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Moody's Economy.com U.S. Macroeconomic Model

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Charts & Tables

U.S. Macro Model System

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Moody's Economy.com produces projections of the U.S. economy and financial markets each month using a large scale econometric model system. This article describes this model system, providing a sense of its theoretical underpinnings and the empirical results for its key sectors and equations.

In the broadest terms, the model system is specified to reflect the interaction between aggregate demand and supply. In the short run, fluctuations in economic activity are primarily determined by shifts in aggregate demand, including personal consumption, gross private investment, net exports, and government expenditures. The level of resources and technology available for production is taken as given. Prices and wages adjust slowly to equate aggregate demand and supply. In the longer term, changes in aggregate supply determine the economy's growth potential. The rate of expansion of the resource and technology base of the economy is the principal determinant of economic growth.

Personal consumption. Consumer spending is disaggregated in the model system into various durable goods categories, nondurable goods, and services.

Real consumption for each spending category is generally modeled as a function of real household cash flow, housing wealth, and financial wealth (see Appendix 1). Household cash flow equals the sum of personal disposable income, capital gain realizations on the sale of financial assets, and net new borrowing (see Chart 1). The growth in household cash flow has substantially outpaced that of disposable income in recent years, due principally to the surge in mortgage equity withdrawal from both increased capital gain realizations on housing and mortgage borrowing (see Chart 2).

This is in contrast to other models in which consumer spending is driven only by personal disposable income. Econometric evidence strongly indicates that it is easier to explain the robust consumer spending of recent years by growth in household cash flow than by disposable income growth alone. That is, cash flow enters into the consumption equations with a higher level of explanatory power and more statistical significance than disposable income, and the historical fit of the equation with cash flow is also measurably stronger (see Appendix 2).

Using cash flow instead of income in the consumption functions adds an additional two cents to the measured wealth effects. That is, simulating the model system with consumption functions modeled using only income yields a housing wealth effect of seven cents; every $1 dollar increase ultimately results in a seven cent increase in consumer spending. Simulating the model system with consumption functions modeled using cash flow, however, yields a housing wealth effect of nine cents.

This model system also provides an explicit accounting of the different wealth effects resulting from changes in housing and financial wealth. The elasticity of consumption with respect to housing wealth is substantially greater than that for financial assets in each of the equations. In the equation for nondurable consumer spending, for example, the measured housing wealth effect is 12 cents, while the wealth effect on financial assets is only three cents. Changing housing wealth has a more powerful wealth effect due to the much broader and deeper ownership of homes than stocks, and to the lower volatility of house prices, which makes households more comfortable changing their spending behavior in response to them.

This is not to say that wage and other types of income are emphasized less in this model than in other models. Indeed, the marginal propensity to consume out of wage and other income is very similar to those found in other models. Moreover, that only household cash flow and wealth terms appear on the right hand side of the consumption functions in this model does not mean that interest rates and confidence, for example do not figure into consumer spending. They do, but only indirectly through the cost of consumer credit borrowing and the cost of financing home equity withdrawal, as well as consumers' confidence and, hence, willingness to take on debt (see Appendix 3).

In addition to the other consumer spending categories, factors particular to the automobile market also have a significant influence on automobile purchases, so they are treated separately within the broader framework of consumer durable purchases. Vehicle sales form a crucial cyclical component of consumer demand, as motor vehicles and parts account for nearly one half of total durable goods consumption. Unit vehicle sales are modeled using household cash flow, household wealth, the relative price of new and used vehicles, gasoline prices and several dummy variables to account for the particularly aggressive use of sales incentives at different times since the mid-1980s, when such incentives were first introduced (see Appendix 4).

Business investment. Gross private investment is broadly disaggregated in the model system into residential investment, fixed business investment and inventory investment.

Chart 1: Where Does All the Extra Cash Come from?
$ bil, real

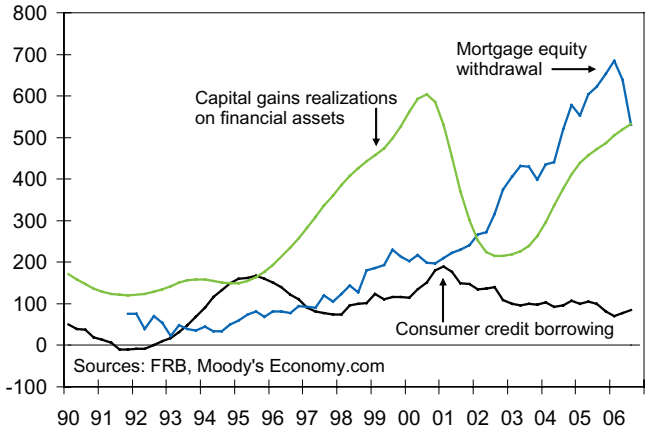
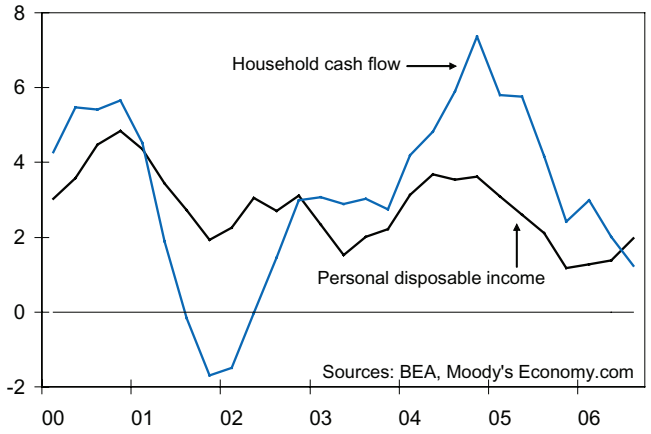


Chart 2: Real Household Cash Flow Outpaces Income
% change year ago, 4 qtr. MA



Fixed investment is further divided into four categories of producers' durable equipment, and nine categories of nonresidential structures. Inventory investment is divided into farm and nonfarm inventory investment. On the demand side, investment is a critical determinant of the business cycle because it responds to, and therefore amplifies, shifts in output. Investment also influences the supply side of the economy since it is the principal determinant of potential output and labor productivity in the long run. Investment spending not only adds to the stock of capital available per worker, but also determines the extent to which the capital stock embodies the latest and most efficient technology.

The specification of the investment equations is based on the neoclassical investment theory of the firm. Following this approach, net investment is modeled as a function of changes in expected output and the cost of capital. The cost of capital is equal to the implicit cost of leasing a capital asset, and therefore reflects the real after-tax cost of funds, tax and depreciation laws, and the price of the asset. More explicitly, the cost of funds is defined as the after-tax cost of debt capital times the debt share of asset financing plus the cost of equity capital times the equity share of asset financing. The cost of debt capital is proxied by the BAA corporate bond yield and the cost of equity capital is assumed to be the ten-year Treasury bond yield plus an exogenously set equity risk premium (see Chart 3).

Although most theoretical analyses assume that businesses do not face constraints on investment funds, in practice there are limits to the availability of credit. Corporate cash flow and debt levels are, therefore, also important determinants in the investment equations.

Additional drivers important to the different categories of investment are also included in the equations. Investment in industrial equipment, for example, is also driven by capacity utilization, and investment in transportation equipment is driven by vehicle sales to account for vehicle purchases by vehicle lessors (see Appendix 5).

Inventory investment is divided into farm and nonfarm inventories. Nonfarm inventory change is further divided into construction and mining, manufacturing, wholesale, and retail inventories. Inventory investment is equal to a fraction of the difference between the desired stock of inventories and actual stocks in the previous period; the desired stock, in turn, depends on sales and the cost of carrying inventories proxied by a short-term interest rate (see Appendix 6).

International trade. Given the rapid growth of global trade over the quarter century and its importance in influencing domestic economic activity, the international trade sector of the model system is particularly important. The trade sector captures the interactions between foreign and domestic prices, interest rates, exchange rates, and product flows. Export prices and volumes are determined by stochastic equations, while nominal trade flows are calculated as identities. The key determinants of export volumes are global real GDP growth and the real trade-weighted value of the U.S. dollar (see Appendix 7). Real imports are determined by specific domestic spending categories and relative prices (see Appendix 8). Global real GDP growth is determined in the Moody's Economy.com international model system and is provided exogenously in this model system. The value of the dollar is determined endogenously based on relative U.S. and global interest rates, global growth, and the U.S. current account deficit.

Government spending. Federal government policies are treated as partially exogenous in the model since legislative and administrative decisions are generally not predictable responses to macroeconomic conditions. Federal

Chart 3: The Weighted Average Cost of Capital
%

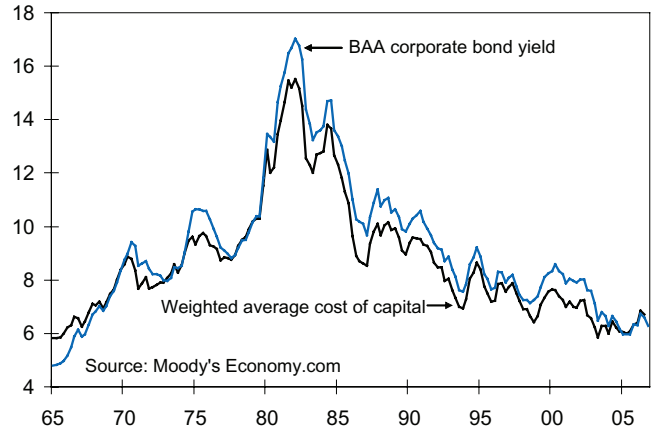
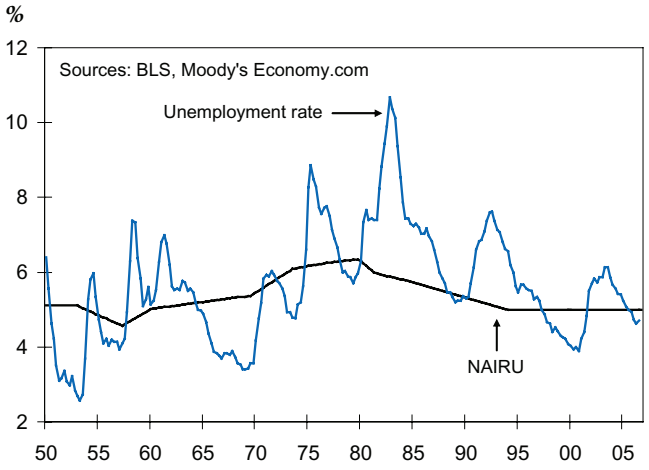


Chart 4: Beyond Full Employment



spending may be disaggregated in several different ways. At its most basic level, federal spending is the sum of consumption and investment expenditures. These two categories are, in turn, subdivided into defense and nondefense categories. Defense and nondefense consumption expenditures are each the sum of compensation and non-compensation purchases.

Total federal government outlays are the sum of defense and nondefense consumption expenditures plus transfer payments, net interest payments, subsidies less current surplus of government enterprises, federal grants to state and local government, less wage accruals net of disbursements. All outlays are exogenous except for transfer payments, which are a function of unemployment insurance payments, and net interest payments, which are a function of interest rates and the publicly-held Treasury debt.

Total federal government receipts are the sum of personal tax receipts, contributions for social insurance, corporate profits tax receipts, and indirect tax receipts. Personal taxes account for the bulk of federal tax collections, comprising nearly one-half of total receipts. Personal tax receipts are equal to the product of the average effective income tax rate and the tax base. The tax base is defined as personal income less nontaxable components of income including other labor income and government transfers. The average effective tax rates are exogenous and form a key policy lever in the model. The federal budget deficit is measured both on a NIPA and on a unified basis.

The state and local government sector is modeled similarly to the federal sector. Revenues are a function of exogenous average effective tax rates and their corresponding national income categories, plus federal aid. Expenditures for all but net interest costs are exogenously determined.

Aggregate supply. The supply side of the economy describes the economy's capabilities for producing output. In this model system, aggregate supply or potential GDP is estimated from a Cobb-Douglas production function that combines factor input growth and improvements in total labor productivity. Factor inputs include labor and business fixed capital. Factor supplies are defined by an estimate of the full-employment labor force and by the existing capital stock of private nonresidential equipment and structures. Total factor productivity is calculated as the residual from the Cobb-Douglas production function estimated at full employment. Potential total factor productivity is derived from a regression of actual TFP on business-cycle specific trend variables.

The key unknown in estimating aggregate supply is determining the full employment level of labor. This level is derived from a measure of potential labor supply and a measure of the long-run equilibrium unemployment rate. This rate, often referred to as the Non-Accelerating Inflation Rate of Unemployment, or NAIRU, is the unemployment rate consistent with steady price and wage inflation. It is also the unemployment rate at which actual GDP equals potential GDP.

Estimation of the NAIRU proceeds with the estimation of an expectations-augmented Phillips curve relationship between inflation and unemployment. The inflation measure used is the chain price index for personal consumption expenditures excluding food and energy. The NAIRU estimated in this Phillips curve is the married male NAIRU. This group is chosen because they are expected to have the greatest attachment to the labor market, and thus be less susceptible to changes in labor force participation than other groups who may be affected more by changing demographic composition, changed work habits, or reduced discrimination, to name several possible factors that drive labor force participation. This stability allows us to estimate a married male NAIRU that is constant over time. Married female and unmarried NAIRU's are derived via regression from the married male NAIRU. These individual NAIRU's are demographically weighted to arrive at an overall NAIRU (see Chart 4). NAIRU is currently estimated to be near 5%.

The growth of aggregate supply is the fundamental constraint on the long-term growth of aggregate demand. When actual GDP is above potential GDP, there is a positive output gap. Given the current 4.5% unemployment rate, the economy is operating just above its potential and there is a small positive output gap. Inflation created by demand that approaches or surpasses potential GDP (a positive output gap) raises credit costs and weakens consumer confidence, thus constraining aggregate demand when the economy is overheating. Conversely, lower inflation and easier credit stimulate demand when economic conditions are slack. Thus, output and employment gaps form the key determinants of prices in the model system, as price movements become the mechanism for restoring the full-employment level of output.

An increase in government spending, for example, narrows the output gap, driving up output prices and lowering the unemployment rate. Higher prices and a tighter labor market then force up wage rates, further igniting inflation, although this effect is partially offset by an increase in labor productivity. Higher inflation and a stronger real economy drive up interest rates and reduce real income gains. The net effect is a dampening of aggregate demand to bring it back in line with aggregate supply.

Inflation. Core consumer prices, excluding energy and food CPI, are the key inflation variable in the model system. Long-term inflation expectations are also important in influencing monetary policy and Treasury bond yields.

Chart 5: Inflation Expectations—Now and Then...
Inflation expectations, %

Core CPI is further broken down into core services and core goods. Core consumer services CPI is largely determined by unit labor costs in the services sector. This reflects the dynamic that firms' pricing decisions are significantly affected by the changing costs of their inputs, the most important being labor. Hence, the behavior of labor costs is a major determinant of the price adjustment process. The compensation equations in the model system are based on an expectations-augmented Phillips curve, where compensation reacts to expected inflation and the gap between unemployment and NAIRU. The deviation of GDP from its potential thus impacts inflation through its affect on compensation growth.

The unit labor cost measure used in this model system combines hourly compensation measures from the employment cost index with productivity and costs. Because the employment cost index's compensation measure excludes volatile stock-options compensation, it is a less volatile compensation measure than hourly compensation as measured in productivity and costs. Consequently, the resulting unit labor cost measure is also less volatile than unit labor costs as reported in productivity and costs, and hence, yields more reliable equations for inflation forecasting purposes.

Core consumer goods prices are also driven by unit labor costs in the goods sector, costs of energy and other commodities, and non-energy import prices. Energy and other commodity prices are principally determined by oil prices and the CRB commodity spot price index, both of which are derived from the Moody's Economy.com industry service and are provided exogenously to this model system. Import prices are, in turn, largely determined by the real trade-weighted value of the U.S. dollar.

It is important to note that the pass-through of changing energy prices to underlying core inflation has seemingly become measurably less pronounced than has been the case historically. This is largely reflected in the model system by the declining share of overall core CPI accounted for by core goods prices.

Core energy and food consumer prices are most fundamentally driven by the price of oil and agricultural prices, which again are determined by the Moody's Economy.com industry service and provided exogenously to this model system.

Long-term inflation expectations are derived from the Treasury Inflation Protected securities market. Five-year, five-year forward yields are used, measuring expected total CPI inflation in the five-year period beginning five years from now. These TIP yields are not influenced by short-term factors such as fluctuations in oil prices that affect other TIP yields. Since the TIP market is only several years old, ten-year expected CPI inflation forecasts from the Philadelphia Federal Reserve survey of economists is used to measure inflation expectations back to 1980 (see Chart 5).

Inflation expectations are modeled to be adaptively formed as a three-year moving average of actual inflation. Expectations have, at times, historically not conformed with this simplistic view, but not often, and not for very long. Model users do have the ability to simulate the model system based on other assumptions regarding how inflation expectations are formed.

Monetary policy. The thrust of monetary policy is captured in the model system through equations for the federal funds rate target, money supply and bank reserves.

The key short-term rate in the model system is the federal funds rate. The federal funds rate equation was estimated over the period beginning in late 1987. This period coincides with Alan Greenspan's and Ben Bernanke's tenures as Fed Chairman. Prior to this period, monetary policy was much less transparent, and for a time during the late 1970s and early 1980s, was based on targeting money supply growth.

The funds rate equation is based on a FOMC reaction function derived using a modified Taylor's rule specification. In this framework, the federal funds rate target is modeled as a function of the economy's estimated potential growth, the difference between inflation expectations and the target inflation rate, and the difference between the actual unemployment rate and NAIRU (see Appendix 9). This specification is based on a modified Taylor's rule as inflation expectations and not actual inflation is included in the equation. Other variables thought to be at times in policymakers' reaction function, such as the value of the dollar and oil prices, were not found to be important explanatory variables.

Potential nominal GDP growth is a proxy for the so-called neutral federal funds rate. At the neutral rate, monetary policy is neither stimulating nor restraining economic growth. The FOMC will set the actual funds rate target relative to the neutral rate depending on where inflation expectations are relative to their inflation target and where the unemployment rate is relative to the natural rate of unemployment. At the current time, the funds rate derived from this equation is very close to the actual funds rate target of 5.25%. This is just above the economy's 4.75% estimated potential GDP growth as the current unemployment rate of 4.6% is just below estimated NAIRU of closer to 5%. Inflation expectations as measured by the five-year, five-year forward TIP yields are within policymakers' inflation target.

Policymakers do not immediately adjust the funds rate target to changes in potential growth, inflation expectations and unemployment. According to the estimation results, it takes the FOMC just over one year to fully adjust to a change in these variables. The FOMC appears a bit more aggressive in responding to large changes in unemployment than to

changes in inflation expectations. This reflects the average response over the past nearly 20 years of the estimation period, however, as there is evidence that policymakers have become increasingly more sensitive to changes in inflation expectations in recent years.

The money demand equations are derived from portfolio theory, in which the demand for cash depends on personal income and the opportunity cost of holding liquid assets relative to other interest-earning instruments. Money is not a single asset, but rather a group of asset categories with varying degrees of liquidity. At one extreme is currency, which can be exchanged directly for assets, and at the other extreme are long-term certificates of deposit. Required reserves are determined by the components of money demand and the required ratio, which is determined by Federal Reserve policymakers and thus set exogenously in the model system.

Financial markets. The yield on the ten-year Treasury bond is the key long-term interest rate in the model system. The federal funds rate and ten-year Treasury yield determine the rest of the term structure of interest rates.

The ten-year Treasury yield is modeled as a function of the federal funds rate, inflation expectations, the difference between the unemployment rate and the natural rate, the current account deficit as a share of GDP, the federal budget deficit as a share of GDP, and inflation volatility (see Appendix 10).

In broad terms, the policy yield curve, which measures the difference between ten-year Treasury yields and the federal funds rate target, is modeled in this specification. The link between the funds rate and ten-year Treasury yields is a loose one, as a percentage point change in the funds rate results in an estimated only 15 basis point change in ten-year yields. Changes in the ten-year yield independent of changes in the current funds rate target are determined in part by bond investors' expectations of future monetary policy. These expectations are, in turn, assumed to be driven by current inflation expectations and the difference between the unemployment rate and NAIRU. Rising inflation expectations and falling unemployment, for example, will generally eventually prompt monetary tightening, thus inducing investors to sell bonds, sending long-term yields higher.

Bond investors' expectations regarding the federal government's future fiscal situation also influence their buying and selling of bonds today. Every percentage point increase in the federal debt to GDP ratio adds approximately four basis points to ten-year Treasury yields.

Rapidly expanding global investor demand for Treasury bonds has also been very important in determining long-term bond yields in recent years. Foreign ownership of publicly-traded Treasury debt has risen from less than one-third to nearly one-half in this decade alone. The U.S. current account deficit as a share of GDP is included in the ten-year Treasury yield equation to proxy for this global demand. For more than a decade, the widening current account deficit has provided global investors with greater financial resources to invest in the Treasury market, thus weighing on long-term yields. Every percentage point increase in the current account deficit to GDP ratio lifts long-term yields by just over ten basis points. This suggests that the widening in the current account deficit since early in the decade has pushed ten-year yields some 75 basis points below what they otherwise would be.

Long-term interest rates have also fallen in recent years due to a narrowing in the term premium; the difference between long-term and short-term rates needed to compensate investors for the added risks of making a long-term investment. Those risks are largely centered around the possibility for large swings in future inflation. Inflation volatility, equal to the standard deviation of a ten-year moving average of total CPI inflation, is included in the specification to capture this factor. Inflation volatility is treated exogenously in the model system.

Stock prices as measured by the S&P 500 are the principal measure of conditions in the equity market. The S&P 500 equation has been estimated over the past nearly half century based on a traditional corporate earnings discount model of stock price determination adjusted to account for an apparent narrowing in the equity risk premium. The principal determinants of stock prices in this model are economy-wide corporate profits, the yield on the ten-year Treasury bond, and the share of the population in their late 40s and 50s.

The share of the population in their late 40s and 50s has a significant impact on the equity risk premium as this age cohort is in its prime earning and saving years, and thus, has more ample financial resources and, thus, lower risk aversion. If the share of the population in their late 40s and 50s is rising, as it has been for the better part of the past decade, then the equity risk premium should narrow. This demographic support to stock market valuations will remain in place for much of the next decade, after which the bulk of the baby boom generation will age into its 60s and its liquidity needs will increase.

Labor market. Payroll employment, household employment, the labor force, the number of unemployed, and the rate of unemployment are determined in the labor market sector.

Private payroll employment is modeled from both the top-down and bottom-up. From the top-down, total private employment is derived as a function of labor hours demanded, which in turn is a function of GDP. In the long run, aggregate labor hours demanded by business is a function of output and labor productivity. Long-term trends in labor productivity are represented by three time trends, which account for the slowdown in productivity post-1973 and the subsequent re-acceleration in productivity post-1995 (see Appendix 11). Hours adjust to their long-run trend after a shock in just about six quarters in this specification. Total payrolls are a function of hours worked.

In the bottom-up approach, payroll employment is also modeled separately at the supersector NAICS level, and the three-digit NAICS level for manufacturing. To properly examine industry-specific employment impacts attributed to changes in aggregate demand, the model system incorporates data from the BEA's 2005 national input-output accounts. These data are used to generate quarterly estimates of gross product originating by industry, which in turn drives employment (see Appendix 12 for an example for the mining industry).

To ensure consistency between the top-down and bottom-up approaches, employment by industry derived from the bottom-up is divided by the sum of all the industry employment estimates derived from the bottom-up. This share is then applied to total private employment estimated from the top-down. Thus, relative industry employment shifts

occur, even though the actual industry employment levels are squeezed to equal the change in the top-down derived payroll employment.

Household employment is modeled as a function of total payroll employment. The two measures of employment can vary over the business cycle, given changes in the number of people holding multiple jobs and the number of self-employed. The labor force is determined by the ratio of employment to population, real hourly compensation and the rate of unemployment. The rate of labor force participation is determined as an identity (see Appendix 13). The number of unemployed and the unemployment rate are determined as identities from the household employment and labor force projections.

Income and profits. While the income side of the National Income and Product accounts is not as carefully followed as the demand side of the accounts, it is this side of the NIPA that makes macroeconomic models truly general equilibrium models. One household's spending is income to another household, while income generated by production is a constraint on final demand. Moreover, the distribution of income among households, businesses, and government has significant effects on the composition of output and on the dynamics of the business cycle.

Personal income is the sum of eight income components. Wages and salaries, the largest income category, is divided into mining, construction, manufacturing and service producing categories. As with employment, wages and salaries are modeled using a top-down and bottom-up approach. Total wages and salaries are modeled as a function of employment, average hours and average hourly earnings (see Appendix 14). From the bottom-up, wages and salaries for each industry are modeled as a function of industry employment, industry average hourly earnings and a broad measure of hours worked (see Appendix 15 for an example for the mining industry). The intermediate values of wages and salaries by industry are then divided by the sum of all the intermediate wage and salary estimates. This share is then applied to total wages and salaries estimated from the top-down. Changes in industry employment and wages thus affect the distribution of wages and salaries across all industries, but not total wages and salaries.

Other labor income is estimated as a function of wages and salaries. To reflect the rapid growth in this category of income over the past quarter century due to rising medical costs and non-wage benefits, a variable representing the national ratio of other labor income to total wages and salaries is added as an explanatory variable in the equation. Contributions for social insurance are also a function of wages and salaries. Interest income is modeled as a function of a weighted average of short- and long-term interest rates. Dividend income is a function of corporate profits. Rental income is driven by the rental CPI and a mortgage rate; the rental CPI captures the implicit rental return to homeowners for owning their own home and the mortgage rate represents the cost associated with making mortgage payments. Proprietors' income is derived from retail sales growth, while transfer payments are a function primarily of unemployment insurance claims.

Corporate profits are determined by the product of sales and corporate profit margins. Sales are, in turn, determined by GDP, and margins by core CPI inflation, unit labor costs, and energy and interest expenses (see Appendix 16). Corporate cash flow is determined by subtracting dividends and corporate tax payments from corporate profits and adding back depreciation allowances.

Housing sector. Within the housing sector of the model system are equations for single-family and multifamily housing permits and starts, existing and new home sales, existing and new median house prices, purchase and refinance mortgage originations, and manufactured housing placements.

In the long run, abstracting from the vagaries of the business cycle, the level of new housing construction is closely linked to the number of household formations. Simply put, if a household is formed, it must live somewhere. Obsolescence of the housing stock and second and vacation home demand also impact new housing construction. Construction in the short term is also influenced by a range of factors influencing new housing demand, including employment growth and the cost and availability of mortgage credit. Housing affordability determines the tenure choice of households between single-family and multifamily homes and manufactured housing units.

The key house-price variable in the model system is the median existing house price from the National Association of Realtors. The OFHEO house price index is also modeled as a lagged function of the median existing price. The median house price equation is specified as a function of factors that influence both the demand for and supply of homes. The demand for homes depends on real income per household, the jobless rate, the number and age of households, real after-tax borrowing costs, and the rental vacancy rate. Real income per household is a determinant of both the ability and willingness of households to purchase a home. Rising income levels will result in increased homebuying activity. The jobless rate is included in the equations as a proxy for consumer confidence. If consumer confidence is low, homebuying will remain lackluster, even if income growth is sturdy. The demographic variable is important because households have different levels of demand for housing services depending on their age. Younger households, for example, are more likely to rent, while older households have already purchased a home and are less likely to move. Finally, the rental vacancy rate is included in the equations to account for the rent/buy decision. A falling vacancy rate generally results in rising rents, and thus makes purchasing a single-family home more attractive.

The supply of homes depends on the housing supply-demand balance, a measure of credit availability, and the cost of construction materials. The housing supply-demand balance is based on the number of starts and the number of new household formations. Over time, the level of housing permits issued will closely follow the number of new household formations, abstracting from demolitions. Credit availability is also important given the reluctance of lenders to make construction and land development loans. The result in many markets has been a lack of development, which should also help to support stronger house-price gains in the future.

Estimates of purchase and refi originations are constructed based on data obtained through the Home Mortgage Disclosure Act. Purchase mortgage originations are modeled as a function of existing home sales, single-family permit issuance, median existing home prices, and

loan-to-value ratios. Refinance originations are modeled as a function of current mortgage rates and the average mortgage rate over the past five years, the average duration of mortgage loans outstanding, and mortgage transaction costs, which are exogenous to the model system.

Credit quality. The model system includes a wide array of consumer and mortgage credit quality variables. These include consumer delinquency rates based on dollar volume and number of loans and auto repossession rates from the American Bankers Association, mortgage delinquency and foreclosure rates from the Mortgage Bankers Association, household debt service burdens and financial obligation ratios, and personal and business bankruptcies by chapter of bankruptcy.

Consumer delinquency rates for auto, credit card, home equity, manufactured housing, and personal and student loans are driven by a similar set of variables, including real personal income, the household financial obligations ratio, the mortgage loan-to-value ratio, and house and vehicle prices. Weaker real income gains and rising financial obligations result in increased delinquency (see Appendix 17). The mortgage loan-to-value ratio is intended to capture broad changes in lenders' underwriting standards. Rising LTVs signal that lenders are growing more aggressive in extending credit, ultimately resulting in increased credit problems. Real house-price growth is also included to capture the ability and willingness of households to extract equity from their homes, which in recent years has been used to repay consumer installment debt and has thus mitigated credit problems. The growth in used vehicle prices, as measured by Manheim, is also included in the auto delinquency equations to proxy for the equity borrowers have in their vehicles.

Mortgage delinquency rates are modeled based on the growth in income and house prices, the financial obligations ratio for homeowners, and the mortgage loan-to-value ratio (see Appendix 18). Income growth and the financial obligations ratio reflect the ability of homeowners to meet their mortgage payments, while house-price growth captures changes in homeowners' equity. The mortgage delinquency rate for subprime mortgage loans also includes the ratio of average and median household incomes—if median incomes are growing slower than average incomes, the subprime segment of the mortgage market is presumably doing less well and delinquencies are likely to be higher. Mortgage foreclosures are modeled as a function of a distributed lag on mortgage delinquency rates.

Conclusions. This article provides a broad overview of the current state of the Moody's Economy.com macro model system. The system is undergoing continual revisions and adjustments to reflect new and changing data, recent macroeconomic theory, new econometric techniques, and increased computing power. The model system has also been changing to accommodate increased demand by users to use the model system as a tool for generating alternative scenarios and understanding the sensitivity of the macroeconomy to fast-changing economic and financial conditions. This article will be also be updated on a more regular basis to reflect the accelerated pace of these changes.

Appendix 1: Consumption Functions

Consumer Spending on Durables ex Vehicles and Furnishings

Quarterly Data from 1990Q2 2006Q3
R Bar Squared = 0.245
Durbin-Watson Statistic = 1.468

Dependent Variable: dlog(Other durables consumption per adult)

	Coefficient	**t-Statistic**
Constant	0.005	2.63
dlog(Real household cash flow per adult, 2 quarter moving average)	0.401	1.94
dlog(Real estate net worth per adult, 2 quarter moving average)	0.206	1.64
dlog(Financial asset net worth per adult, 2 quarter moving average)	0.159	2.32

Consumer Spending on Nondurables

Quarterly Data from 1985Q3 2006Q3
R Bar Squared = 0.335
Durbin-Watson Statistic = 2.462

Dependent Variable: dlog(Nondurables consumption per adult)

	Coefficient	**t-Statistic**
Constant	0.002	2.94
dlog(Real household cash flow per adult, 2 quarter moving average)	0.251	3.92
dlog(Real estate net worth per adult, 2 quarter moving average)	0.120	3.09
dlog(Financial asset net worth per adult, 2 quarter moving average)	0.031	1.48

Consumer Spending on Services

Quarterly Data from 1991Q1 2006Q3
R Bar Squared = 0.320
Durbin-Watson Statistic = 2.008

Dependent Variable: dlog(Services consumption per adult)

	Coefficient	**t-Statistic**
Constant	0.003	6.45
dlog(Real household cash flow per adult, 3 quarter moving average)	0.119	2.11
dlog(Real estate net worth per adult, 3 quarter moving average)	0.048	1.69
dlog(Financial asset net worth per adult, 3 quarter moving average)	0.047	2.75

Note:

(1) Household cash flow includes personal disposable income and cash proceeds from capital gains realizations on stocks, MEW and consumer credit borrowing

(2) Adult population is defined as population 16-years and older

(3) dlog stands for log difference

Appendix 2: Mortgage Equity Withdrawal Matters

Comparing estimated consumption functions using cashflow and disposable income

		Disposable Cashflow	Disposable Income	Housing Wealth	Non-Housing Wealth	Adjusted R Squared
Nondurable Consumption						
	Cashflow	0.25	-	0.12	0.03	0.31
		(3.9)		(3.1)	(1.5)	
	Disposable Income	-	0.28	0.14	0.05	0.24
			(2.5)	(3.5)	(2.5)	
Service Consumption						
	Cashflow	0.12	-	0.05	0.05	0.28
		(2.1)		(1.7)	(2.8)	
	Disposable Income	-	0.12	0.05	0.06	0.26
			(1.5)	(1.7)	(3.6)	
Other Durable Consumption						
	Cashflow	0.4	-	0.21	0.16	0.21
		(1.9)		(1.7)	(2.3)	
	Disposable Income	-	0.48	0.24	0.29	0.18
			(1.4)	(1.9)	(2.9)	

Notes:

(1) log-Difference, per capita, real $ specifications

(2) Estimations are performed from 1991Q1 to 2005Q1 to conform with the availability of MEW historical data.

(3) Only the results for the cashflow, income, and wealth terms are shown.

(4) t-statistics in paranthesis.

(5) Other durable consumption includes everything from books to pleasure boats.

Appendix 3: Other Cash Flow

Quarterly Data from 1990Q1 2005Q3

R Bar Squared = 0.841

Durbin-Watson Statistic = 2.057

Dependent Variable: log(Other cash flow of households)

	Coefficient	t-Statistic
Constant	-3.413	-1.23
log(Real median house prices, 6 quarter moving average)	0.937	1.67
log(Real SP500 index, 6 quarter moving average)	0.360	1.72
log(Consumer confidence)	0.834	3.82
Real 10-year Treasury yield	-0.200	-3.54

Note:

Other cash flow includes cash proceeds from capital gains realizations on stocks, MEW and consumer credit borrowing. Other cash flow and personal disposable income together give household cash flow.

Appendix 4: Vehicle Sales

Quarterly Data from 1991Q1 2005Q3
R Bar Squared = 0.748
Durbin-Watson Statistic = 1.322

Dependent Variable: log(Vehicle sales per adult)

	Coefficient	t-Statistic
Constant	-3.757	-21.63
Dummy variable for incentives driven sales spurts in 00Q1, 01Q4, 05Q3	0.075	3.33
log(Household cash flow per adult, 3 quarter moving average)	0.227	1.22
log(Total net worth per adult, 3 quarter moving average)	0.128	1.11
log(Core CPI/Used vehicles prices)	-0.461	-4.86
log(Gasoline prices)	-0.073	-1.66

Appendix 5: Nonresidential Fixed Investment

Quarterly Data from 1990Q3 2000Q4
R Bar Squared = 0.218
Durbin-Watson Statistic = 1.942

Dependent Variable: dlog(Fixed investment, industrial equipment)

	Coefficient	t-Statistic
Constant	-0.086	-0.31
Weighted average cost of capital (WACC), 40 quarter moving average	-0.007	-1.23
dlog(Price of industrial equipment/Hourly earnings in manufacturing, lagged 1 quarter)	-0.465	-1.01
dlog(Real trade weighted dollar, 12 quarter moving average)	-1.648	-2.16
Capacity utilization in manufacturing, 4 quarter moving average	0.002	0.59
dlog(Real consumption growth)	1.337	1.76

Note:
(1) WACC stands for the weighted average cost of capital. WACC is defined as the after tax cost of debt capital times the debt share of asset financing plus the cost of equity capital times the equity share of asset financing. The after-tax cost of debt capital is the BAA corporate yield times one minus the effective corporate tax rate and the cost of equity capital is the 10-yr. Treasury yield plus a 3% equity risk premium.

Appendix 6: Real Inventory Investment

Quarterly Data from 1952:4 to 2003:1
R Bar Squared = 0.216
Durbin-Watson Statistic = 0.802

Dependent variable: Real inventory investment

	Coefficient	T-Statistic
Constant	135.437	3.45
(Real stock of inventories, lagged 1 quarter)/(Real final sales, lagged 1 quarter)	-745.040	-3.28
dlog(Real final sales)	47.903	0.20
dlog(Real final sales, lagged 1 quarter)	656.603	2.66
dlog(Real final sales, lagged 2 quarters)	992.548	4.18

Note:
(1) Final sales are GDP less the change in inventories.

Appendix 7: Real Exports of Goods

Quarterly Data from 1987:2 to 2003:2
R Bar Squared = 0.101
Durbin-Watson Statistic = 1.709

Dependent variable: dlog(Real exports of goods)

	Coefficient	T-Statistic
Constant	0.008	1.46
dlog(Real trade-weighted U.S. dollar, 2 quarter moving average)	-0.067	-0.28
dlog(Global GDP, 4 quarter moving average)	0.794	2.29

Appendix 8: Auto Imports

Quarterly Data from 1973:1 to 2003:2
R Bar Squared = 0.061
Durbin-Watson Statistic = 2.09

Dependent variable: dlog(Real imports of autos per adult)

	Coefficient	T-Statistic
Constant	-0.409	-1.40
log(Real trade-weighted dollar)	0.090	1.42
pdl(dlog(Real personal consumption, motor vehicles and parts),2)	0.184	0.79
pdl(dlog(Real business investment, transportation equipment),2)	0.406	1.97

Note:
(1) pdl(...,#) stands for a polynomial distributed lag of order #

Appendix 9: Federal Funds Rate

Quarterly Data from 1987Q1 2006Q3
R Bar Squared = 0.994
Durbin-Watson Statistic = 0.654

Dependent Variable: Federal funds rate

	Coefficient	t-Statistic
Potential nominal GDP growth	0.125	4.92
Inflation expectations	0.344	3.88
Difference, Unemployment rate and Natural rate	-0.425	-5.35
Federal Funds Rate, lagged 1 quarter	0.801	19.82

Appendix 10: 10-year Treasury Yield

Quarterly Data from 1987Q1 2006Q3
R Bar Squared = 0.994
Durbin-Watson Statistic = 1.325

Dependent Variable: 10-Year Treasury Bond Yield

	Coefficient	t-Statistic
Federal funds rate	0.149	2.67
Inflation expectations	1.362	11.27
Difference, Unemployment rate and Natural rate	-0.303	-2.40
Ratio of current account to GDP	0.119	3.30
Ratio of federal debt outstanding to GDP	0.035	7.44
Inflation volatility	0.021	3.56

Appendix 11: Aggregate hours worked, total private sector

Long-Run Relatiopnship

Quarterly Data from 1952:1 to 2003:2
R Bar Squared = 0.996
Durbin-Watson Statistic = 0.25

Dependent variable: log(Aggregate hours worked, total private sector)

	Coefficient	T-Statistic
Constant	1.656	19.08
log(Aggregate output, total private sector)	0.746	27.29
Linear time trend	-0.004	-14.73
Linear time trend 1973:1 forward	0.003	27.61
Linear time trend 1995:1 forward	-0.003	-13.86

Short-Run Relatiopnship

Quarterly Data from 1952:2 to 2003:2
R Bar Squared = 0.619
Durbin-Watson Statistic = 1.17

Dependent variable: dlog(Aggregate hours worked, total private sector)

	Coefficient	T-Statistic
Constant	-0.001	-1.39
Error correction residual, lagged 1 quarter	-0.180	-5.83
dlog(Aggregate output, total private sector)	0.468	15.38

Appendix 12: Intermediate estimate of mining industry (NAICS 21) employment

Quarterly Data from 1958:2 to 2003:2
R Bar Squared = 0.017
Durbin-Watson Statistic = 1.85

Dependent variable: dlog(Intermediate estimate of mining industry (NAICS 21) employment)

	Coefficient	T-Statistic
Constant	0.002	0.50
dlog(Mining GPO)	0.107	1.30
dlog(Labor output per hour, 3 quarter moving average, lagged 1 quarter)	-1.024	-2.20

Appendix 13: Labor Force

Quarterly Data from 1953:2 to 2003:2
R Bar Squared = 0.997
Durbin-Watson Statistic = 1.70

Dependent variable: log(Labor force per adult population)

	Coefficient	T-Statistic
Constant	-0.116	-4.61
log(Labor force per adult population, lag 1)	0.757	16.04
Linear time trend 1957 forward	-0.001	-3.53
Linear time trend 1960 forward	0.000	2.01
Linear time trend 1969 forward	0.001	3.39
Linear time trend 1973 forward	0.000	0.13
Linear time trend 1980 forward	-0.000	-0.62
Linear time trend 1981 forward	0.000	0.33
Linear time trend 1990 forward	-0.000	-4.19
pdl(log(Real compensation per hour),4)	0.048	3.73
pdl((Difference, Unemployment rate and Natural rate, lagged 1 quarter),4)	-0.001	-1.58

Note:

(1) pdl(...,#) stands for a polynomial distributed lag of order #

Appendix 14: Total Wage and Salary Income

Quarterly Data from 1964:2 to 2003:2
R Bar Squared = 0.51
Durbin-Watson Statistic = 2.68

Dependent variable: dlog(Wage and salary income)

	Coefficient	T-Statistic
Constant	0.005	4.55
dlog(Average hourly earnings*Average weekly hours)	0.705	7.01
dlog(Payroll employment)	0.881	8.09

Appendix 15: Intermediate estimate of mining industry (NAICS 21) Wage and Salary Income

Quarterly Data from 2001:2 to 2003:2

R Bar Squared = 0.38

Durbin-Watson Statistic = 2.80

Dependent variable: dlog(Mining wage and salary income)

	Coefficient	T-Statistic
Constant	0.001	0.14
dlog(Mining payroll employment*Mining average hourly earnings*Average weekly hours)	1.582	2.32

Appendix 16: Corporate Profit Margins After Tax

Quarterly Data from 1965Q2 2006Q3

R Bar Squared = 0.200

Durbin-Watson Statistic = 1.906

Dependent Variable: dlog(After-tax corporate profit margins)

	Coefficient	t-Statistic
Constant	0.007	0.77
dlog(Core PCE inflation)	2.133	2.22
dlog(Unit labor costs)	-2.618	-5.21
dlog(Crude oil price)	-0.053	-1.53
dlog(Corporate interest payments)	-0.089	-1.01

Appendix 17: Auto Direct Delinquency Rate, $

Quarterly Data from 1996Q1 2006Q1
R Bar Squared = 0.829
Durbin-Watson Statistic = 1.109

Dependent Variable: Delinquencies on auto direct loans

	Coefficient	t-Statistic
Constant	-15.686	-4.88
Real personal income growth	-8.470	-5.18
Financial obligations ratio, 4 quarter moving average	0.600	6.78
Mortgage loan-to-value ratio	0.094	3.63
Real used vehicle price growth	-2.286	-2.86
Real house price growth, 4 quarter moving average	-6.502	-5.06

Appendix 18: MBA Delinquency Rate for Prime Loans

Quarterly Data from 1998Q1 2006Q1
R Bar Squared = 0.479
Durbin-Watson Statistic = 0.883

Dependent Variable: MBA Mortgage delinquencies, prime loans

	Coefficient	t-Statistic
Constant	-16.742	-2.51
Personal income growth	-9.860	-3.89
House price growth, 8 quarter moving average	-21.736	-3.91
Homeowners' financial obligation ratio, 4 quarter moving average	0.761	3.14
Mortgage loan-to-value ratio, 4 quarter moving average	0.107	2.36

Appendix 19: Mortgage Delinquency Rate for Subprime Loans

Quarterly Data from 1998Q1 2005Q2
R Bar Squared = 0.825
Durbin-Watson Statistic = 1.900

Dependent Variable: MBA Mortgage delinquencies, subprime loans

	Coefficient	t-Statistic
Constant	13.995	19.07
Real income proxy growth	-38.720	-3.18
Real house price growth, 4 quarter moving average	-75.895	-6.96
Ratio of average income and median income per household growth, 12 qtr. MA	189.600	4.42