STORES_DLBSD) = -0.000948231239961 + 0.0171400471862*D(WNC_STORES_DLBSD(-1)) + 0.0548503559342*DLOG(GDPR/NP16A) + 0.162003373023*(DLOG(WNC_STORES_FTREND(-1))-WNC_STORES_DLBSD(-1))

Eqn 149: D(WSC_STORES_DLBSD) = -0.00187108875875 + 0.474214224476*D(WSC_STORES_DLBSD(-1)) + 0.0966613552765*DLOG(GDPR/NP16A) + 0.380572504971*(DLOG(WSC_STORES_FTREND(-1))-WSC_STORES_DLBSD(-1))

Eqn 150: TOTAL_STORES_DLBSD = 0.192076478 * ENC_STORES_DLBSD + 0.058434199 * ESC_STORES_DLBSD + 0.127053217 * MA_STORES_DLBSD + 0.063659912 * MTN_STORES_DLBSD + 0.049933047 * NENG_STORES_DLBSD + 0.143656911 * PAC_STORES_DLBSD + 0.178647927 * SATL_STORES_DLBSD + 0.075184192 * WNC_STORES_DLBSD + 0.111354116 * WSC_STORES_DLBSD

WARE Warehouse; manufacturing and wholesale trade, public and federally-owned warehouses

Eqn 151: D(ENC_WARE_DLBSD) = -0.000735497305982 + 0.487162345652*D(ENC_WARE_DLBSD(-1)) + 0.0241993159975*DLOG(IFNRER/NP16A) + 0.359671965825*(DLOG(ENC_WARE_FTREND(-1))-ENC_WARE_DLBSD(-1))

Eqn 152: D(ESC_WARE_DLBSD) = -0.00149883372756 + 0.374415450362*D(ESC_WARE_DLBSD(-1)) + 0.0528038052214*DLOG(GDPR/NP16A) + 0.321366268892*(DLOG(ESC_WARE_FTREND(-1))-ESC_WARE_DLBSD(-1))

Eqn 153: D(MA_WARE_DLBSD) = -4.52105880672e-05 + 0.234789455812*D(MA_WARE_DLBSD(-1)) - 0.0108447517006*DLOG(NP16A) + 0.421524185536*(DLOG(MA_WARE_FTREND(-1))-MA_WARE_DLBSD(-1))

Eqn 154: D(MTN_WARE_DLBSD) = -0.00631009312419 + 0.0717410778331*D(MTN_WARE_DLBSD(-1)) + 0.284940869895*DLOG(JQPCMHFE) + 0.27080418353*(DLOG(MTN_WARE_FTREND(-1))-MTN_WARE_DLBSD(-1))

Eqn 155: D(NENG_WARE_DLBSD) = -0.00140552495376 + 0.215126096779*D(NENG_WARE_DLBSD(-1)) + 0.083870269185*DLOG(GDPR/NP16A) + 0.399885422487*(DLOG(NENG_WARE_FTREND(-1))-NENG_WARE_DLBSD(-1))

Eqn 156: D(PAC_WARE_DLBSD) = -0.000861766748144 + 0.466799200652*D(PAC_WARE_DLBSD(-1)) + 0.00219395160839*DLOG(IFNRER/NP16A) + 0.310831300645*(DLOG(PAC_WARE_FTREND(-1))-PAC_WARE_DLBSD(-1))

Eqn 157: D(SATL_WARE_DLBSD) = -0.00142356466277 + 0.465690458518*D(SATL_WARE_DLBSD(-1)) + 0.00611253042312*DLOG(IFNRER/NP16A) + 0.499132746502*(DLOG(SATL_WARE_FTREND(-1))-SATL_WARE_DLBSD(-1))

Eqn 158: D(WNC_WARE_DLBSD) = -0.00521975359574 + 0.138803050681*D(WNC_WARE_DLBSD(-1)) + 0.416431273128*DLOG(NP16A) + 0.445752834344*(DLOG(WNC_WARE_FTREND(-1))-WNC_WARE_DLBSD(-1))

Eqn 159: D(WSC_WARE_DLBSD) = -0.00022371311624 + 0.400913851463*D(WSC_WARE_DLBSD(-1)) + 0.0127799728308*DLOG(IFNRER/NP16A) + 0.282518280442*(DLOG(WSC_WARE_FTREND(-1))-WSC_WARE_DLBSD(-1))

Eqn 160: TOTAL_WARE_DLBSD = 0.17950886 * ENC_WARE_DLBSD + 0.06263526 * ESC_WARE_DLBSD + 0.119819702 * MA_WARE_DLBSD + 0.059237673 * MTN_WARE_DLBSD + 0.035214647 * NENG_WARE_DLBSD + 0.16874443 * PAC_WARE_DLBSD + 0.177854488 * SATL_WARE_DLBSD + 0.077634802 * WNC_WARE_DLBSD + 0.119350138 * WSC_WARE_DLBSD

Census Division Totals

Eqn 161: ENC_TOTAL_DLBSD = 0.036844405 * ENC_AMUSE_DLBSD + 0.050853197 * ENC_AUTO_DLBSD + 0.009408377 * ENC_DORM_DLBSD + 0.103175527 * ENC_EDUC_DLBSD +

0.042632644 * ENC_HEALTH_DLBSD + 0.017717483 * ENC_HOTEL_DLBSD + 0.233521442 * ENC_MFG_DLBSD + 0.013294102 * ENC_MISCNR_DLBSD + 0.15063035 * ENC_OFFICE_DLBSD + 0.013121729 * ENC_PUB_DLBSD + 0.045953184 * ENC_REL_DLBSD + 0.167767869 * ENC_STORES_DLBSD + 0.11507969 * ENC_WARE_DLBSD

Eqn 162: ESC_TOTAL_DLBSD = 0.040417518 * ESC_AMUSE_DLBSD + 0.051698228 * ESC_AUTO_DLBSD + 0.019107618 * ESC_DORM_DLBSD + 0.112505124 * ESC_EDUC_DLBSD + 0.049297607 * ESC_HEALTH_DLBSD + 0.023634695 * ESC_HOTEL_DLBSD + 0.212005319 * ESC_MFG_DLBSD + 0.013315649 * ESC_MISCNR_DLBSD + 0.130669536 * ESC_OFFICE_DLBSD + 0.016991786 * ESC_PUB_DLBSD + 0.055729252 * ESC_REL_DLBSD + 0.153703403 * ESC_STORES_DLBSD + 0.120924265 * ESC_WARE_DLBSD

Eqn 163: MA_TOTAL_DLBSD = 0.040020788 * MA_AMUSE_DLBSD + 0.048623699 * MA_AUTO_DLBSD + 0.011588963 * MA_DORM_DLBSD + 0.11926505 * MA_EDUC_DLBSD + 0.049858354 * MA_HEALTH_DLBSD + 0.021776156 * MA_HOTEL_DLBSD + 0.19621626 * MA_MFG_DLBSD + 0.012039916 * MA_MISCNR_DLBSD + 0.180530719 * MA_OFFICE_DLBSD + 0.015937497 * MA_PUB_DLBSD + 0.052575384 * MA_REL_DLBSD + 0.148664332 * MA_STORES_DLBSD + 0.102902883 * MA_WARE_DLBSD

Eqn 164: MTN_TOTAL_DLBSD = 0.042943366 * MTN_AMUSE_DLBSD + 0.065824214 * MTN_AUTO_DLBSD + 0.019924415 * MTN_DORM_DLBSD + 0.120975187 * MTN_EDUC_DLBSD + 0.038873954 * MTN_HEALTH_DLBSD + 0.056363195 * MTN_HOTEL_DLBSD + 0.101592652 * MTN_MFG_DLBSD + 0.021211195 * MTN_MISCNR_DLBSD + 0.157549338 * MTN_OFFICE_DLBSD + 0.022287221 * MTN_PUB_DLBSD + 0.042278267 * MTN_REL_DLBSD + 0.184301875 * MTN_STORES_DLBSD + 0.125875122 * MTN_WARE_DLBSD

Eqn 165: NENG_TOTAL_DLBSD = 0.037328078 * NENG_AMUSE_DLBSD + 0.057139436 * NENG_AUTO_DLBSD + 0.016427733 * NENG_DORM_DLBSD + 0.122941916 * NENG_EDUC_DLBSD + 0.046330219 * NENG_HEALTH_DLBSD + 0.023203023 * NENG_HOTEL_DLBSD + 0.205329823 * NENG_MFG_DLBSD + 0.009884216 * NENG_MISCNR_DLBSD + 0.183819107 * NENG_OFFICE_DLBSD + 0.016766386 * NENG_PUB_DLBSD + 0.050420219 * NENG_REL_DLBSD + 0.151822858 * NENG_STORES_DLBSD + 0.078586984 * NENG_WARE_DLBSD

Eqn 166: PAC_TOTAL_DLBSD = 0.038750802 * PAC_AMUSE_DLBSD + 0.066585399 * PAC_AUTO_DLBSD + 0.01885492 * PAC_DORM_DLBSD + 0.099216517 * PAC_EDUC_DLBSD + 0.037738144 * PAC_HEALTH_DLBSD + 0.031190101 * PAC_HOTEL_DLBSD + 0.151027225 * PAC_MFG_DLBSD + 0.019865965 * PAC_MISCNR_DLBSD + 0.177561752 * PAC_OFFICE_DLBSD + 0.017620708 * PAC_PUB_DLBSD + 0.031560106 * PAC_REL_DLBSD + 0.166489772 * PAC_STORES_DLBSD + 0.143538589 * PAC_WARE_DLBSD

Eqn 167: SATL_TOTAL_DLBSD = 0.040138222 * SATL_AMUSE_DLBSD + 0.061969539 * SATL_AUTO_DLBSD + 0.018256288 * SATL_DORM_DLBSD + 0.110969624 * SATL_EDUC_DLBSD + 0.04523952 * SATL_HEALTH_DLBSD + 0.035796236 * SATL_HOTEL_DLBSD + 0.155628361 * SATL_MFG_DLBSD + 0.016959722 * SATL_MISCNR_DLBSD + 0.163890167 * SATL_OFFICE_DLBSD +

0.020148077 * SATL_PUB_DLBSD + 0.042551525 * SATL_REL_DLBSD + 0.166667276 * SATL_STORES_DLBSD + 0.121785442 * SATL_WARE_DLBSD

Eqn 168: WNC_TOTAL_DLBSD = 0.04035799 * WNC_AMUSE_DLBSD + 0.059514595 * WNC_AUTO_DLBSD + 0.014240526 * WNC_DORM_DLBSD + 0.110614864 * WNC_EDUC_DLBSD + 0.051925268 * WNC_HEALTH_DLBSD + 0.024173282 * WNC_HOTEL_DLBSD + 0.170644109 * WNC_MFG_DLBSD + 0.013955833 * WNC_MISCNR_DLBSD + 0.154125762 * WNC_OFFICE_DLBSD + 0.016890665 * WNC_PUB_DLBSD + 0.055106133 * WNC_REL_DLBSD + 0.164089005 * WNC_STORES_DLBSD + 0.124361968 * WNC_WARE_DLBSD

Eqn 169: WSC_TOTAL_DLBSD = 0.041515462 * WSC_AMUSE_DLBSD + 0.062121329 * WSC_AUTO_DLBSD + 0.01633049 * WSC_DORM_DLBSD + 0.119392701 * WSC_EDUC_DLBSD + 0.04652586 * WSC_HEALTH_DLBSD + 0.026828149 * WSC_HOTEL_DLBSD + 0.131612547 * WSC_MFG_DLBSD + 0.015417145 * WSC_MISCNR_DLBSD + 0.165730625 * WSC_OFFICE_DLBSD + 0.01751435 * WSC_PUB_DLBSD + 0.053485703 * WSC_REL_DLBSD + 0.169883048 * WSC_STORES_DLBSD + 0.133642591 * WSC_WARE_DLBSD

Eqn 170: TOTAL_TOTAL_DLBSD = 0.187613478 * ENC_TOTAL_DLBSD + 0.062299169 * ESC_TOTAL_DLBSD + 0.140048197 * MA_TOTAL_DLBSD + 0.056602409 * MTN_TOTAL_DLBSD + 0.053895133 * NENG_TOTAL_DLBSD + 0.141396156 * PAC_TOTAL_DLBSD + 0.175649242 * SATL_TOTAL_DLBSD + 0.075083705 * WNC_TOTAL_DLBSD + 0.107412511 * WSC_TOTAL_DLBSD

Appendix C3: Regional Industrial Output and Employment Models

Regional Industrial Output Model

Endogenous variables:

REV{I}_{R} Output in billions of real 2009 dollars for sector I, region R (e.g. REVIND1_ENC)

Codes and descriptions of the sectors are presented in Table A14. Codes and descriptions of the regions are in Table B6.

Exogenous variables:

{R}_{I}_outsh Share of sector I in region R

Equations:

REV{I}_{R} = REV{I}_national * {R}_{I}_outsh

where

REV{I}_{R} = Output for sector I, region R

REV{I}_national = Output for sector I (national)

{R}_{I}_outsh = Share of sector I in region R

Regional employment model

Endogenous variables:

EMP{I}_{R} Employment in millions for sector I, region R (e.g. EMPIND1_ENC)

Codes and descriptions of the sectors are presented in Table A14. Codes and descriptions of the regions are in Table B6.

Exogenous variables:

{R}_{I}_empsh Share of sector I in region R

Equations:

EMP{I}_{R} = EMP{I}_national*{R}_{I}_empsh

where

EMP{I}_{R} = Employment for sector I, region R

EMP{I}_national = Employment for sector I (national)

{R}_{I}_empsh = Share of sector I in region R