

FRB/US Equation Documentation

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Introduction

FRB/US is a large-scale quarterly macroeconomic model of the U.S. economy, containing roughly 300 equations and identities. However, the number of "core" stochastic equations is much smaller -- around 40 equations. In this documentation, equations are grouped into 11 sectors, each of which is introduced by a brief discussion of its major features and concluded with a list of definitions of variables. In addition, important equations are accompanied by a small amount of explanatory text. A more complete description of the principles underlying the design of FRB/US and its system properties is available in a number of studies, including:

- Flint Brayton and Peter Tinsley, eds., [A Guide to FRB/US: A Macroeconomic Model of the United States](#), FEDS working paper 1996-42 (October 1996).
- Flint Brayton, Andrew Levin, Ralph Tryon, and John Williams, [The Evolution of Macro Models at the Federal Reserve Board](#), FEDS working paper 97-29 (May 1997); also published in *Carnegie Rochester Conference Series on Public Policy*, December 1997, 47, 43-81.
- Flint Brayton, Eileen Mauskopf, David Reifschneider, Peter Tinsley, and John Williams, [The Role of Expectations in the FRB/US Macroeconomic Model](#), *Federal Reserve Bulletin*, April 1997, 83 (4), 227-245.
- David Reifschneider, Robert Tetlow, and John Williams, [Aggregate Disturbances, Monetary Policy, and the Macroeconomy: The FRB/US Perspective](#), *Federal Reserve Bulletin*, January 1999, 85 (1), 1-19.
- Flint Brayton, Morris Davis, Peter Tulip, [Polynomial Adjustment Costs in FRB/US](#) May 2000
- Michael Kiley, [Business Investment in the Federal Reserve Board's U.S. Model](#), April 2001
- Flint Brayton, [Potential Output in FRB/US](#), May 2002

Types of equations. Equations in FRB/US fall into four types: (1) polynomial adjustment cost specifications (PAC), (2) present value relationships (PV), (3) conventional error corrections and other types of behavioral relationships, and (4) identities.

PAC equations. Numerous references will be made to "polynomial adjustment cost" (or PAC) equations, a specification which is used to characterize dynamic behavior based on an explicit cost minimization framework. In this framework, agents seek to minimize the expected present value of squared deviations of current and future values of the decision variable from a target (or steady-state) path plus adjustment costs associated with squared changes in the level, the growth rate, and higher-order growth terms of the decision variable. The PAC approach is used in equations for three categories of consumption, residential construction, investment in producers' durable equipment, inventories, aggregate price and wage equations, labor hours, and dividend payments. In each of these equations, the core structure specifies that the current change in the decision variable depends on:

- the lagged deviation of the decision variable from its target;
- lagged changes in the decision variable; and
- a weighted sum of expected future changes in the target variable.

In computing the weighted sum of expected future changes in the target, the weights are a non-linear function of the adjustment cost parameters and do not sum to unity; the sum is given in each variable's definition. For a detailed discussion of the PAC approach, see [Polynomial Adjustment Costs in FRB/US](#).

PV equations. Financial markets are assumed to be free of adjustment costs. This applies to the equations for five- and ten-year government bonds, AAA and BAA corporate bonds, and the price of equity. Long-term bond rates equal the present discounted value of expected future short-term rates, adjusted for time-varying risk/term premiums. Similarly, equity prices equal the present discounted value of future dividend payments, after adjustment for an exogenous risk premium.

Error-correction and other behavioral equations. Most of the core equations in FRB/US are specified in the PAC and PV frameworks. For the remaining core equations and other more peripheral relationships as well, conventional error-correction specifications without explicit expectations terms are used in the majority of instances. Equations of this type include export and import volumes, labor force participation, and the price of imports.

Identities. Two comments are in order concerning the numerous identities contained in FRB/US. First, the use of chain-aggregated price and quantity indexes in the National Income and Product Accounts makes the relationship between lower and higher-level aggregates quite complex. In the model, these relationships are closely approximated by identities that aggregate using Divisia indexes; chain-aggregation formulas are used only in the case of GDP and other variables that include inventory investment as a component. Second, many other types of accounting identities are simplified in order to reduce the number of variables included in the system; for these quasi-identities, exogenous multiplicative scaling variables are used to link the variable in question with its major components.

Expectations. PAC and PV equations contain explicit expectations variables. Each expectation is a weighted average of future values, with weights dictated by the structure of the optimization associated with the equation. The PAC and PV equations were estimated using a single-equation technique in which proxies for the expectations variables were constructed from forecasts of small VARs. In FRB/US simulations, two options are currently available for expectations. "VAR" expectations use the same VARs that were employed in estimation. In this case, each expectation can be expressed as a linear function of past and, in some cases, contemporaneous observations on the variables appearing in the VARs. The second option is expectations that are model consistent in the sense of being the same as the future simulated values of the relevant variables. In

either case, the formulas for these variables are given in sector Z.

Conventions for naming variables. In addition to the use of a standard set of prefixes (such as "E" for expenditure, "G" for government, and "R" for interest rate) names in FRB/US follow several other conventions. A "Q" prefix denotes the nonstationary component of the "target" or "desired" level of a variable. For example, EC is consumption spending and QEC is the non-cyclical part of desired consumption. A "Z" prefix refers to a variable that is an expectation. These variables frequently are the weighted sum of expected future changes in the target. Often, the target is split into different components with corresponding "Z" variables representing the weighted sum of expected future changes in the components.

Equation statistics. For most equations, the equation text shows coefficients and t-statistics (in brackets) immediately before each explanatory variable. For explanatory variables that enter as distributed lags, however, the equation text gives the coefficient sum, and the individual lag coefficients and t-statistics are reported beneath the equation text. Coefficients that are constrained in estimation have "const." in the place of a t-statistic. The constraints in PAC and PV equations typically arise from the theoretical derivation. Below the equation text and any distributed lag coefficients, standard regression statistics are shown. For PAC and PV equation, a set of diagnostic LM test statistics is also reported. The tests are based on regressions of equation residuals on the set of explanatory variables and added regressors. In the tests for serial correlation, the added regressors are lagged residuals. In the test for overidentifying restrictions, the added regressors are the VAR variables that enter the equation in restricted form through the constructed expectations variables.

Household Expenditures

The sector contains polynomial adjustment cost (PAC) equations for consumer spending on nondurable goods and services (broadly defined), expenditures on durable goods, and residential investment. The level of complexity in this sector is greater than that of other sectors because forward-looking terms are present both in the dynamic equations -- where agents calculate the present value of expected changes in the target values -- and in the equations for the target variables. As an example of the latter, target consumption depends on permanent income, with the latter equal to a weighted average of expected future income.

Desired spending on nondurable goods and services is derived from the assumption that households maximize the present value of utility associated with consumption, subject to a lifetime budget constraint. The assumption that an intertemporal budget constraint matters for current consumption introduces the need for measures of permanent income and hence forward-looking terms in the target specification. However, households are assumed to be highly risk-averse and subject to uninsurable income uncertainty, and the construction of permanent income imposes a very high discount rate on future income -- 25 percent per annum.

Owing to habit persistence and other frictions, actual spending is assumed to respond gradually to changes in target consumption: the estimated dynamic equation implies an adjustment speed of 50 percent after one year. The equation also indicates that a significant proportion (10 percent) of consumption is accounted for by liquidity-constrained households, and that spending is sensitive to cyclical changes in income risk -- an effect proxied by the expected future level of the output gap.

Desired rates of investment in consumer durables and housing are derived from the specification of desired service flows from durables and housing. The desired share of these service flows in total consumption of nondurable goods and services is assumed to be inversely proportional to the ratio of the rental price of these assets to the price of aggregate consumption. The dynamic equations allow for accelerator-type behavior of investment; that is, investment may temporarily overshoot its long-run target level when determinants of the desired service flow change.

a.1 EC: Consumption, cw 2000\$ (FRB/US definition)

FRB/US total consumer spending is approximated by the Divisia aggregate of expenditures on non-durable goods and non-housing services (ECO), housing services (ECH) and the service flow from durable goods (YHPCD+JKCD).

$$\begin{aligned} \log(\mathbf{EC}) = & \log(\mathbf{EC}_{t-1}) + \\ & .5 * (\mathbf{PCOR} * \mathbf{PCNIA} * \mathbf{ECO} / (\mathbf{EC} * \mathbf{PCNIA})) \\ & + \mathbf{PCOR}_{t-1} * \mathbf{PCNIA}_{t-1} * \mathbf{ECO}_{t-1} / (\mathbf{EC}_{t-1} * \mathbf{PCNIA}_{t-1}) \\ & * \text{del}(1:\log(\mathbf{ECO})) \\ & + .5 * (\mathbf{PCHR} * \mathbf{PCNIA} * \mathbf{ECH} / (\mathbf{EC} * \mathbf{PCNIA})) \\ & + \mathbf{PCHR}_{t-1} * \mathbf{PCNIA}_{t-1} * \mathbf{ECH}_{t-1} / (\mathbf{EC}_{t-1} * \mathbf{PCNIA}_{t-1}) \\ & * \text{del}(1:\log(\mathbf{ECH})) \\ & + .5 * ((\mathbf{PCDR} * \mathbf{PCNIA} * \mathbf{YHPCD} + \mathbf{PCDR} * \mathbf{PCNIA} * \mathbf{JKCD}) / (\mathbf{EC} * \mathbf{PCNIA})) \\ & + (\mathbf{PCHR}_{t-1} * \mathbf{PCNIA}_{t-1} * \mathbf{YHPCD}_{t-1} + \mathbf{PCHR}_{t-1} * \mathbf{PCNIA}_{t-1} * \mathbf{JKCD}_{t-1}) / (\mathbf{EC}_{t-1} * \mathbf{PCNIA}_{t-1}) \\ & * \text{del}(1:\log(\mathbf{YHPCD} + \mathbf{JKCD})) \end{aligned}$$

a.2 QEC: Desired level of consumption (FRBUS definition), trending component

The model definition of aggregate consumption of nondurable goods and services differs from the NIPA definition by including the imputed service flow from the stock of consumer durables. Desired nondurable consumption is a function of both the level of permanent income (ZYH) and its composition. In the estimated specification, the ratio of consumption to permanent income depends on the ratios to permanent income of permanent transfer income (ZYHT), permanent property income (ZYHP), and property wealth (WPS and WPO). The estimated coefficients on these ratios measure the degree to which the propensity to spend out of these components of wealth differs from the propensity to spend out of labor income. The latter propensity is estimated to have increased slightly during the mid-1980s, as indicated by the positive coefficient on DCON*ZYH: DCON is a dummy variable equal to 0 prior to 1986, and 1 after 1988, with a linear segment connecting these points between these two dates. Note: In addition to the above terms, desired consumption in FRB/US is also a function of the output gap, with the latter a proxy for the uncertainty associated with, and thus the discount rate applied to, future income. The expected output gap term is not included in the target

specification for QEC because it is I(0), but instead appears in the dynamic consumption equation.

$$\begin{aligned} \text{QEC} = & 0.794 * \text{ZYH} \\ & + 0.0187 * (\text{DCON} * \text{ZYH}) \\ & + 0.206 * \text{ZYHT} \\ & - 0.552 * \text{ZYHP} \\ & + 0.0456 * (\text{WPS} + \text{WPO}) \end{aligned}$$

a.3 ECD: Consumer expenditures on durable goods, cw 2000\$

The growth rate of household investment in consumer durables is modeled using the PAC specification, with spending error-correcting to its long-run target. The target has two components -- an I(1) component, QECD, that is a function of overall target consumption and the cost of capital for consumer durables, and an I(0) component, ZGAPC2. ZGAPC2 is the weighted average of expected future output gaps, computed using the PAC weights implied by the estimated coefficients of the model, and is a proxy for future income uncertainty.

$$\begin{aligned} \text{del}(1: \log(\text{ECD})) = & 0.179 * \log(\text{QECD}_{t-1} / \text{ECD}_{t-1}) \\ & - 0.146 * \text{del}(1: \log(\text{ECD}_{t-1})) \\ & + 0.00106 \\ & + 1.00 * \text{ZECD} \\ & + 1.93 * \text{ZGAPC2} / 100 \end{aligned}$$

Regression statistics

Adjusted R2:	.1518
Sum of squared residuals:	.1479
Standard error of regression:	.0301
Durbin-Watson statistic:	1.993
Sample period:	1964:q2 - 2005:q4
Estimation date:	August 25, 2006
:	

a.4 QECD: Target level of consumption of durable goods, trending component

The specification of the target level of spending on consumer durable goods is proportional to overall target consumption, with the proportionality factor a function of the relative rental rate on such goods. The relative rental rate is the product of two factors -- the relative purchase price of consumer durables, PCDR, and the real financial cost of capital (plus depreciation) for such goods, RCCD. The steady-state condition for the stock of consumer durables is converted to one for gross outlays by multiplying the stock condition by the sum of two factors -- the depreciation rate for durable goods, and the steady-state growth rate of the target capital stock. The latter factor equals the sum of trend output growth (HGGDPT) and the trend rate of decline in the relative price of consumer durable goods (HGPCDR, weighted by the real rental rate elasticity).

$$\text{QECD} = \text{QEC}$$

$$* (\text{JRCD}/4 + \text{HGGDPT}/400 - 0.655 * \text{HGPCDR}/400)$$

$$* \exp(2.75 - 0.655 * \log(\text{PCDR} * \text{RCDD}))$$

a.5 EH: Residential investment expenditures, cw 2000\$

The growth rate of residential investment is modeled using the general PAC specification, with spending error-correcting to its long-run target, QEH. QEH is a function of overall target consumption and the cost of capital for housing and is assumed to follow an I(1) process. (Elsewhere in the household sector, the target also has an I(0) component that controls for the expected cyclical state of the economy, which serves as a proxy for future income uncertainty. However, in the housing equation, this term is not statistically significant.) Besides the standard PAC terms, the equation also includes two additional regressors -- the first and second lags of changes in the nominal mortgage rate. These terms are included to capture (approximately) the temporary effects of downpayment requirements and other borrowing constraints on housing investment when nominal interest rates change. A shift in the coefficients on these terms is allowed between 1982:Q4 and 1983:Q1 because the final repeal of Reg. Q in the early 1980s changed the sensitivity of residential construction to interest rates.

$$\begin{aligned} \text{del}(1 : \log(\text{EH})) &= 0.0937 * \log(\text{QEH}_{t-1}/\text{EH}_{t-1}) \\ &+ 0.253 * \text{del}(1 : \log(\text{EH}_{t-1})) \\ &+ 0.233 * \text{del}(1 : \log(\text{EH}_{t-2})) \\ &+ 0.00412 \\ &+ 1.00 * \text{ZEH} \\ &- 0.0526 * \text{del}(1 : \text{RME}_{t-1}) \\ &- 0.0137 * \text{del}(1 : \text{RME}_{t-2}) \\ &+ 0.0340 * \text{D83} * \text{del}(1 : \text{RME}_{t-1}) \\ &+ 0.00348 * \text{D83} * \text{del}(1 : \text{RME}_{t-2}) \end{aligned}$$

Regression statistics

Adjusted R2:	.5177
Sum of squared residuals:	.1675
Standard error of regression:	.0325
Durbin-Watson statistic:	1.955
Sample period:	1964:q2 - 2005:q4
Estimation date:	August 25, 2006

a.6 QEH: Target level of residential investment, trending component

The specification of the target level of residential investment is based on the assumption that the desired housing stock is proportional to overall target consumption, with the proportionality factor a function of the relative rental rate on housing. The relative rental rate is the product of two factors -- the price of new construction expressed relative to consumption prices, PHR*PXP/PCNIA, and the real financial cost of capital (plus depreciation) for housing, RCCH. The steady-state condition for the housing stock is converted

to one for gross investment by multiplying the stock condition by the sum of two factors -- the depreciation rate for housing, and the steady-state growth rate of the target housing stock. The latter factor equals trend output growth (HGGDPT). (Note: unlike consumer durables, no adjustment is made to the steady-state growth of the target stock to control for trend movements in the relative price of housing construction, because the series does not show a pronounced trend.)

$$\begin{aligned} \text{QEH} &= \text{QEC} \\ &* (\text{JRH}/4 + \text{HGGDPT}/400) \\ &* \exp(2.31 - 0.277 * (\log(\text{PHR} * \text{PXP}/\text{PCNIA}) + \log(\max(\text{RCCH}, 1)))) \end{aligned}$$

a.7 ECNIA: Personal consumption expenditures, cw 2000\$ (NIPA definition)

NIPA total consumer spending is approximated by the Divisia aggregate of expenditures on non-durable goods and non-housing services (ECO), durable goods (ECD), and housing services (ECH).

$$\begin{aligned} \log(\text{ECNIA}) &= \log(\text{ECNIA}_{t-1}) + \\ &.5 * .01 * (\text{PCOR} * \text{PCNIA} * \text{ECO}/\text{ECNIA} \\ &+ \text{PCOR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECO}_{t-1}/\text{ECNIA}_{t-1}) \\ &* \text{del}(1:\log(\text{ECO})) \\ &+ .5 * .01 * (\text{PCDR} * \text{PCNIA} * \text{ECD}/\text{ECNIA} \\ &+ \text{PCDR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECD}_{t-1}/\text{ECNIA}_{t-1}) \\ &* \text{del}(1:\log(\text{ECD})) \\ &+ .5 * .01 * (\text{PCHR} * \text{PCNIA} * \text{ECH}/\text{ECNIA} \\ &+ \text{PCHR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECH}_{t-1}/\text{ECNIA}_{t-1}) \\ &* \text{del}(1:\log(\text{ECH})) \end{aligned}$$

a.8 ECNIAN: Personal consumption expenditures, current \$ (NIPA definition)

$$\text{ECNIAN} = .01 * \text{PCNIA} * \text{ECNIA}$$

a.9 EHN: Residential investment expenditures

$$\text{EHN} = .01 * \text{PHR} * \text{PXP} * \text{EH}$$

a.10 JKCD: Consumption of fixed capital, consumer durables

$$\log(\mathbf{JKCD}) = \log(\mathbf{JRCD}) + \log(\mathbf{KCD}_{t-1})$$

a.11 KCD: Stock of consumer durables, cw 2000\$

$$\mathbf{KCD} = .25*\mathbf{ECD} + (1-\mathbf{JRCD}/4)*\mathbf{KCD}_{t-1}$$

a.12 KH: Stock of residential structures, cw 2000\$

$$\mathbf{KH} = .25*\mathbf{EH} + (1-\mathbf{JRH}/4)*\mathbf{KH}_{t-1}$$

a.13 RCCD: Cost of capital for consumer durables

The real user cost of the stock of consumer durable goods (excluding the purchase price of new goods) equals the sum of the depreciation rate (JRCD) and the real after-tax interest rate. The latter is approximated by the new auto loan rate minus expected inflation over the next five years.

$$\mathbf{RCCD} = 100*\mathbf{JRCD} + \mathbf{RCAR} - \mathbf{ZPI5}$$

a.14 RCCH: Cost of capital for residential investment

The real user cost of housing (excluding the purchase price of new construction) equals the depreciation rate JRH, plus the real after-tax mortgage rate $(1-\mathbf{TRFPM}/100)*\mathbf{RME}-\mathbf{ZPI10}$, plus the effective marginal property tax rate $(1-\mathbf{TRFPM}/100)*\mathbf{TRSPP}$. Note: TRFPM is the marginal federal income tax rate for the taxpayers with household incomes that are twice the median; this group is considered the most representative of households who itemize.

$$\mathbf{RCCH} = 100*\mathbf{JRH} + (1-\mathbf{TRFPM}/100)*(\mathbf{RME}+100*\mathbf{TRSPP}) - \mathbf{ZPI10}$$

a.15 YHPCD: Income, household, property, imputed flow from stock of consumer durables, real

$$\log(\mathbf{YHPCD}) = \log(0.0537 \text{ [(const.)]}) + \log(\mathbf{KCD}_{t-1})$$

a.16 ECO: Consumer expenditures on non-durable goods and non-housing services, cw 2000\$

The rate of growth of consumer spending on non-durable goods and non-housing services is modeled using the a second-order PAC specification. Thus, actual spending growth deviates from expected future growth in target consumption by enough to close gradually any gap between the levels of actual and desired spending. Note that the target is given by the target for total FRB/US consumption (QEC), scaled by the relative price (PCOR). The nominal share of ECO in EC is subsumed in the constant term.

Aside from these standard PAC terms, the equation also includes an term that attempts to control for the effects of liquidity constraints. Specifically, the standard framework has been modified to allow for the possibility that a fixed percentage of consumption is accounted for by households whose consumption moves one-for-one with labor and transfer income. Aggregating across unconstrained and constrained households yields a functional form in which the liquidity-constrained share of total spending is approximated by the coefficient on the difference between contemporaneous income growth and expected growth in future target "other" consumption (ZECO).

$$\begin{aligned} \text{del}(1: \log(\text{ECO})) &= 0.0942 * \log((\text{QEC}_{t-1}/\text{PCOR}_{t-1})/\text{ECO}_{t-1}) \\ &+ 0.162 * \text{del}(1:\log(\text{ECO}_{t-1})) \\ &- 0.0318 \\ &+ 1.00 * \text{ZECO} \\ &+ 0.527 * (\text{del}(1:\log(\text{YHL}+\text{YHT})) - \text{ZECO}) \end{aligned}$$

Regression statistics

Adjusted R2:	.3082
Sum of squared residuals:	.003011
Standard error of regression:	.004298
Durbin-Watson statistic:	1.904
Sample period:	1964:q2 - 2005:q4
Estimation date:	August 25, 2006
:	

a.17 ECH: Consumer expenditures on housing services, cw 2000\$

The ratio of housing services (ECH) to the housing stock (KH(-1)) is related to two lags of itself as well as a smoothed measure of the mortgage rate, RRMET.

$$\begin{aligned} \text{del}(1 : (\text{ECH})/\text{KH}(-1)) &= 0.00374 \\ &- 0.0419 * \text{ECH}_{t-1}/\text{KH}_{t-2} \\ &+ 0.605 * \text{del}(1 : \text{ECH}_{t-1}/\text{KH}_{t-2}) \\ &+ 0.00251 * \text{RRMET}/100 \end{aligned}$$

Regression statistics

Adjusted R2:	.4148
Sum of squared residuals:	7.29E-06
Standard error of regression:	.000246
Durbin-Watson statistic:	1.983
Sample period:	1975:q1 - 2005:q4
Estimation date:	August 25, 2006

Business Expenditures

In the model, business investment is broken down into four categories: high-tech equipment and software (computers, software, and telecommunication equipment); other equipment; non-residential structures; and inventories.

Growth in real spending on high-tech E&S, other equipment, and nonresidential structures is modeled using a modified version of the PAC specification. As with a standard PAC equation, investment responds to the lagged gap between actual and target investment, expected future growth in target investment, and lagged growth in actual spending. However, because some firms are estimated to be liquidity constrained, aggregate equipment spending is also sensitive to changes in cash flow in the short run. In contrast to these three components of business fixed investment, growth in the stock of inventories is modeled in a simple error-correction framework. For all four types of business investment, actual spending converges to its target level in the long run.

For the two components of E&S spending and non-residential structures investment, target levels are defined as the rate of investment necessary to hold the capital-output ratio at its optimal level. In the case of the inventories, the target is expressed in stock not flow terms, because the dependent variable is the growth of stocks. The four individual targets are derived jointly under the assumption that the aggregate production function is Cobb-Douglas with three factors of production -- quality-adjusted hours, energy, and an aggregate capital services bundle. (The capital services bundle is measured as the chain-weighted aggregate of the flow of capital services from each of the four types of capital stocks.) Substitution of one type of capital for another within the capital services bundle is not Cobb-Douglas, however, but is approximated using a translog specification. According to the estimated version of this specification, the demand for each type of capital depends not only its own cost of capital, but also on the cost of capital for high-tech equipment and the cost of capital for non-residential structures. Estimated price elasticities vary across type of capital, but in all cases the elasticity of the target with respect to business output is constrained to equal unity.

b.1 EPDC: Investment in computers, software, and communication equipment, cw 2000 \$

Growth in outlays for high-tech equipment and software is modeled using a standard PAC specification; as with the other components of BFI, an important ad hoc role was found for lagged output growth.

$$\begin{aligned} \text{del}(1 : \log(\text{EPDC})) = & \\ & -0.0478 \\ & + 0.0500 * \log(\text{QEPDC}_{t-1}/\text{EPDC}_{t-1}) \\ & + \text{B2(L)} \{ \text{sum } 0.630 \} * \text{del}(1 : \log(\text{EPDC}_{t-1})) \\ & + 0.302 * \text{ZXBC} \\ & + 0.302 * \text{ZVPDC} \\ & + 0.698 * \text{del}(1 : \log(\text{XB}_{t-1})) \end{aligned}$$

Distributed lag coefficients

Name	Value
B2 ₀	0.272
B2 ₁	0.358
B2SUM	0.630

Regression statistics

R ² :	0.172567
Sum of squared residuals:	0.094046
Standard error of regression:	0.028473
Sample period:	1976 1 2005 4
Estimation date:	September 2006

b.2 QEPDC: Desired level of investment in high-tech equipment, trending comp.

The target rate of investment is defined as the rate necessary to keep the capital-output ratio at its optimal value (VPDC).

$$\begin{aligned} \log(\text{QEPDC}) = & 0.00 \\ & + 1.00 * \log(\text{XB}) \\ & + 1.00 * \log(\text{VPDC}) \\ & + 1.00 * \log(\text{HGX}/100 + \text{JRPDC} + 4 * \text{HGVPDC}) \end{aligned}$$

b.3 EPDCN: E&S investment in computers, software, and communication equipment, current \$

$$\text{EPDCN} = .01 * \text{PPDCR} * \text{PXP} * \text{EPDC}$$

b.4 EPDO: E&S investment, excluding computers, software, and communication equipment, cw 2000 \$

The equation for growth in outlays on non-high-tech equipment differs from the standard PAC equation by allowing for a response lag that is one quarter longer than usual, reflecting a delivery/gestation lag in investment. In addition, an important ad hoc role was found for lagged output growth.

$$\begin{aligned} \text{del}(1 : \log(\text{EPDO})) = & \\ & - 0.0506 \\ & + 0.0500 * \log(\text{QEPDO}_{t-2}/\text{EPDO}_{t-2}) \\ & + \text{B2(L) } \{ \text{sum } 0.161 \} * \text{del}(1 : \log(\text{EPDO}_{t-1})) \\ & + 0.375 * \text{ZXBO}_{t-1} \\ & + 0.375 * \text{ZVPDO}_{t-1} \\ & + 0.625 * (\text{del}(1 : \log(\text{XB}_{t-1}))) \end{aligned}$$

Distributed lag coefficients

Name	Value
B2 ₀	-0.0165
B2 ₁	0.177
B2SUM	0.161

Regression statistics

R ² :	0.243912
Sum of squared residuals:	0.087969
Standard error of regression:	0.025067
Sample period:	1970 1 2005 4
Estimation date:	September 2006

b.5 QEPDO: Desired level of investment in eq. excl. high-tech, trending comp.

The target rate of investment is defined as the rate necessary to keep the capital-output ratio at its optimal value (VPDO).

$$\begin{aligned} \log(\text{QEPDO}) = & 0.00 \\ & + 1.00 * \log(\text{XB}) \\ & + 1.00 * \log(\text{VPDO}) \\ & + 1.00 * \log(\text{HGX}/100 + \text{JRPDO}) \end{aligned}$$

b.6 EPDON: E&S investment, excluding computers, software, and communication equipment, current \$

$$\text{EPDON} = .01 * \text{PPDOR} * \text{PXP} * \text{EPDO}$$

b.7 EPDN: Investment in producers' durable equipment

$$EPDN = EPDCN + EPDON$$

b.8 EPD: Investment in producers' durable equipment, cw 2000\$

Total outlays on equipment and software is a Divisia aggregate of its two components, high-tech and other.

$$\begin{aligned} \log(EPD) = & \log(EPD_{t-1}) \\ & + .5 * (\frac{EPDON}{EPDN} + \frac{EPDON_{t-1}}{EPDN_{t-1}}) * \text{del}(1:\log(EPDO)) \\ & + .5 * (\frac{EPDCN}{EPDN} + \frac{EPDCN_{t-1}}{EPDN_{t-1}}) * \text{del}(1:\log(EPDC)) \end{aligned}$$

b.9 EPS: Investment in nonresidential structures, cw 2000\$

The equation for growth in spending on non-residential structures differs from the standard PAC equation by allowing for a response lag that is one quarter longer than usual, reflecting a delivery/gestation lag in investment. In addition, an important ad hoc role was found for lagged output growth. A dummy variable for the fourth quarter of 2001 is included to account for the unprecedented fluctuation that quarter related to the destruction of the World Trade Center.

$$\begin{aligned} \text{del}(1 : \log(EPS)) = & \\ & -0.0323 \\ & + 0.0250 * \log(QEPS_{t-2}/EPS_{t-2}) \\ & + B2(L) \{ \text{sum } 0.403 \} * \text{del}(1 : \log(EPS_{t-1})) \\ & + 0.554 * ZXBS_{t-1} \\ & + 0.554 * ZVPS_{t-1} \\ & + 0.446 * (\text{del}(1 : \log(XB_{t-1}))) \\ & - 0.101 * D01Q4 \end{aligned}$$

Distributed lag coefficients

Name	Value
B2 ₀	0.241
B2 ₁	0.163
B2SUM	0.403

Regression statistics

$$R^2: \quad 0.262046$$

Sum of squared residuals: 0.092095
 Standard error of regression: 0.025740
 Durbin Watson statistic: 2.038053
 Sample period: 1970:q1 - 2005:q4
 Estimation date: September 2006

b.10 QEPS: Desired level of investment in structures, trending comp.

The target rate of investment is defined as the rate necessary to keep the capital-output ratio at its optimal value (VPS).

$$\begin{aligned} \log(\text{QEPS}) = & 0.00 \\ & + 1.00 * \log(\text{XB}) \\ & + 1.00 * \log(\text{VPS}) \\ & + 1.00 * \log(\text{HGX}/100 + \text{JRPS}) \end{aligned}$$

b.11 EPSN: Investment in nonresidential structures

$$\text{EPSN} = .01 * \text{PPSR} * \text{PXP} * \text{EPS}$$

b.12 KI: Stock of private inventories, cs 2000\$

Changes in the real stock of business inventories follow changes in sales with a median lag of 2 quarters. Changes in sales have temporary but no permanent effects on the inventory-sales ratio. Other shocks have permanent effects. Changes in the inventory-sales ratio are partially reversed four quarters later. Apart from these short-term dynamics, the inventory-sales ratio follows a random walk, with a small downward drift that is captured by the intercept.

$$\begin{aligned} \text{del}(1 : \log(\text{KI})) = & -0.000955 \\ & + 0.525 * \text{del}(1 : \log(\text{KI}_{t-1})) \\ & + 0.244 * \text{del}(1 : \log(\text{EFS}_{t-1})) \\ & + 0.231 * \text{del}(1 : \log(\text{EFS}_{t-2})) \\ & - 0.124 * \text{del}(1 : \log(\text{KI}_{t-4}/\text{EFS}_{t-4})) \end{aligned}$$

Regression statistics

R²: 0.53725
 Sum of squared residuals: 0.0039651
 Standard error of regression: 0.0049781

Durbin-Watson statistic:	2.0765
Sample period:	1965 1 2005 4
Estimation date:	AUGUST 2006
Stability (Chow test at midpoint):	p =
Serial Correlation (up to 4th order):	p =

b.13 EI: Change in private inventories, cw 2000\$

$$EI = 4 * \Delta(1 : KI)$$

b.14 EIN: Change in business inventories, current \$

$$EIN = .01 * PXP * PKIR * EI$$

b.15 KPDC: Stock of computers, software, and communication equipment, cw 2000 \$

The equation for the stock of computers differs from the standard specification in that differences in the prices of investment and capital are taken into account by measuring the contribution of investment to the increase in the capital stock in terms of the price of capital goods.

$$KPDC = 0.25 * EPDC * (PPDCR / PKPDCR) + (1 - JRPDC / 4) * KPDC_{t-1}$$

b.16 KPDO: Stock of E&S capital excluding computers, software, and communication equipment, cw 2000 \$

$$KPDO = 0.25 * EPDO + (1 - JRPDO / 4) * KPDO_{t-1}$$

b.17 KPS: Stock of nonresidential structures, cw 2000\$

$$KPS = 0.25 * EPS + (1 - JRPS / 4) * KPS_{t-1}$$

b.18 HKS: Growth rate of KS, cw 2000\$ (compound annual rate)

The growth rate of capital services is modeled as a weighted average of the growth rates of four capital stocks. The weights are measures of income shares earned by each type of capital. A residual component, which makes the equation an identity, accounts for the use of partially aggregated capital stocks rather than disaggregated capital stocks, omission of several types of capital (owner-occupied housing, land), and approximation error in the constructed income share weights.

$$\begin{aligned} \text{HKS} = & 400 * (\text{YKPDCN} * \text{del}(1 : \log(\text{KPDC})) + \text{YKPDON} * \text{del}(1 : \log(\text{KPDO}))) \\ & + \text{YKPSN} * \text{del}(1 : \log(\text{KPS})) + \text{YKIN} * \text{del}(1 : \log(\text{KI})) / \\ & (\text{YKPDCN} + \text{YKPDON} + \text{YKPSN} + \text{YKIN}) + \text{HKSr} \end{aligned}$$

b.19 KS: Capital services, 2000 \$

$$\log(\text{KS}) = \log(\text{KS}_{t-1}) + \text{HKS}/400$$

b.20 RPD: After-tax real financial cost of capital for producers' durable equipment

The firm's financing cost is measured as a weighted average of borrowing costs in debt and equity markets, where the weights are chosen to optimize the fit of the equation for equipment investment. The cost of debt finance is proxied by the yield on 5-year Treasury bonds plus a risk premium measured by the spread between the BAA bond rate and the yield on 10-year Treasury bonds, and allows for the tax deductibility of interest payments. The expected rate of inflation over a 5-year horizon is subtracted from the after-tax nominal yield to obtain the real after-tax rate of interest. The cost of equity finance is measured as the expected real return to equity.

$$\text{RPD} = 0.5 * (6.8 + (1 - \text{TRFCIM}) * (\text{RG5E} + \text{RBAAE} - \text{RG10E}) - \text{ZPIB5}) + 0.5 * \text{REQ}$$

b.21 RTINV: Current dollar rent per unit of inventories

The cost, over one year, of using one unit of inventory capital is equal to the relative purchase price of new investment ($\text{PKIR} * \text{PXP} / \text{PXB}$) multiplied by the real rate of interest (RPD) minus the trend growth rate of the relative price of inventories (GPKIR).

$$\begin{aligned} \text{RTINV} = & (.01 * \text{RPD} - .01 * \text{HGPKIR}) \\ & * (\text{mave}(2 : \text{PXP}_t * \text{PKIR}_t)) / \text{PXB} \end{aligned}$$

b.22 RTPDC: Current dollar rent per unit of new computers, software, and communications equipment

The log cost, over one year, of using one unit of high-tech capital is equal to the sum of three terms: the relative purchase price of new investment ($PKPDCR \cdot PXP/PXB$); the depreciation rate ($JRPDC$) plus the real rate of interest (RPD) less the trend growth rate of relative high-tech prices ($GPPDCR$); and the tax adjustment for depreciation, the investment tax credit, and the corporate marginal tax rate.

$$\begin{aligned} RTPDC &= (.01 \cdot RPD + JRPDC - .01 \cdot HGPDCR) \\ &\quad * ((1 - .01 \cdot TAPDTC - TRFCIM) \cdot (1 - TAPDDP \cdot .01 \cdot TAPDTC) \cdot TAPDDC) / (1 - TRFCIM) \\ &\quad * (\text{mave}(2 : PXP_t \cdot PKPDCR_t)) / PXB \end{aligned}$$

b.23 RTPDO: Current dollar rent per unit of other equipment

The log cost, over one year, of using one unit of non-high-tech equipment is equal to the sum of three terms: the relative purchase price of new investment ($PPDOR \cdot PXP/PXB$); the depreciation rate ($JRPDO$) plus the real rate of interest (RPD) less the trend growth rate of relative high-tech prices ($GPPDOR$); and a tax adjustment for depreciation, the investment tax credit, and the corporate marginal tax rate.

$$\begin{aligned} RTPDO &= (.01 \cdot RPD + JRPDO - .01 \cdot HGPDOR) \\ &\quad * ((1 - .01 \cdot TAPDTC - TRFCIM) \cdot (1 - TAPDDP \cdot .01 \cdot TAPDTC) \cdot TAPDDC) / (1 - TRFCIM) \\ &\quad * (\text{mave}(2 : PXP_t \cdot PPDOR_t)) / PXB \end{aligned}$$

b.24 RTPS: Current dollar rent per unit of new nonresidential structures

The log cost, over one year, of using one unit of structures capital has three components: the relative purchase price of new investment ($PPSR \cdot PXP/PXB$); the depreciation rate ($JRPS$) plus the real rate of interest (RPD) less the trend growth rate of the relative price of structures ($GPPSR$); and the tax adjustment for depreciation and the marginal corporate tax rate.

$$\begin{aligned} RTPS &= (.01 \cdot RPD + JRPS - .01 \cdot HGPPSR) \\ &\quad * ((1 - TRFCIM) \cdot TAPSDA) / (1 - TRFCIM) \\ &\quad * (\text{mave}(2 : PXP_t \cdot PPSR_t)) / PXB \end{aligned}$$

b.25 TAPDDC: Present value of depreciation allowances for high-tech equipment and software

The expression represents the present value of the various statutory depreciation allowances that have existed over time. The nominal rate of interest, used to compute the present value of the statutory allowance, is the after-tax cost to the firm of borrowing in debt and equity markets. The dummy variables $D81$, equal to 1 after

1980 and 0 before, and D87, equal to 1 after 1986, control for changes in depreciation rules: Prior to 1981, firms could elect to compute depreciation using either a straight-line or sum-of-years formula, but after that date accelerated depreciation was allowed under a 150 percent declining balance formula through 1986 and a 200 declining balance formula thereafter.

$$\begin{aligned}
 \text{TAPDDC} = & .5 * D2003 + .5 * D2003 * (2.0 / (2.0 + .01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5}))) \\
 & + .3 * D2002 + .7 * D2002 * (2.0 / (2.0 + .01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5}))) \\
 & + (D87 - D2002 - D2003) * (2.0 / (2.0 + .01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5}))) \\
 & + (D81 - D87) * (1.5 / (1.5 + .01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5}))) \\
 & + (1 - D81) \\
 & * (((1 - \text{TAPDAD}) * (1 - \exp(-.01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5})))) \\
 & / (.01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5}))) \\
 & + \text{TAPDAD} * 2 * (1 - (1 - \exp(-.01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5})))) \\
 & / (.01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5}))) \\
 & / (.01 * \text{TAPDSC} * (\text{RPD} + \text{ZPIB5})))
 \end{aligned}$$

b.26 TAPDDO: Present value of depreciation allowances for non-high-tech equipment

The expression represents the present value of the various statutory depreciation allowances that have existed over time. The nominal rate of interest, used to compute the present value of the statutory allowance, is the after-tax cost to the firm of borrowing in debt and equity markets. The dummy variables D81, equal to 1 after 1980 and 0 before, and D87, equal to 1 after 1986, control for changes in depreciation rules: Prior to 1981, firms could elect to compute depreciation using either a straight-line or sum-of-years formula, but after that date accelerated depreciation was allowed under a 150 percent declining balance formula through 1986 and a 200 declining balance formula thereafter.

$$\begin{aligned}
 \text{TAPDDO} = & .5 * D2003 + .5 * D2003 * (2.0 / (2.0 + .01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5}))) \\
 & + .3 * D2002 + .7 * D2002 * (2.0 / (2.0 + .01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5}))) \\
 & + (D87 - D2002 - D2003) * (2.0 / (2.0 + .01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5}))) \\
 & + (D81 - D87) * (1.5 / (1.5 + .01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5}))) \\
 & + (1 - D81) \\
 & * (((1 - \text{TAPDAD}) * (1 - \exp(-.01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5})))) \\
 & / (.01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5}))) \\
 & + \text{TAPDAD} * 2 * (1 - (1 - \exp(-.01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5})))) \\
 & / (.01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5}))) \\
 & / (.01 * \text{TAPDSO} * (\text{RPD} + \text{ZPIB5})))
 \end{aligned}$$

b.27 TAPSDA: Present value of depreciation allowances for nonresidential structures

The expression represents the present value of the various statutory depreciation allowances that have existed over time. The nominal rate of interest, used to compute the present value of the statutory allowance, is the after-tax cost to the firm of borrowing in debt and equity markets.

$$\text{TAPSDA} = (1 - \text{TAPSAD}) * (1 - \exp(-0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})) /$$

$$\begin{aligned}
& (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL}) + \\
& \text{TAPSAD} * (1 - \text{D69}) * 2 * \\
& (1 - (1 - \text{EXP}(-0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})) / \\
& (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})) / (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL}) \\
& + \text{TAPSAD} * (\text{D69} - \text{D81}) * (1.5 / \\
& (1.5 + .01 * \text{TAPSSL} * (\text{RPD} + \text{ZPIB5}))) * \\
& (1 - \text{exp}(-0.5 - 0.33 * (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL}))) + \\
& (\text{exp}(-0.5) / (0.67 * (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL}))) * \\
& (\text{exp}(-0.33 * (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})) - \\
& \text{exp}(-0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})))) \\
& + \text{TAPSAD} * (\text{D81} - \text{D86}) * (1.75 / \\
& (1.75 + .01 * \text{TAPSSL} * (\text{RPD} + \text{ZPIB5}))) * \\
& (1 - \text{exp}(-0.75 - 0.428 * (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL}))) + \\
& (\text{exp}(-0.75) / (0.572 * (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL}))) * \\
& (\text{exp}(-0.428 * (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})) - \\
& \text{exp}(-0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})))) \\
& + \text{TAPSAD} * \text{D86} * (1 - \text{EXP}(-0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})) / \\
& (0.01 * (\text{RPD} + \text{ZPIB5}) * \text{TAPSSL})
\end{aligned}$$

b.28 VPDC: Desired hi-tech equipment-output ratio

The production function is Cobb-Douglas in capital services. However, individual capital stocks enter through a translog cost function, where the long-run determinants are the user costs of comp., soft, and comm. eq. and the user cost of structures, as these two determinants are non-stationary historically. Homogeneity is imposed in the cost function, but symmetry is not.

$$\begin{aligned}
\text{VPDC} &= ((\text{PKPDCR} / \text{PPDCR}) / \text{RTPDC}) \\
& * (0.0209 \\
& - 0.0796 * \text{LOG}(\text{RTPDC} * \text{PXB} / \text{PXP}) \\
& - 0.0553 * \text{LOG}(\text{RTPS} * \text{PXB} / \text{PXP}))
\end{aligned}$$

b.29 VPDO: Desired ex. hi-tech equipment-output ratio

The production function is Cobb-Douglas in capital services. However, individual capital stocks enter through a translog cost function, where the long-run determinants are the user costs of comp., soft, and comm. eq. and the user cost of structures, as these two determinants are non-stationary historically. Homogeneity is imposed in the cost function, but symmetry is not.

$$\begin{aligned}
\text{VPDO} &= (1 / \text{RTPDO}) \\
& * (0.177 - 0.00782 * \text{LOG}(\text{RTPDC} * \text{PXB} / \text{PXP}) \\
& - 0.0553 * \text{LOG}(\text{RTPS} * \text{PXB} / \text{PXP}))
\end{aligned}$$

b.30 VPS: Desired structures-output ratio

The production function is Cobb-Douglas in capital services. However, individual capital stocks enter through a translog cost function, where the long-run determinants are the user costs of comp., soft, and comm. eq. and the user cost of structures, as these two determinants are non-stationary historically. Homogeneity is imposed in the cost function, but symmetry is not.

$$\begin{aligned} \text{VPS} = & (1/\text{RTPS}) \\ & * (0.720 + 0.0281 * \text{LOG}(\text{RTPDC} * \text{PXB}/\text{PXP}) \\ & + 0.183 * \text{LOG}(\text{RTPS} * \text{PXB}/\text{PXP})) \end{aligned}$$

b.31 HGVPDC: trend growth rate of VPDC

The trend growth rate of the capital-output ratio is estimated using a one-sided H-P filter (lambda = 6400) for the level of the capital-output ratio

$$\begin{aligned} \text{HGVPDC} = & 1.84 * \text{HGVPDC}_{t-1} \\ & - 0.853 * \text{HGVPDC}_{t-2} \\ & + 0.0115 * \log(\text{VPDC}/\text{VPDC}_{t-1}) \end{aligned}$$

b.32 HGVPDO: trend growth rate of VPDO

The trend growth rate of the capital-output ratio is estimated using a one-sided H-P filter (lambda = 6400) for the level of the capital-output ratio

$$\begin{aligned} \text{HGVPDO} = & 1.84 * \text{HGVPDO}_{t-1} \\ & - 0.853 * \text{HGVPDO}_{t-2} \\ & + 0.0115 * \log(\text{VPDO}/\text{VPDO}_{t-1}) \end{aligned}$$

b.33 HGVPS: trend growth rate of VPS

The trend growth rate of the capital-output ratio is estimated using a one-sided H-P filter (lambda = 6400) for the level of the capital-output ratio

$$\begin{aligned} \text{HGVPS} = & 1.84 * \text{HGVPS}_{t-1} \\ & - 0.853 * \text{HGVPS}_{t-2} \\ & + 0.0115 * \log(\text{VPS}/\text{VPS}_{t-1}) \end{aligned}$$

Foreign Trade

The core of the foreign trade sector is a pair of behavioral equations for the volume of exports and nonoil imports. In addition, there is an equation determining domestic crude energy consumption (and thus the volume of oil imports), as well as a variety of identities and quasi-identities for aggregate real and nominal exports and imports, U.S. net foreign investment income, the current account balance, and the net foreign asset position of the United States.

c.1 EX: Exports of goods and services, cw 2000 \$

The growth of exports is modeled in an error-correction format. In the long run, the volume of exports depends on foreign output (FGDP), export prices relative to foreign prices ($PXR*PXP*FPX/FPC$), and a time trend. The long-run income elasticity of exports is constrained to equal unity so that the model is stable along its steady-state growth path. The short-run income elasticity is almost 3. The long-run price elasticity of demand is -0.9. The effect of large dock strikes in the 1960s and 1970s is removed by dummifying out affected quarters.

$$\begin{aligned} \text{del(1 : log(EX))} = & -0.105 * (\log(\text{EX}_{t-1}) - \log(\text{FGDP}_{t-1})) \\ & + 0.940309 * \log(\text{PXR}_{t-1} * \text{PXP}_{t-1} * \text{FPX}_{t-1} / \text{FPC}_{t-1}) \\ & + 0.000109 * \text{T47} \\ & + 0.658 \\ & + 2.14 * ((\log(\text{FGDP}) - \log(\text{FGDP}_{t-2})) / 2) \\ & + 0.910 * ((\log(\text{FGDP}_{t-2}) - \log(\text{FGDP}_{t-6})) / 4) \\ & + 1.00 * \text{DDOCKX} \end{aligned}$$

Regression statistics

R ² :	.78043
Sum of squared residuals:	.047713
Standard error of regression:	.017378
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006
Serial Correlation (up to 4th order):	p =

c.2 EXN: Exports of goods and services, current \$

$$\text{EXN} = .01 * \text{PXP} * \text{PXR} * \text{EX}$$

c.3 EMO: Imports of goods and services ex. petroleum, cw 2000\$

The growth of non-oil imports (EMO) is modeled in an error-correction format. In the long run, the volume of imports depends on the level of domestic income (a weighted average of GDP and disposable income), relative non-oil import prices, the output gap, and a time trend. The long-run income elasticity of non-oil imports is constrained to equal unity so that the model is stable along its steady-state growth path. The inclusion of the level of the output gap means the short-to-medium-run income elasticity (holding potential output constant) is 2.6. The coefficient on the relative price facing buyers (PMO/PGDP), -0.7, represents the price elasticity of demand. The coefficient on the relative price facing sellers (PMO*FPXM/FPCM) 0.4 represents the price elasticity of supply. Short-run import growth is a function of the lagged difference between actual and steady-state non-oil imports, the change in the output gap and dock strikes. The effect of large dock strikes in the 1960s and 1970s is removed by including a dummy constructed by Peter Isard (IFDP No. 60, 1975)

$$\begin{aligned} \text{del}(1 : \log(\text{EMO})) = & -0.267 * (\log(\text{EMO}_{t-1}) - 0.33 * \log(\text{YH}_{t-1}) - 0.67 * \log(\text{XGDP}_{t-1})) \\ & + 0.743170 * \log(\text{PMO}_{t-1} / \text{PGDP}_{t-1}) \\ & - 0.443955 * (\log((\text{PMO}_{t-1} * \text{FPXM}_{t-1}) / \text{FPCM}_{t-1})) \\ & + 0.00284 * \text{T47} \\ & - 1.66 \\ & + 1.41 * ((\text{XGAP2} - \text{XGAP2}_{t-1}) / 100) \\ & + 1.29 * ((\text{XGAP2}_{t-1} - \text{XGAP2}_{t-2}) / 100) \\ & + 0.427 * (\text{XGAP2}_{t-2} / 100) \\ & + 0.717 * \text{del}(1 : \log(\text{DDOCKM})) \\ & + 0.357 * \log(\text{DDOCKM}_{t-1}) \end{aligned}$$

Regression statistics

R ² :	.70509
Sum of squared residuals:	.060524
Standard error of regression:	.019697
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006
Serial Correlation (up to 4th order):	p =

c.4 EMON: Imports of goods and services ex. petroleum

$$\text{EMON} = .01 * \text{PMO} * \text{EMO}$$

c.5 CENG: Consumption of crude energy (oil, coal, natural gas), 2000 \$

Real growth in economy-wide consumption of crude energy (oil, natural gas, and coal) is determined in an error-correction format, in which the long-run level of consumption is proportional to aggregate gross output (XG) and the trend optimal energy-output ratio (VEOA). In the short run, energy consumption growth is also affected by lagged growth, growth in the optimal energy-output ratio, growth in spot energy prices relative to trend (VEO/VEOA), and growth in gross output.

$$\begin{aligned} \text{del}(1 : \log(\text{CENG})) = & \\ & -0.245 * (\log(\text{CENG}_{t-1}) - \log(\text{XG}_{t-1} * \text{VEOA}_{t-1})) \\ & - 0.854 \\ & + \text{B1(L) } \{\text{sum } 1.43 \} * \text{del}(1 : \log(\text{XG}_t)) \\ & + 0.0226 * \text{del}(1 : \log(\text{VEOA})) \\ & + \text{B3(L) } \{\text{sum } -0.433 \} * \text{del}(1 : \log(\text{CENG}_{t-1})) \end{aligned}$$

Distributed lag coefficients

Name	Value
B1 ₀	0.702
B1 ₁	0.731
B1SUM	1.43
B3 ₀	-0.246
B3 ₁	-0.187
B3SUM	-0.433

Regression statistics

R ² :	.34028
Sum of squared residuals:	.095448
Standard error of regression:	.024578
Durbin-Watson statistic:	2.0611
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

c.6 EMP: Petroleum imports, cw 2000\$

EMP equals the difference between domestic energy consumption and production multiplied by an exogenous conversion factor.

$$\text{EMP} = \text{UEMP} * (\text{CENG} - \text{XENG})$$

c.7 EMPN: Petroleum imports, current \$

$$\text{EMPN} = .01 * \text{PMP} * \text{EMP}$$

c.8 EMN: Imports of goods and services, current \$

$$\text{EMN} = \text{EMON} + \text{EMPN}$$

c.9 EM: Imports of goods and services, cw 2000\$

Total export volumes are approximated by the Divisia aggregate of oil and non-oil imports.

$$\begin{aligned} \log(\text{EM}) &= \log(\text{EM}_{t-1}) \\ &+ .5 * (\text{EMON}/\text{EMN} + \text{EMON}_{t-1}/\text{EMN}_{t-1}) * \text{del}(1:\log(\text{EMO})) \\ &+ .5 * (\text{EMPN}/\text{EMN} + \text{EMPN}_{t-1}/\text{EMN}_{t-1}) * \text{del}(1:\log(\text{EMP})) \end{aligned}$$

c.10 FCBN: US current account balance, current \$

The current account balance is equal to net exports (EXN - EMN) plus net foreign investment income (FYNIN), plus a discrepancy (FCBRN).

$$\text{FCBN} = \text{EXN} - \text{EMN} + \text{FYNIN} + \text{FCBRN}$$

c.11 FCBRN: US current account balance residual, current \$

The discrepancy in the current account balance is assumed to be proportional to nominal potential output.

$$\text{FCBRN} = \text{UFCBR} * \text{PXG} * \text{XGPOT} / 100$$

c.12 FNFIN: Net foreign investment

$$\text{FNFIN} = \text{FCBN} + \text{FNFIRN}$$

c.13 FNFIR: Discrepancy between net foreign investment and current account balance

$$\text{FNFIR} = \text{UFNFIR} * (.01 * \text{PXG} * \text{XGPOT})$$

c.14 FNIN: Net stock of claims of US residents on the rest of the world, current \$

The change in the net foreign investment position is equal to the current account balance expressed at a quarterly rate.

$$\begin{aligned} \text{del}(1 : \text{FNIN}) &= .25 * \text{FCBN} \\ &+ .54 * (\text{del}(1 : \log(\text{FPC})) * \text{FNICN}_{t-1}) \\ &- .32 * (\text{del}(1 : \log(\text{PGDP})) * \text{FNILN}_{t-1}) \\ &- .67 * (\text{del}(1 : \log(\text{FPX})) * \text{FNICN}_{t-1}) \\ &+ .06 * (\text{del}(1 : \log(\text{FPX})) * \text{FNILN}_{t-1}) \\ &+ \text{FNIRN} \end{aligned}$$

c.15 FTCIN: Corporate taxes paid to rest of world, current \$

Corporate taxes paid to the rest of the world are assumed to be proportional to nominal GDP.

$$\text{FTCIN} = \text{UFTCIN} * \text{YNICPN}$$

c.16 FYNIN: Net investment income received from the rest of the world, current \$

$$\text{FYNIN} = \text{FYNICN} - \text{FYNILN}$$

c.17 HGEMP: Petroleum imports, cw 2000\$, trend growth rate

$$\begin{aligned} \text{HGEMP} &= 0.900 * \text{HGEMP}_{t-1} \\ &+ 0.100 * 400 * \log(\text{EMP}/\text{EMP}_{t-1}) \end{aligned}$$

c.18 FNICN: Gross stock of claims of US residents on the rest of the world, current \$

$$\begin{aligned} \text{del}(1:\text{FNICN})/\text{XGDPTN} &= .54 * \text{del}(1: \log(\text{FPC})) * \text{FNICN}_{t-1} / \text{XGDPTN} \\ &\quad - .67 * \text{del}(1: \log(\text{FPX})) * \text{FNICN}_{t-1} / \text{XGDPTN} \\ &\quad + \text{RFNICT} \end{aligned}$$

c.19 FNILN: Gross stock of liabilities of US residents to the rest of the world, current \$

$$\text{FNILN} = \text{FNICN} - \text{FNIN}$$

c.20 FYNICN: Gross investment income received from the rest of the world, current \$

$$\text{FYNICN} = .01 * \text{RFYNIC} * \text{FNICN}_{t-1}$$

c.21 FYNILN: Gross investment income paid to the rest of the world, current \$

$$\text{FYNILN} = .01 * \text{RFYNIL} * \text{FNILN}_{t-1}$$

c.22 RFYNIC: Average yield earned on gross claims of US residents on the rest of the world

$$\begin{aligned} \text{del}(1 : \text{RFYNIC}) &= 0.264 \\ &\quad - 0.152 * (\text{RFYNIC}_{t-1} - \text{RFYNIL}_{t-1}) \\ &\quad + 0.156 * \text{del}(1 : \text{RFYNIC}_{t-1}) \\ &\quad + 0.652 * \text{del}(1 : \text{RFYNIL}) \end{aligned}$$

Regression statistics

R ² :	.40994
Sum of squared residuals:	14.829
Standard error of regression:	.32545
Durbin-Watson statistic:	2.2732
Sample period:	1970:q1 - 2005:q4
Estimation date:	August 2006

c.23 RFYNIL: Average yield earned on liabilities of US residents on the rest of the world

$$\begin{aligned} \text{del}(1 : \text{RFYNIL}) &= 0.138 \\ &- 0.244 * \text{RFYNIL}_{t-1} \\ &+ 0.0932 * \text{RG10}_{t-1} \\ &+ 0.0825 * \text{RTB}_{t-1} \\ &+ 0.0383 * \text{REQP}_{t-1} \\ &+ 0.106 * \text{del}(1 : \text{RFYNIL}_{t-1}) \\ &+ 0.133 * \text{del}(1 : \text{RG10}) \\ &+ 0.261 * \text{del}(1 : \text{RTB}) \\ &+ 0.0614 * \text{del}(1 : \text{REQP}) \end{aligned}$$

Regression statistics

R ² :	.61779
Standard error of regression:	.23705
Durbin-Watson statistic:	2.2958
Sample period:	1970:q1 - 2005:q4
Estimation date:	August 2006

c.24 FNIRN: Net stock of claims of US residents on the rest of the world, residual

$$\text{FNIRN} = \text{UFNIR} * \text{XGDPN}$$

Aggregate Output Identities

This sector contains aggregate identities determining the level of various measures of real aggregate output and demand. Some of these aggregates, such as GDP and final sales, are built up from component expenditure categories that are determined in other sectors of the model. Other aggregates, such as government output, are linked by exogenous conversion ratios to a related indicator (e.g., government employment). In either case, historical data for the various aggregates are typically based on series published by the Commerce Department. However, two measures -- output of the nonfarm business sector (less housing and energy and

net of indirect business taxes), and final sales excluding government compensation, imports and indirect business taxes -- are special FRB/US constructs. The former is the measure of output used in the model's aggregate production function, while the latter is used to define the main price variable in the determination of wages and prices.

In addition to these measures of aggregate output and demand, the sector also contains a set of equations determining the level of potential output -- that is, the level of production consistent with full employment in the labor market and labor productivity at its trend. Two related measures of potential output are used in the model. The first (XGPOT) refers to the maximum sustainable level of production in the adjusted nonfarm business sector; the second is XGDPT, which denotes the level of potential GDP.

d.1 XFS: Final sales of gross domestic product, cw 2000\$

The real final sales category of GDP is approximated by the Divisia aggregate of its components.

$$\begin{aligned}
 \log(\text{XFS}) &= \log(\text{XFS}_{t-1}) \\
 &+ .5 * (\frac{\text{ECNIAN}}{\text{XFSN}} + \frac{\text{ECNIAN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{ECNIA})) \\
 &+ (\frac{\text{EHN}}{\text{XFSN}} + \frac{\text{EHN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EH})) \\
 &+ (\frac{\text{EPDCN}}{\text{XFSN}} + \frac{\text{EPDCN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EPDC})) \\
 &+ (\frac{\text{EPDON}}{\text{XFSN}} + \frac{\text{EPDON}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EPDO})) \\
 &+ (\frac{\text{EPSN}}{\text{XFSN}} + \frac{\text{EPSN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EPS})) \\
 &+ (\frac{\text{EGFON}}{\text{XFSN}} + \frac{\text{EGFON}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EGFO})) \\
 &+ (\frac{\text{EGFIN}}{\text{XFSN}} + \frac{\text{EGFIN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EGFI})) \\
 &+ (\frac{\text{EGFLN}}{\text{XFSN}} + \frac{\text{EGFLN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EGFL})) \\
 &+ (\frac{\text{EGSON}}{\text{XFSN}} + \frac{\text{EGSON}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EGSO})) \\
 &+ (\frac{\text{EGSIN}}{\text{XFSN}} + \frac{\text{EGSIN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EGSI})) \\
 &+ (\frac{\text{EGSLN}}{\text{XFSN}} + \frac{\text{EGSLN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EGSL})) \\
 &+ (\frac{\text{EXN}}{\text{XFSN}} + \frac{\text{EXN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EX})) \\
 &- (\frac{\text{EMON}}{\text{XFSN}} + \frac{\text{EMON}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EMO})) \\
 &- (\frac{\text{EMPN}}{\text{XFSN}} + \frac{\text{EMPN}_{t-1}}{\text{XFSN}_{t-1}} * \text{del}(1:\log(\text{EMP}))
 \end{aligned}$$

d.2 XGDP: GDP, cw 2000\$

Real gross domestic output (XGDP) is the chain-weighted aggregate of final sales and inventory investment.

$$\begin{aligned}
 \text{XGDP} &= \text{XGDP}_{t-1} * \text{SQRT}(\\
 & (\frac{\text{XFSN}_{t-1}}{\text{XGDPN}_{t-1}} * \frac{\text{XFS}}{\text{XFS}_{t-1}} \\
 & + (.01 * \frac{\text{EI}_{t-1} * \text{PKIR}_{t-1} * \text{PXP}_{t-1}}{\text{XGDPN}_{t-1}} * \frac{\text{EI}}{\text{EI}_{t-1}}) \\
 & * 1/ \\
 & (\frac{\text{XFSN}}{\text{XGDPN}} * \frac{\text{XFS}_{t-1}}{\text{XFS}} \\
 & + (.01 * \frac{\text{EI} * \text{PKIR} * \text{PXP}}{\text{XGDPN}} * \frac{\text{EI}_{t-1}}{\text{EI}})
 \end{aligned}$$

d.3 HGGDP: Growth rate of GDP, cw 2000\$ (compound annual rate)

$$\text{HGGDP} = 400 * \text{del}(1 : \log(\text{XGDP}))$$

d.4 XGV: Government sector output, cw 2000\$

$$\text{XGV} = \text{XGVN} / (.01 * \text{PXGV})$$

d.5 XHHI: Output of households and institutions, cw 2000\$

Output of households and institutions is proportional to potential output in the adjusted nonfarm business sector (XGPOT).

$$\text{XHHI} = \text{UXHHI} * \text{XGPOT}$$

d.6 XB: Business sector output, cw 2000\$

Real business output (XB) is approximated by the Divisia aggregate of real GDP less real output in the government and households and institutions sectors.

$$\begin{aligned} \log(\text{XB}) = & \log(\text{XB}_{t-1}) \\ & + .5 * (\text{XGDPN}/\text{XBN} + \text{XGDPN}_{t-1}/\text{XBN}_{t-1}) * \text{del}(1:\log(\text{XGDP})) \\ & - .5 * (\text{XGVN}/\text{XBN} + \text{XGVN}_{t-1}/\text{XBN}_{t-1}) * \text{del}(1:\log(\text{XGV})) \\ & - .5 * (\text{XHHIN}/\text{XBN} + \text{XHHIN}_{t-1}/\text{XBN}_{t-1}) * \text{del}(1:\log(\text{XHHI})) \end{aligned}$$

d.7 XFB: Output of farm sector , cw 2000\$

The output of farms is linked to potential GDP (XGPOT) via an exogenous conversion ratio (UXFB).

$$\text{XFB} = \text{UXFB} * \text{XGPOT}$$

d.8 XNFB: BLS NFB output, 2000\$

BLS NFB output is the Divisia aggregate of business sector output (XB) minus the output of the farm sector (XFB).

$$\begin{aligned}\log(\text{XNFB}) &= \log(\text{XNFB}_{t-1}) \\ &+ .5 * (\text{XBN}/\text{XNFBN} + \text{XBN}_{t-1}/\text{XNFBN}_{t-1}) * \text{del}(1:\log(\text{XB})) \\ &- .5 * (\text{XFBN}/\text{XNFBN} + \text{XFBN}_{t-1}/\text{XNFBN}_{t-1}) * \text{del}(1:\log(\text{XFB}))\end{aligned}$$

d.9 XENG: Crude energy production, c2 2000\$

Output of fossil energy is linked to aggregate potential output (XGPOT) via an exogenous conversion ratio (UXENG).

$$\text{XENG} = \text{UXENG} * \text{XGPOT}$$

d.10 XG: Output of nonfarm, nonhousing business sector plus oil imports (net of IBT)

Gross output of the adjusted non-farm non-energy business sector is the Divisia aggregate of BLS business sector output (XNFB) and oil imports (EMP).

$$\begin{aligned}\log(\text{XG}) &= \log(\text{XG}_{t-1}) \\ &+ .5 * (\text{XNFBN}/(\text{XNFBN} + \text{EMP}) + \text{XNFBN}_{t-1}/(\text{XNFBN}_{t-1} + \text{EMP}_{t-1})) * \text{del}(1:\log(\text{XNFB})) \\ &+ .5 * (\text{EMP}/(\text{XNFBN} + \text{EMP}) + \text{EMP}_{t-1}/(\text{XNFBN}_{t-1} + \text{EMP}_{t-1})) * \text{del}(1:\log(\text{EMP}))\end{aligned}$$

d.11 XP: Final sales plus imports less gov. labor and ind. bus. taxes, cw 2000\$

Real domestic final purchases, excluding government compensation but including exports, are approximated by the Divisia aggregate of its components.

$$\begin{aligned}\log(\text{XP}) &= \log(\text{XP}_{t-1}) \\ &+ .5 * (\text{ECNIA}/\text{XPN} + \text{ECNIA}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{ECNIA})) \\ &+ .5 * (\text{EHN}/\text{XPN} + \text{EHN}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EH})) \\ &+ .5 * (\text{EPDCN}/\text{XPN} + \text{EPDCN}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EPDC})) \\ &+ .5 * (\text{EPDON}/\text{XPN} + \text{EPDON}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EPDO})) \\ &+ .5 * (\text{EPSN}/\text{XPN} + \text{EPSN}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EPS})) \\ &+ .5 * (\text{EGFON}/\text{XPN} + \text{EGFON}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EGFO})) \\ &+ .5 * (\text{EGFIN}/\text{XPN} + \text{EGFIN}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EGFI})) \\ &+ .5 * (\text{EGSON}/\text{XPN} + \text{EGSON}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EGSO}))\end{aligned}$$

$$\begin{aligned}
 & + .5 * (\text{EGSIN}/\text{XPN} + \text{EGSIN}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EGSI})) \\
 & + .5 * (\text{EXN}/\text{XPN} + \text{EXN}_{t-1}/\text{XPN}_{t-1}) * \text{del}(1:\log(\text{EX}))
 \end{aligned}$$

d.12 EFS: Business final sales, cw 2000\$

Real business final sales (EFS) equal the chain-weighted aggregate of business sector output less inventory investment.

$$\begin{aligned}
 \text{EFS} = & \text{EFS}_{t-1} * \text{SQRT}(\\
 & ((\text{XBN}_{t-1}/\text{EFSN}_{t-1}) * (\text{XB}/\text{XB}_{t-1}) \\
 & - (.01 * \text{EI}_{t-1} * \text{PKIR}_{t-1} * \text{PXP}_{t-1} / \text{EFSN}_{t-1}) * (\text{EI}/\text{EI}_{t-1})) \\
 & * 1/ \\
 & ((\text{XBN}/\text{EFSN}) * (\text{XB}_{t-1}/\text{XB}) \\
 & - (.01 * \text{EI} * \text{PKIR} * \text{PXP} / \text{EFSN}) * (\text{EI}_{t-1}/\text{EI}))
 \end{aligned}$$

d.13 HMFPT: Trend growth rate of multifactor productivity

$$\text{HMFPT} = 0.00 + 1.00 * \text{HMFPT}_{t-1}$$

d.14 MFPT: Multifactor productivity, trend level

$$\log(\text{MFPT}) = 0.00 + \log(\text{MFPT}_{t-1}) + \text{HMFPT}/400$$

d.15 VEO: Desired energy-output ratio

The optimal energy-output ratio for new equipment (VEO) is proportional to the inverse of the relative price of energy inputs, given a KLE Cobb-Douglas production function. PXB is the price index for business output, and PCENG is a price index for fossil energy inputs.

$$\log(\text{VEO}) = \log(\text{PXB}/\text{PCENG})$$

d.16 VEOA: Average energy-output ratio of existing capital stock

Given Cobb-Douglas production, the optimal energy-output ratio for new equipment (VEO) is proportional to the inverse of the relative price of energy. However, the putty-clay assumption means that the average energy-output ratio for the existing stock of capital (VEOA) will be roughly proportional to a distributed lag of past optimal energy-output ratios (VEOA). An adjustment speed of 1.2 percent per quarter yields a series for VEOA that provides the best fit for the model's energy (CENG) equation. Note: Since the mid-1990s, actual energy use has fallen short of the level consistent with lagged price movements. This shortfall is captured by a trend break that starts in 1994:Q1; this term (UVEOA) reduces the growth rate of VEOA thereafter by 2.5 percent at an annual rate.

$$\begin{aligned}\log(\text{VEOA}) &= 0.988 * \log(\text{VEOA}_{t-1}) \\ &+ 0.0120 * \log(\text{VEO}_{t-1}) \\ &+ \text{UVEOA}\end{aligned}$$

d.17 XGPOT: Potential output of bus. sector ex. energy, housing, and farm, cw 2000\$

Potential output (XGPOT) is based on a three-factor KLE Cobb-Douglas production function. In addition to measures of factor inputs, the equation also contains trend multi-factor productivity (MFPT), which is actual MFP smoothed with the HP filter.

Potential labor input depends on trend employment (LEPPOT), trend hours per worker (QLWW), and trend labor quality (LQUALT). Capital input is measured by capital services (KS), and energy input by the energy-output ratio for the existing stock of capital (VEOA). Because the latter is the ratio of energy to output, rather than energy by itself, solving the equation for output results in the whole right hand side being divided by one minus the energy share parameter.

$$\begin{aligned}\log(\text{XGPOT}) &= (0.700 * (\log(\text{LEPPOT}) + \log(\text{QLWW}) + \log(\text{LQUALT})) \\ &+ 0.265 * \log(\text{KS}) \\ &+ 0.0350 * \log(\text{VEOA}) \\ &+ \log(\text{MFPT}) / (1-0.0350)\end{aligned}$$

d.18 HGX: Growth rate of XGPOT, cw 2000\$ (compound annual rate)

$$\begin{aligned}\text{HGX} &= (.7 * (\text{HLEPT} + \text{HQLWW} + 400 * \text{del}(1 : \log(\text{LQUALT}))) + .265 * \text{HKS} \\ &+ .035 * 400 * \text{del}(1 : \log(\text{VEOA})) + \text{HMFPT}) / .965\end{aligned}$$

d.19 EMPT: Petroleum imports trend, cw 2000\$

The trend component of oil imports is updated in simulations using an error-correction equation that ensures gradual adjustment of the trend to actual imports (EMP). In the historical data, however, EMPT is obtained by H-P filtering EMP.

$$\begin{aligned} \text{del}(1: \log(\text{EMPT})) &= 0.100 \text{ [(const.)]} * \log(\text{EMP}_{t-1}/\text{EMPT}_{t-1}) \\ &+ 1.00 \text{ [(const.)]} * \text{HGEMP}/400 \end{aligned}$$

d.20 XFBT: Output of housing and farm sectors, trend, cw 2000\$

The trend component of agricultural and housing output is updated in simulations using an error-correction equation that ensures gradual adjustment of the trend to actual output (XFB). In the historical data, however, XFBT is obtained by H-P filtering XFB.

$$\begin{aligned} \text{del}(1: \log(\text{XFBT})) &= 0.100 \text{ [(const.)]} * \log(\text{XFB}_{t-1}/\text{XFBT}_{t-1}) \\ &+ 1.00 \text{ [(const.)]} * \text{HGXFB}/400 \end{aligned}$$

d.21 HGXFB: Output of farm sector , cw 2000\$, trend growth rate

$$\begin{aligned} \text{HGXFB} &= 0.900 * \text{HGXFB}_{t-1} \\ &+ 0.100 * 400 * \log(\text{XFB}/\text{XFB}_{t-1}) \end{aligned}$$

d.22 XGVT: Government output, trend, cw 2000\$

The trend component of government output is updated in simulations using an error-correction equation that ensures gradual adjustment of the trend to actual output (XGV). In the historical data, however, XGVT is obtained by H-P filtering XGV.

$$\begin{aligned} \text{del}(1: \log(\text{XGVT})) &= 0.100 \text{ [(const.)]} * \log(\text{XGV}_{t-1}/\text{XGVT}_{t-1}) \\ &+ 1.00 \text{ [(const.)]} * \text{HGXGV}/400 \end{aligned}$$

d.23 HGXGV: Government sector output, cw 2000\$, trend growth rate

$$\begin{aligned} \text{HGXGV} &= 0.900 * \text{HGXGV}_{t-1} \\ &+ 0.100 * 400 * \log(\text{XGV}/\text{XGV}_{t-1}) \end{aligned}$$

d.24 XHHIT: Output of households and institutions, trend, cw 2000\$

The trend component of households and institutions output is updated in simulations using an error-correction equation that ensures gradual adjustment of the trend to actual output (XHHI). In the historical data, however, XHHIT is obtained by H-P filtering XHHI.

$$\begin{aligned} \text{del}(1: \log(\text{XHHIT})) &= 0.100 \text{ [(const.)]} * \log(\text{XHHI}_{t-1}/\text{XHHIT}_{t-1}) \\ &+ 1.00 \text{ [(const.)]} * \text{HGXHHI}/400 \end{aligned}$$

d.25 HGXHHI: Output of households and institutions, cw 2000\$, trend growth rate

$$\begin{aligned} \text{HGXHHI} &= 0.900 * \text{HGXHHI}_{t-1} \\ &+ 0.100 * 400 * \log(\text{XHHI}/\text{XHHI}_{t-1}) \end{aligned}$$

d.26 XGAP: Output gap for bus. sector ex. energy, housing, and farm (actual - potential)

XGAP is the percentage gap between actual and trend output for the adjusted nonfarm business sector.

$$\text{XGAP} = 100 * \log(\text{XG}/\text{XGPOT})$$

d.27 XGAP2: Output gap for GDP (actual - potential)

XGAP2 is the percentage gap between actual and trend GDP.

$$\begin{aligned} \text{XGAP2} &= \\ &+ .5 * ((\text{XGN}/\text{UXGN})/\text{XGDPN} \\ &+ (\text{XGN}_{t-1}/\text{UXGN}_{t-1})/\text{XGDPN}_{t-1}) \\ &* \text{XGAP} \\ &- .5 * (\text{EMP}/\text{XGDPN} + \text{EMP}_{t-1}/\text{XGDPN}_{t-1}) \\ &* 100 * \text{LOG}(\text{EMP}/\text{EMPT}) \\ &+ .5 * (\text{XFB}/\text{XGDPN} + \text{XFB}_{t-1}/\text{XGDPN}_{t-1}) \\ &* 100 * \text{LOG}(\text{XFB}/\text{XFBT}) \\ &+ .5 * (\text{XGVN}/\text{XGDPN} + \text{XGVN}_{t-1}/\text{XGDPN}_{t-1}) \\ &* 100 * \text{LOG}(\text{XGV}/\text{XGVT}) \\ &+ .5 * (\text{XHHIN}/\text{XGDPN} + \text{XHHIN}_{t-1}/\text{XGDPN}_{t-1}) \\ &* 100 * \text{LOG}(\text{XHHI}/\text{XHHIT}) \end{aligned}$$

d.28 HGGDPT: Growth rate of XGDPT, cw 2000\$ (compound annual rate)

HGGDPT =

$$\begin{aligned}
 & + .5 * ((\underline{XGN}/\underline{UXGN})/\underline{XGDPN}) \\
 & + (\underline{XGN}_{t-1}/\underline{UXGN}_{t-1})/\underline{XGDPN}_{t-1}) \\
 & * \underline{HGX} \\
 & - .5 * (\underline{EMPN}/\underline{XGDPN} + \underline{EMPN}_{t-1}/\underline{XGDPN}_{t-1}) \\
 & * 400*\text{del}(1 : \log(\underline{EMPT})) \\
 & + .5 * (\underline{XFBN}/\underline{XGDPN} + \underline{XFBN}_{t-1}/\underline{XGDPN}_{t-1}) \\
 & * 400*\text{del}(1 : \log(\underline{XFBT})) \\
 & + .5 * (\underline{XGVN}/\underline{XGDPN} + \underline{XGVN}_{t-1}/\underline{XGDPN}_{t-1}) \\
 & * 400*\text{del}(1 : \log(\underline{XGVT})) \\
 & + .5 * (\underline{XHHIN}/\underline{XGDPN} + \underline{XHHIN}_{t-1}/\underline{XGDPN}_{t-1}) \\
 & * 400*\text{del}(1 : \log(\underline{XHHIT}))
 \end{aligned}$$

d.29 XGDPT: Potential GDP, cs 2000\$

Potential GDP equals actual GDP less the output gap.

$$\log(\underline{XGDPT}) = \log(\underline{XGDP}) - .01*\underline{XGAP2}$$

d.30 XGDPTN: Potential GDP, nominal

Trend nominal potential GDP equals the sum of its nominal components: adjusted trend nonfarm business output (XGPOT), trend farm and housing output (XFBT), trend government output (XGVT), and trend output of households and institutions, less trend oil imports (EMPT), all evaluated at their respective prices.

$$\begin{aligned}
 \underline{XGDPTN} = & .01*\underline{PXG}*\underline{XGPOT}/\underline{UXGN} \\
 & + .01*(\underline{PXFBR}*\underline{PXB}*\underline{XFBT} + \underline{PXGV}*\underline{XGVT} + \underline{PXHHIR}*\underline{PXB}*\underline{XHHIT} - \underline{PMP}*\underline{EMPT})
 \end{aligned}$$

d.31 XNFBT: potential NFB output

$$\begin{aligned}
 \log(\underline{XNFBT}) = & \log(\underline{XNFB}) \\
 & - .5*((\underline{XNFBN}+\underline{EMPN})/\underline{XNFBN} + (\underline{XNFBN}_{t-1}+\underline{EMPN}_{t-1})/\underline{XNFBN}_{t-1}) * .01*\underline{XGAP} \\
 & + .5*(\underline{EMPN}/\underline{XNFBN} + \underline{EMPN}_{t-1}/\underline{XNFBN}_{t-1}) * \log(\underline{EMP}/\underline{EMPT})
 \end{aligned}$$

Labor Market

This sector determines a variety of labor market variables, including hours worked, private employment in the nonfarm business sector, and household employment and labor force participation. The chief equation in the sector is that for growth in hours worked, which is modeled using the polynomial adjustment cost (PAC) framework. Over time, hours worked error-corrects to a long-run equilibrium level consistent with aggregate output and trend labor productivity. The latter is defined in a manner consistent with the aggregate production function, and thus depends on the optimal capital/output and energy/output ratios (which in turn are functions of relative factor prices).

e.1 LHP: Aggregate labor hours, nonfarm business sector (employee and self-employed)

In addition to determining the dynamics of hours adjustment, estimates of the FRB/US hours equation also yield historical values of the trend multifactor productivity (mfp). The latter enters the equation implicitly as a level through its contribution to the target level of hours (QLHP) and as a growth rate through its contribution to the growth rate of trend labor productivity (HLPRDT). Multifactor productivity is modeled as a random walk with drift, which requires that the hours equation be estimated using the Kalman filter.

The level of trend mfp (MFPT) and its growth rate (HMFPT) also appear explicitly in the hours equation, but these terms are present only to make the timing of the implicit contributions consistent with the manner in which the equation was estimated. For example, the first lag of QLHP contains the first lag of MFPT, but we interpret the MFPT series that results from estimating the hours equation as corresponding to contemporaneous MFPT. The extra MFPT term shifts the dating to achieve this.

Hours worked follows the polynomial adjustment cost framework, modified to allow for some portion of labor hours adjusting costlessly. The portion of the equation that corresponds to the costly adjusting hours consists of the three conventional PAC terms -- the degree hours were out of equilibrium last period, lagged hours growth, and expected growth in target hours (ZLHP). The portion of hours that adjust costlessly is captured by the current growth in target hours (the growth rate of XG less the growth rate of trend output per hour, HLPRDT). The coefficient on the latter indicates that nearly 40 percent of hours adjust costlessly and more than 60 percent of hours adjust according to the PAC specification. Lagged growth in target hours enters because of the aggregation of the two types of hours. Based on the derivation of the aggregate equation, its coefficient is restricted to be the negative of the product of the second and fifth coefficients.

$$\begin{aligned}
 \text{del}(1 : \log(\text{LHP})) = & \\
 & 0.216 * (\log(\text{QLHP}_{t-1}/\text{LHP}_{t-1}) - \text{del}(1 : \log(\text{MFPT}))/0.965) \\
 & + 0.174 * \text{del}(1 : \log(\text{LHP}_{t-1})) \\
 & + 0.00 \\
 & + 0.609 * \text{ZLHP} \\
 & + 0.391 * (\text{del}(1 : \log(\text{XG})) - \text{HLPRDT}_{t-1}/400 - \text{del}(1 : \text{HMFPT})/(0.965*400)) \\
 & - 0.0680 * (\text{del}(1 : \log(\text{XG}_{t-1})) - \text{HLPRDT}_{t-2}/400 - \text{del}(1 : \text{HMFPT}_{t-1})/(0.965*400))
 \end{aligned}$$

Regression statistics

R²:
 Sum of squared residuals:
 Standard error of regression:
 Sample period: 1961 1 2005 4
 Estimation date: Aug 2005
 or:

e.2 QLHP: Desired level of nonfarm business labor hours, trending component

The equilibrium level of aggregate hours equals gross output (XG) divided by trend labor productivity (LPRDT).

$$QLHP = \frac{XG}{LPRDT}$$

e.3 LWW: Workweek, nonfarm business sector (employee and self-employed)

The average workweek in the private nonfarm business sector is a random walk with a small downward drift plus a cyclical term.

The drift term implies that the workweek declines 0.3 percent a year on average.

The cyclical term is measured in terms of the acceleration of total hours. Its coefficient means that, on average, one third of a shift in total hours (LHP) comprises a change in the workweek, with two-thirds being a change in the workforce. The contribution from the workweek phases down to zero over the next few quarters.

Two components of potential output, the trend workweek and the expected growth in the trend workweek, are derived from coefficients estimated within the workweek equation.

The equation is coded so as to allow the user to eliminate permanent shocks, by setting the coefficient on lagged QLWW/LWW to a small positive value. This can be useful in long-run simulations. For normal purposes, this error-correction coefficient is set to zero. When freely estimated, this coefficient is negative.

$$\begin{aligned} \text{del}(1 : \log(LWW)) = & -0.000930 \\ & + 0.360 * (\text{del}(1 : \log(LHP)) - \text{HGLHP}_{t-1}) \\ & + 0.0100 * \log(\text{QLWW}_{t-1}/LWW_{t-1}) \end{aligned}$$

Regression statistics

R²: .64071
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

e.4 QLWW: Trend workweek, nonfarm business sector (employee and self-employed)

The cyclically-adjusted, or trend, workweek follows a random walk with drift. In estimation, the drift term (HQLWW) is estimated to be a constant and is the annualized intercept in the LWW equation.

$$\log(\text{QLWW}) = \log(\text{QLWW}_{t-1}) + \frac{\text{HQLWW}}{400}$$

e.5 HQLWW: Trend growth rate of workweek

The expected change in the trend workweek is the constant from the workweek equation, multiplied by 400 to be on an annualized percent change basis.

$$\text{HQLWW} = 400 * -0.000750$$

e.6 LEP: Employment in nonfarm business sector (employee and self-employed)

Employment in the non-farm business sector equals aggregate hours divided by the average workweek.

$$\text{LEP} = \frac{\text{LHP}}{\text{LWW}}$$

e.7 LEO: Discrepancy between civilian employment and NFB + gov. emp.

The behavior of LEO -- the difference between total employment in the household survey and the sum of private nonfarm employment (LEP) and government employment (LEF + LES) -- is modeled by the LUR equation

$$\text{LEO} = \text{LEH} - (\text{LEP} + \text{LEF} + \text{LES})$$

e.8 LEF: Federal civilian employment ex. gov. enterprise

Federal employment is proportional to constant-dollar federal government expenditures on employee compensation (EGFL), adjusted for trend productivity. Because the national accounts assume that there is no productivity growth in the government sector, the dummy variable DGLPRD is set to 0 over history. In

long-run simulations, however, DGLPRD is set to 1.0 to ensure that the government shares of employment and GDP are stationary.

$$\log(\mathbf{LEF}) = \log(\mathbf{ULEF}) + \log(\mathbf{EGFL}) - \mathbf{DGLPRD} * \log(\mathbf{LPRDT})$$

e.9 LES: S&L government employment ex. gov. enterprise

State and local employment is proportional to constant-dollar S&L government expenditures on employee compensation (EGSL), adjusted for trend productivity. Because the national accounts assume that there is no productivity growth in the government sector, the dummy variable DGLPRD is set to 0 over history. In long-run simulations, however, DGLPRD is set to 1.0 to ensure that the government shares of employment and GDP are stationary.

$$\log(\mathbf{LES}) = \log(\mathbf{ULES}) + \log(\mathbf{EGSL}) - \mathbf{DGLPRD} * \log(\mathbf{LPRDT})$$

e.10 LEH: Civilian employment (break adjusted)

Civilian employment from the household survey is the sum of nonfarm business employment (LEP), state and local government employment (LES), federal government employment (LEF), and the employment discrepancy (LEO). LEO is determined by the LUR equation.

$$\mathbf{LEH} = (1 - (\mathbf{LUR}/100)) * \mathbf{LF}$$

e.11 LFPR: Labor force participation rate

The participation rate grows, on average, at its trend rate (HQLFPR) which varies slowly over time. It also adjusts toward its equilibrium level (QLFPR), another slowly varying unobserved variable. The unobserved variables have the following structure:

$$\mathbf{QLFPR} = \mathbf{QLFPR}(-1) + \mathbf{HQLFPR} + \text{err}_1$$

$$\mathbf{HQLFPR} = \mathbf{HQLFPR}(-1) + \text{err}_2$$

The relative size of the shocks, combined with the error-correction coefficient mean that 63 percent of surprises to participation represent permanent level shifts, 4 percent represent shifts in the growth rate and the remaining 33 percent are transitory.

Cyclical variation in the participation rate is captured by including the gap between the unemployment rate and the NAIRU, which is lagged to avoid coefficient bias that might arise from measurement error that is common to LUR and LFPR.

Coefficients and the relative size of the shocks are estimated by the Kalman filter.

$$\begin{aligned} \text{del}(1: \text{LFPR}) &= \text{HQLFPR} \\ &+ 0.254 [2.3] * (\text{QLFPR} - \text{LFPR}_{t-1}) \\ &- 0.000357 [2.2] * (\text{LUR}_{t-1} - \text{LURNAT}_{t-1}) \end{aligned}$$

Regression statistics

R²:

standard deviation of I(0) error: .001828 (t=14.5)

standard deviation of I(1) error: .001213 (t=2.1)

standard deviation of I(2) error: .0000777 (t=1.8)

Log-likelihood: 1098.381

Sample period: 1948:q3 - 2005:q4

Estimation date: August 2006

e.12 QLFPR: Trend labor force participation rate (one-sided Kalman filter estimate)

The predicted change in the trend participation rate equals the one-sided Kalman filter estimate of the trend drift in the participation rate. The historical error of this equation differs from zero to the extent that shocks to the participation rate also lead to permanent shifts in the level of the trend.

$$\text{QLFPR} = \text{QLFPR}_{t-1} + \text{HQLFPR}$$

e.13 HQLFPR: Drift component of change in QLFPR (one-sided Kalman filter estimate)

$$\text{HQLFPR} = 0.00 + 1.00 * \text{HQLFPR}_{t-1}$$

e.14 LF: Civilian labor force (break adjusted)

$$\text{LF} = \text{LFPR} * \text{N16}$$

e.15 LUR: Civilian unemployment rate (break adjusted)

The equation for the unemployment rate is a dynamic Okun's law relationship. It determines the discrepancy between household and payroll employment (LEO) to ensure that the output gap and the unemployment gap co-move in a reasonable manner.

$$\begin{aligned}
 \text{LUR} &= \text{LURNAT} \\
 &+ 0.880 * (\text{LUR}_{t-1} - \text{LURNAT}_{t-1}) \\
 &+ 0.311 * \text{del}(1: \text{LUR}_{t-1} - \text{LURNAT}_{t-1}) \\
 &- 0.0641 * \text{XGAP2} \\
 &- 0.153 * \text{del}(1: \text{XGAP2})
 \end{aligned}$$

Regression statistics

R^2 : 0.982
 Standard error: 0.1168
 Sample period: 1986q1-2005q4
 Estimation date: August 2006

e.16 LURBLS: Civilian unemployment rate (published)

$$\text{LURBLS} = \text{LUR}$$

e.17 LURDA: Demographically-adjusted unemployment rate

LURDA is an aggregate of unemployment rates for five age-sex categories, with weights based on the demographic mix of the late 1960s. In model simulations, the demographically-adjusted unemployment rate is linked to the standard civilian unemployment rate (LUR) via an exogenous demographic adjustment factor (LURDF).

$$\text{LURDA} = \text{LUR} - \text{LURDF}$$

e.18 QLEP: Desired level of nonfarm business employment

The desired level of private non-farm employment equals aggregate hours in the private non-farm business sector divided by the trend workweek.

$$\text{QLEP} = \text{LHP} / \text{QLWW}$$

e.19 QLF: Desired level of civilian labor force

The trend labor force is equal to the product of the trend participation rate and the size of the population age

16 and up. The former term is obtained historically by H-P filtering the actual participation rate.

$$QLF = \underline{QLFPR} * N16$$

e.20 LEFT: Federal civilian employment ex. gov. enterprise, trend

Trend employment in the federal government sector increases with the trend component of the labor force (QLF) and adjusts gradually to actual federal government employment (LEF).

$$\begin{aligned} LEFT &= 0.900 [(const.)] * LEFT_{t-1} * \underline{QLF/QLF}_{t-1} \\ &+ 0.100 [(const.)] * \underline{LEF} \end{aligned}$$

e.21 LEST: S&L government employment ex. gov. enterprise, trend

Trend employment of state and local governments increases with the trend component of the labor force (QLF) and adjusts gradually to actual state and local government employment (LES).

$$\begin{aligned} LEST &= 0.900 [(const.)] * LEST_{t-1} * \underline{QLF/QLF}_{t-1} \\ &+ 0.100 [(const.)] * \underline{LES} \end{aligned}$$

e.22 LEPPOT: Potential employment in nonfarm business sector

The trend level of employment in the nonfarm business sector consists of potential economy-wide employment less trend employment in other sectors. Potential economy-wide employment equals the product of the trend labor force (QLF) and the proportion of the labor force employed in equilibrium (1.0 minus the natural rate of unemployment, LURNAT). Trend employment in sectors other than nonfarm business consists of trend government employment (LEST + LEFT) and trend "other" employment (QLEOR * QLF).

$$LEPPOT = \underline{QLF} * (1 - 0.01 * LURNAT - QLEOR) - \underline{LEFT} - \underline{LEST}$$

e.23 HLEPT: Trend growth rate of potential employment in the adjusted nonfarm business sector

HLEPT is the growth rate of potential employment in the adjusted nonfarm business sector, with the contribution of labor force participation measured as the drift component of the change in trend participation (as given by the one-sided Kalman filter estimate, HQLFPR, taken from the LFPR equation), not as the total change in trend participation, and the contribution of the "other" employment component measured by its

constant trend drift (HLEPT.A1, taken from the LEO equation) rather than its overall growth rate.

$$\begin{aligned} \text{HLEPT} = & 400 * \text{del}(1 : \log(\text{LEPPOT})) \\ & + 400 * \text{N16} * ((\text{HQLFPR} - \text{del}(1 : \text{QLFPR})) * (1 - .01 * \text{LURNAT} - \text{QLEOR}) \\ & + (\text{del}(1 : \log(\text{QLEOR})) - -.00463) * \text{QLFPR} * \text{mave}(2 : \text{QLEOR}_t) \\ & / \text{mave}(2 : \text{LEPPOT}_t) \end{aligned}$$

e.24 HGLHP: Aggregate labor hours, nonfarm business sector, trend growth rate

The growth rate of aggregate hours is used in the workweek equation.

$$\begin{aligned} \text{HGLHP} = & 0.700 * \text{HGLHP}_{t-1} \\ & + 0.300 * \text{del}(1 : \log(\text{LHP})) \end{aligned}$$

e.25 LPRDT: Trend labor productivity

Trend labor productivity in the adjusted nonfarm business sector is the ratio of potential output in that sector to trend total hours. The latter is the product of potential employment (LEPPOT) and the trend in hours per worker (QLWW).

$$\log(\text{LPRDT}) = \log(\text{XGPOT}) - \log(\text{LEPPOT}) - \log(\text{QLWW})$$

e.26 HLPRDT: Trend growth rate of output per hour

$$\text{HLPRDT} = \text{HGX} - \text{HLEPT} - \text{HQLWW}$$

Nominal Income

This sector consists mainly of accounting identities. The first set of equations specifies that measures of

nominal output equal the product of associated prices and real quantities. The second set of equations is for variables appearing on the income side of the national accounts. In this block, liberal use is made of multiplicative conversion factors, so that the full set of variables that appear in the NIPA identities do not have to be included in FRB/US. This part of the sector also contains estimated equations for interest payments by consumers to business, the implicit yield on household financial assets, and dividends.

The sector also determines measures of after-tax household income and its primary components -- labor, transfers, and property -- which are used in the consumption sector. Property income is defined more broadly than in the NIPA accounts. It includes the following additional items: imputed income from the stock of consumer durables, less consumer interest payments to business; corporate retained earnings; and inflation losses on the stock of government debt. These modifications to the definition of household income imply that households see through the corporate veil, and adjust interest income to exclude that portion which compensates for inflation. (Inflation adjustments to interest earned on corporate debt are not necessary, since an offsetting adjustment would need to be made to the definition of corporate profits.)

f.1 EFSN: Business final sales, current \$

$$\text{EFSN} = \text{XBN} - \text{EIN}$$

f.2 EGPDIN: Gross private domestic investment

$$\text{EGPDIN} = \text{EPDN} + \text{EPSN} + \text{EHN} + \text{EIN}$$

f.3 JCCACN: Consumption of fixed capital, corporate, current \$

Corporate consumption of fixed capital (JCCACN) is the product of an exogenous conversion factor (UJCCAC) and non-government consumption of fixed capital less depreciation of the housing stock.

$$\text{JCCACN} = \text{UJCCAC} * (\text{JCCAN} - \text{JYGFGN} - \text{JYGFEN} - \text{JYGSGN} - \text{JYGSN} \\ - .01 * \text{JRH} * \text{PHR}_{t-1} * \text{PXP}_{t-1} * \text{KH}_{t-1})$$

f.4 JCCAN: Consumption of fixed capital, current \$

Consumption of fixed capital (CFC) equals government CFC (four components) plus private CFC. The latter depends on the product of three factors: depreciation rates (JRH, JRPS, JRPDC, JRPDO), real business capital stocks (KH, KPS, KPDC, DKPO), and the prices of new investment or capital goods (the relative prices PHR,

PPSR, PKPDCR, and PPDOR, multiplied by PXP). Because investment prices are used in place of capital prices in three of the four instances, an exogenous conversion factor (UJCCA) is used to make the equation an identity.

$$\begin{aligned} \text{JCCAN} = & \text{JYGFGN} + \text{JYGFEN} + \text{JYGSGN} + \text{JYGSEN} + .01 * \text{UJCCA} * \text{PXP}_{t-1} \\ & * (\text{PHR}_{t-1} * \text{KH}_{t-1} * \text{JRH} + \text{PPSR}_{t-1} * \text{KPS}_{t-1} * \text{JRPS} \\ & + \text{PKPDCR}_{t-1} * \text{KPDC}_{t-1} * \text{JRPDC} + \text{PPDOR}_{t-1} * \text{KPDO}_{t-1} * \text{JRPDO}) \end{aligned}$$

f.5 JYGFEN: CFC, federal government enterprises

$$\text{JYGFEN} = \text{UJYGFE} * (.01 * \text{PGDP} * \text{XGDPT})$$

f.6 JYGFGN: CFC, federal government, general

$$\text{JYGFGN} = \text{UJYGFG} * (.01 * \text{PGDP} * \text{XGDPT})$$

f.7 JYGSEN: CFC, state and local government enterprises

$$\text{JYGSEN} = \text{UJYGSE} * (.01 * \text{PGDP} * \text{XGDPT})$$

f.8 JYGSGN: CFC, state and local government, general

$$\text{JYGSGN} = \text{UJYGSG} * (.01 * \text{PGDP} * \text{XGDPT})$$

f.9 JYNCN: Noncorporate business CFC

$$\text{JYNCN} = \text{JCCAN} - \text{JCCACN} - \text{JYGFGN} - \text{JYGFEN} - \text{JYGSGN} - \text{JYGSEN}$$

f.10 QYHIBN: Equilibrium level of interest paid by consumers to business

The equilibrium level of consumer interest payments to business, expressed relative to nominal consumption expenditures, is a function of a post-1979 dummy, the rate of interest on new car loans, the share of nominal spending on durable goods in total consumption, and a time trend. Coefficient values are taken from a regression of the actual ratio on the explanatory variables.

$$\begin{aligned} \log(\text{QYHIBN}) = & \log(\text{ECNIAN}) \\ & + \log(-0.0125) \\ & + 0.00297 * \text{D79A} \\ & + 0.000670 * \text{RCAR} \\ & + 0.207 * .01 * \text{PCDR} * \text{PCNIA} * \text{ECD} / \text{ECNIAN} \\ & + 2.00\text{E-}05 * \text{T47} \end{aligned}$$

f.11 QYNIDN: Desired level of dividends

The long-run level of dividends (QYNIDN) is modeled as a fraction of after-tax corporate profits, with a shift in the desired ratio starting in 1980. Coefficient values are taken from a regression of the log of the actual ratio of dividends to after-tax profits on the explanatory variables. Note: the max function is used to prevent simulation problems arising from attempts to take the log of a negative number.

$$\begin{aligned} \log(\text{QYNIDN}) = & -0.909 \\ & + 0.286 * \text{D79A} \\ & + 1.00 * \log(\max(\text{YNICPN} - \text{TFCIN} - \text{TSCIN}, .01)) \end{aligned}$$

f.12 RRMET: Real mortgage rate, trend

$$\begin{aligned} \text{RRMET} = & 0.905 * \text{RRMET}_{t-1} \\ & + 0.0952 * (\text{RME} - \text{ZPI10}) \end{aligned}$$

f.13 RSPNIA: Personal saving rate

$$\text{RSPNIA} = 100 * \text{YHSN} / \text{YDN}$$

f.14 TRYH: Average tax rate on household income

The average tax rate on household income is constructed as the ratio of personal income taxes (TFPN + TSPN) to the sum of labor income (YNLN) and taxable property income (YHPTN). Transfer income is assumed not to be taxed.

$$\text{TRYH} = (\text{TFPN} + \text{TSPN}) / (\text{YHLN} + \text{YHPTN})$$

f.15 WDNFCN: Net financial liabilities, nonfinancial nonfarm corporations

Net financial liabilities are modeled in an error-correction format, where the long-run desired ratio of net liabilities to nominal potential GDP depends on a time trend. In the short run, growth in the ratio depends on the gap between the actual and the long-run ratio, the output gap, and lagged changes in the ratio.

$$\begin{aligned} \text{del}(1: \log(\text{WDNFCN})) &= -0.0415 * \log(\text{WDNFCN}_{t-1} / (\text{YNIN}_{t-1} - \text{YNILN}_{t-1})) \\ &+ 0.00824 \\ &+ 0.162 * \text{del}(1: \log(\text{WDNFCN}_{t-1})) \\ &+ 0.315 * \text{del}(1: \log(\text{WDNFCN}_{t-2})) \\ &+ 0.00199 * \text{XGAP2} \end{aligned}$$

Regression statistics

R ² :	.4396
Sum of squared residuals:	.021738
Standard error of regression:	.013516
Durbin-Watson statistic:	2.0159
Sample period:	1975:q1 - 2005:q4
Estimation date:	August 2006

f.16 XBN: Business sector output, current \$

$$\text{XBN} = \text{XGDPN} - \text{XGVN} - \text{XHHIN}$$

f.17 XFBN: Output of farm sector, current \$

$$\text{XFBN} = .01 * \text{PXFBR} * \text{PXB} * \text{XFB}$$

f.18 XFSN: Final sales of gross domestic product, current \$

$$\text{XFSN} = \text{XGDPN} - \text{EIN}$$

f.19 XGDPN: GDP, current \$

$$\text{XGDPN} = \text{XPN} + \text{EIN} - \text{EMN} + \text{EGFLN} + \text{EGSLN}$$

f.20 XGN: Output of business sector ex. energy, housing, and farm, current \$

Nominal gross (of energy) output in the adjusted nonfarm business sector (XGN) equals BLS nonfarm output excluding housing, plus oil imports, less indirect business taxes associated with the nonfarm business sector and business transfer payments. The latter two items are excluded so that nominal output (and its price, PXG) is measured at factor cost. Because energy is an input in the production of nonfarm output, the sector's gross output is measured inclusive of energy use (domestic and imported), and thus oil imports are added.

The multiplicative term in the equation for XGN (UXGN) captures the difference between the BLS and BEA measures of nonfarm output (the BEA measure is XBN - XFBN), the difference between total indirect business taxes (TFIBN + TSIBN) and the fraction associated with nonfarm output excluding housing, and the effect of business transfer payments.

$$\text{XGN} = \text{UXGN} * (\text{XNFBN} + \text{EMPN})$$

f.21 XGVN: Government sector output, current \$

Government sector output equals the sum of compensation and depreciation. Because a small amount of compensation in XGVN is not included in EGFLN and EGSLN, a multiplicative factor (UXGV) is included to make the equation an identity.

$$\text{XGVN} = \text{UXGV} * (\text{EGFLN} + \text{EGSLN} + \text{JYGFGN} + \text{JYGSGN})$$

f.22 XHHIN: Output of households and institutions, current \$

$$\text{XHHIN} = .01 * \text{PXHHIR} * \text{PXB} * \text{XHHI}$$

f.23 XNFBN: BLS NFB output

$$\text{XNFBN} = \text{XBN} - \text{XFBN}$$

f.24 XPN: Final sales plus imports less gov. labor and ind. bus. taxes, current \$

$$\text{XPN} = .01 * \text{PXP} * \text{XP}$$

f.25 YCSN: Net corporate cash flow with IVA and CCA

$$\text{YCSN} = \text{YNICPN} - \text{TFCIN} - \text{TSCIN} - \text{FTCIN} - \text{YNIDN} + \text{JCCACN}$$

f.26 YDN: Disposable income

$$\text{YDN} = \text{UYD} * (\text{YPN} - \text{TFPN} - \text{TSPN})$$

f.27 YH: Income, household, total (real after-tax)

$$\text{YH} = \text{YHL} + \text{YHT} + \text{YHP}$$

f.28 YHGAP: Income, household, total, ratio to XGDP, cyclical component (real after-tax)

YHGAP is the percentage deviation of the actual from the trend ratio of household income to GDP (YHSRH and ZYHST, respectively).

$$\text{YHGAP} = 100 * (\text{YHSRH} / \text{ZYHST} - 1)$$

f.29 YHIBN: Income, household, consumer interest payments to business

The growth rate of consumer interest payments to business (deflated by the PCE chain-weight price index) is modeled using an error correction specification. Explanatory variables are the lagged gap between equilibrium and actual interest payments, the lagged growth rate of interest payments, and the current growth rate of the durable goods share of total consumption.

$$\begin{aligned} \text{del}(1 : \log(\text{YHIBN})) &= 1.00 * \text{mave}(4 : \text{PICXFE}_{t-1}/1600 \\ &- 0.142 \\ &+ 0.0578 * \log(\text{ECNIAN}_{t-1}/\text{YHIBN}_{t-1}) \\ &+ 0.440 * (\text{del}(1 : \log(\text{YHIBN}_{t-1})) - \text{mave}(4 : \text{PICXFE}_{t-1}/1600)) \\ &+ 0.0186 * \text{D79A} \\ &+ 0.00204 * \text{RCAR}_{t-1} \\ &+ 0.0479 * \log(.01 * \text{PCDR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECD}_{t-1} / \text{ECNIAN}_{t-1}) \\ &+ 0.00479 * \text{del}(1 : \text{RFFE}) \end{aligned}$$

Regression statistics

R ² :	.43144
Sum of squared residuals:	.049641
Standard error of regression:	.017782
Durbin-Watson statistic:	2.0168
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

f.30 YHIN: Income, household, net interest and rent

The exogenous conversion factor (UYHI) used in the household interest and rental income identity reflects the deduction in the measurement of GSINTN of dividends received by state and local governments.

$$\text{YHIN} = \text{UYHI} * (\text{YNIIN} + \text{GFINTN} + \text{GSINTN} + \text{YHIBN})$$

f.31 YHL: Income, household, labor compensation (real after-tax)

$$\text{YHL} = (1 - \text{TRYH}) * \text{YHLN} / (.01 * \text{PCNIA})$$

f.32 YHLN: Income, household, labor compensation

$$\text{YHLN} = \text{UYHLN} * (\text{YNILN} - \text{TFSIN} - \text{TSSIN})$$

f.33 YHP: Income, household, property (real after-tax)

$$\text{YHP} = ((1 - \text{TRYH}) * \text{YHPTN} + \text{YHPNTN}) / (.01 * \text{PCNIA})$$

f.34 YHPGAP: Income, household, property, ratio to YH, cyclical component (real after-tax)

YHPGAP is the percentage deviation of the actual from the trend ratio of household property income to total household income (YHPSHR and ZYHPST, respectively).

$$\text{YHPGAP} = 100 * (\text{YHPSHR} / \text{ZYHPST} - 1)$$

f.35 YHPNTN: Income, household, property, non-taxable component

Household non-taxable property income in FRB/US includes several items not included in the NIPA definition of personal income: imputed income from the stock of consumer durables, less consumer interest payments to business; corporate retained earnings; and inflation losses on the stock of government debt.

$$\begin{aligned} \text{YHPNTN} = & .01 * \text{PCNIA} * \text{PCDR} * \text{YHPCD} \\ & - \text{YHIBN} + \text{YNICPN} - \text{TFCIN} - \text{TSCIN} - \text{YNIDN} \\ & - .01 * \text{ZPI10} * (\text{GFDBTN} + \text{GSDBTN}) \\ & + \text{UYHPNT} * \text{XGDPTN} \end{aligned}$$

f.36 YHPSHR: Income, household, property, ratio to YH (real after-tax)

$$\text{YHPSHR} = \text{YHP} / \text{YH}$$

f.37 YHPTN: Income, household, property, taxable component

Household taxable property income in FRB/US includes interest and rental income, dividends, and self-employed income. The multiplicative factor UYHPTN adjusts for the difference between total dividends (YNIDN) and personal dividend income, which reflects dividends paid to state and local governments.

$$\text{YHPTN} = \text{UYHPTN} * (\text{YNISEN} + \text{YHIN} + \text{YNIDN})$$

f.38 YHSHR: Income, household, total, ratio to XGDP (real after-tax)

$$YHSHR = \frac{YH}{XGDP}$$

f.39 YHSN: Personal saving

$$YHSN = \frac{YHLN + YHTN + YHPTN - TFPN - TSPN - ECNIAN - YHIBN}{+ UYHSN * XGDPTN}$$

f.40 YHT: Income, household, transfer (real after-tax), net basis

$$YHT = \frac{YHTN}{(.01 * PCNIA)}$$

f.41 YHTGAP: Income, household, transfer, ratio to YH, cyclical component (real after-tax)

YHTGAP is the percentage deviation of the actual from the trend ratio of household transfer income to total household income (YHTSHR and ZYTHST, respectively).

$$YHTGAP = 100 * \left(\frac{YHTSHR}{ZYHTST} - 1 \right)$$

f.42 YHTN: Income, household, transfer payments. net basis

The exogenous conversion factor (UYHTN) in the identity for transfer payments to persons (YHTN) reflects the omission of business transfer payments from the equation.

$$YHTN = UYHTN * (GFTN + GSTN)$$

f.43 YHTSHR: Income, household, transfer, ratio to YH (real after-tax)

$$\text{YHTSHR} = \frac{\text{YHT}}{\text{YH}}$$

f.44 YKIN: Income from stock of inventories

$$\text{YKIN} = .01 * \frac{\text{RTINV}}{\text{PXB}} * \text{mave}(2 : \text{KI}_t)$$

f.45 YKPDCN: Income from stock of computer, software, and communications capital

$$\text{YKPDCN} = .01 * \frac{\text{RTPDC}}{\text{PXB}} * \text{mave}(2 : \text{KPDC}_t)$$

f.46 YKPDON: Income from stock of E&S capital, excluding computer, software, and communications

$$\text{YKPDON} = .01 * \frac{\text{RTPDO}}{\text{PXB}} * \text{mave}(2 : \text{KPDO}_t)$$

f.47 YKPSN: Income from stock of nonresidential structures

$$\text{YKPSN} = .01 * \frac{\text{RTPS}}{\text{PXB}} * \text{mave}(2 : \text{KPS}_t)$$

f.48 YNICPN: Income, national, corporate profits

Corporate profits (YNICPN) are the residual component of national income (YNIN - YNILN - YNIIN - YNISEN). To mitigate numerical problems while iteratively solving the model period by period, the max command is used to place a positive lower bound on profits; this constraint never binds on the converged solution.

$$\text{YNICPN} = \text{UYNICP} * \max(\frac{\text{YNIN} - \text{YNILN} - \text{YNIIN} - \text{YNISEN} - \text{TFIBN} - \text{TSIBN} + \text{GFSUBN} + \text{GSSUBN} + \text{TFCIN} + \text{TSCIN}}{\text{XGDPN}} + .01 * \text{XGDPN})$$

f.49 YNIDN: Income, national, dividend component

Dividends are modeling using the polynomial adjustment cost framework. Thus growth in real dividends depends on the three standard PAC terms -- the degree to which dividends were out of equilibrium last period, lagged dividend growth, and expected dividend growth (ZYNID). The PAC specification restricts the coefficient on the latter to unity, but the expectation variable itself has an internal weight sum of .97. Note: The equation adjusts for the mammoth one-time Microsoft cash payout of late 2004 by subtracting the payout (YMSDN) from NIPA dividends.

$$\begin{aligned} \text{del}(1 : \log((\text{YNIDN}-\text{YMSDN})/\text{PXB})) = & \\ & 0.0485 [4.20744570789] * \log(\text{QYNIDN}_{t-1}/(\text{YNIDN}_{t-1}-\text{YMSDN}_{t-1})) \\ & + 0.444 [6.70885710873] * \text{del}(1 : \log((\text{YNIDN}_{t-1}-\text{YMSDN}_{t-1})/\text{PXB}_{t-1})) \\ & + 0.000878[.569232080425] \\ & + 1.00 [(constr.)] * \text{ZYNID} \end{aligned}$$

Regression statistics		Diagnostic Tests (p-values)	
R ² :	.27181	Error serial correlation (lag 1):	.94
Sum of squared residuals:	.061358	Error serial correlation (lags 1-4):	.29
Standard error of regression:	.019522	Error serial correlation (lags 1-12):	.58
Sample period:	1965 1 2005 4	Overidentifying restrictions (17):	.0026
Estimation date:	AUGUST 2006		

f.50 YNIIN: Income, national, net interest and rental income component

The ratio of net interest plus rental income to net financial liabilities depends on measures of short- and long-term rates of interest, with the bond rate coefficient restricted to be one in the long run. Net interest plus rental income also includes the (real) return to housing. This return is estimated to have a component that is proportional to the housing stock and a component that varies with the product of the real rate of interest and the housing stock.

$$\begin{aligned} \text{YNIIN}/(\text{YNIN}(-1)-\text{YNILN}(-1)) = 0.0163 & \\ & + 0.797 * (\text{YNIIN}_{t-1}/(\text{YNIN}_{t-2}-\text{YNILN}_{t-2})) \\ & + 0.0650 * (.01 * \text{RRMET} * .01 * \text{PHR}_{t-1} * \text{PXP}_{t-1} * \text{KH}_{t-1}/(\text{YNIN}_{t-1}-\text{YNILN}_{t-1})) \\ & + 0.203 * ((.01 * \text{RBAAE}) * (\text{WDNFCN}_{t-1}/(\text{YNIN}_{t-1}-\text{YNILN}_{t-1}))) \\ & + 0.935 * (.01 * \text{del}(1 : \text{RBAAE} * (\text{WDNFCN}_{t-1}/(\text{YNIN}_{t-1}-\text{YNILN}_{t-1})))) \\ & + 0.787 * (.01 * \text{FNIN}_{t-1}/(\text{YNIN}_{t-1}-\text{YNILN}_{t-1})) \end{aligned}$$

Regression statistics

R ² :	.97032
Sum of squared residuals:	.0075701
Standard error of regression:	.0079759
Durbin-Watson statistic:	1.8085
Sample period:	1975:q1 - 2005:q4
Estimation date:	August 2006

f.51 YNILN: Income, national, labor component

The exogenous conversion factor (UYL) in the identity for labor income reflects: (1) the omission of labor income in the farm and household and institutions sectors from the equation; and (2) the use of a measure of aggregate hours that includes not only hours of employees but also hours of the self-employed.

$$\text{YNILN} = 0.01 * \text{UYL} * (\text{PL} * \text{LHP} + \text{PGFL} * \text{EGFL} + \text{PGSL} * \text{EGSL})$$

f.52 YNIN: Income, national, total

The exogenous conversion factor (UYNI) in the identity for national income (YNIN) reflects the omission of the statistical discrepancy and business transfer payments from the equation.

$$\text{YNIN} = \text{UYNI} * (\text{XGDPN} + \text{FYNNIN} - \text{JCCAN})$$

f.53 YNISEN: Income, national, proprietors

Proprietors' income (nonfarm and farm) is modelled as the product of an exogenous conversion factor (uysen) and nominal output of the business sector (XBN).

$$\text{YNISEN} = \text{UYSEN} * \text{XBN}$$

f.54 YPN: Income, personal

The exogenous conversion factor (UYP) used in the personal income identity reflects the omission of a miscellaneous set of adjustments, such as the difference between total and personal dividend payments, and the omission of business transfers payments to households.

$$\text{YPN} = \text{UYP} * (\text{YHLN} + \text{YHTN} + \text{YHPTN})$$

Wages and Prices

The FRB/US model contains a large number of individual price series; however, wage and price dynamics in the system are determined by only a few equations. The key long-run relationship in the wage-price sector is contained in the equation for the target price of adjusted non-farm business output (QPXG). The target price is proportional to trend unit labor costs; this same long-run relationship, inverted, also determines the target level of compensation per hour (QPL).

The targets for aggregate prices and wages in turn help to determine actual rates of wage and price inflation. This is done through the polynomial adjustment cost (PAC) framework, so that, for example, current wage inflation depends on lagged wage inflation, expected future growth in target wages (i.e., price inflation adjusted for productivity growth), and the lagged difference between actual and target wages. Because the equilibrium level of the real wage -- that is, the labor income share -- depends on the level of resource utilization in the labor market, current wage inflation also depends on the (weighted) average gap between the actual unemployment rate and the NAIRU expected to prevail into the future. Modifications to the standard PAC framework also cause wage inflation to depend on changes in payroll taxes and the minimum wage.

Price inflation is modeled in a similar manner, except that the target price of adjusted business output is not used to determine the actual price of such output directly. Instead, the target output price (QPXG) is used to define a target price of adjusted final sales (QPXP) through an accounting identity; this accounting identity makes the target price of domestic sales a function of import prices, among other factors. The latter target is then used in the context of the PAC framework to determine the rate of price inflation for adjusted final sales; as with wages, price inflation depends on lagged price inflation, expected future growth in target price inflation, the weighted average gap between the unemployment rate and the NAIRU, and the lagged difference between the actual and target price level. Modifications to the standard PAC framework imply that energy prices and non-oil import prices influence the current inflation rate more quickly than would be predicted by the standard PAC specification alone.

In addition to these two key aggregate wage and price equations, the sector also includes several important behavioral equations for core consumer prices, non-oil imports, crude energy prices, and so forth. These equations are modeled using simple error-correction specifications. Finally, a number of other prices are determined via accounting identities, or by using simple markup equations that make one price proportional to another.

g.1 PCNIA: Price index for personal consumption expenditures, cw (NIA definition)

The model's wage-price sector contains three key structural equations, for compensation per hour (PIPL), PCE consumer prices (pcnia), and an aggregate price for household and business investment, government output excluding labor compensation, and exports (pxnc). The three equations are estimated simultaneously under the assumption that expectations are rational and that they share common estimates of the NAIRU and the equilibrium markup of the NFB price level over trend unit labor costs. The estimated system contains the three structural equations, which are specified using the polynomial adjustment cost framework, and a set of auxiliary equations (some of which are VARs) for other endogenous variables in the system, including the

gap between a demographically adjusted measure of the unemployment rate and the NAIRU, and the federal funds rate. These auxiliary equations are not part of FRB/US, although their structures are implicit in the formulas for the expectations variables that appear in the main price and wage equations under VAR-based expectations. Notably, the auxiliary funds rate equation contains the FRB/US series on long-run inflation expectations (PTR) as a measure of the perception of policymakers' target rate of inflation, and thus PTR ends up being an important determinant of medium-run VAR-based inflation expectations in the wage-price system. Under this type of expectations, the system has a long-run unemployment sacrifice ratio of 5.8 under the assumption that PTR adjusts to movements in actual inflation at a speed of 10 percent per quarter.

The PAC approach specifies the dynamic behavior of consumer prices (PCNIA) in relationship to the behavior of its target price level. The latter consists of: (1) a non-stationary component (QPCNIA) that is built up from the level of trend unit labor costs in the adjusted-NFB sector and estimates of wedges between aggregate final sales prices and NFB prices and between consumer prices and final sales prices; and (2) a term to capture cyclical variation in the target price markup that depends on the gap between the unemployment rate and the NAIRU.

In the consumption price equation, adjustment dynamics are captured by four lags of consumer price inflation and the lagged gap between the actual price level and non-stationary component of the target price level. Expectations enter via ZPC, which is a weighted average of expected future rates of growth of QPCNIA, and ZLURC, which is a weighted average of expected future unemployment gaps. The effective duration of expectations is dictated by the estimated nature of adjustment costs implicit in the structure of adjustment dynamics. The wage-price system is estimated with inflation neutrality restrictions that, in the consumer price equation, set the sum of coefficients on lagged inflation (.60) plus the "internal" coefficient sum on expected target price inflation (.40, in ZPC) to unity. Without the neutrality restrictions, the equilibrium values of the unemployment rate and income shares would not be invariant to the rate of inflation.

Four additional terms appear in the equation. Two extend the PAC framework to account for the faster adjustment of consumption prices to energy and food price changes than to changes in other input prices. A third term (PIMOR) allows a faster passthrough of changes in nonoil import prices. The remaining term captures effects of the Nixon wage-price controls (DWPCP).

$$\begin{aligned} \text{del}(1 : \log(\text{PCNIA})) &= 0.0535 * \log(\text{QPCNIA}_{t-1}/\text{PCNIA}_{t-1}) \\ &+ \text{A2(L)} \{ \text{sum } 0.599 \} * \text{del}(1 : \log(\text{PCNIA}_{t-1})) \\ &+ 1.00 * \text{ZPC} \\ &- 0.0144 * \text{ZLURC} \\ &+ 1.01 * (\text{UCES} * \text{del}(1 : \log(\text{PCER}))) \\ &+ 0.389 * \text{PIMOR} \\ &- 0.00149 * \text{DWPCP} \\ &+ 0.854 * (\text{UCFS} * \text{del}(1 : \log(\text{PCFR}))) \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.191
A2 ₁	0.130
A2 ₂	0.0878
A2 ₃	0.190
A2SUM	0.599

Regression statistics

Sample period: 1966:q1 - 2005:q4

Estimation date: August 2006

Estimated by: John Roberts

g.2 PXNC: Price of adjusted final sales excluding consumption

The model's wage-price sector contains three key structural equations, for compensation per hour (PIPL), PCE consumer prices (pcnia), and an aggregate price for household and business investment, government output excluding labor compensation, and exports (pxnc). The three equations are estimated simultaneously under the assumption that expectations are rational and that they share common estimates of the NAIRU and the equilibrium markup of the NFB price level over trend unit labor costs. The estimated system contains the three structural equations, which are specified using the polynomial adjustment cost framework, and a set of auxiliary equations (some of which are VARs) for other endogenous variables in the system, including the gap between a demographically adjusted measure of the unemployment rate and the NAIRU, and the federal funds rate. These auxiliary equations are not part of FRB/US, although their structures are implicit in the formulas for the expectations variables that appear in the main price and wage equations under VAR-based expectations. Notably, the auxiliary funds rate equation contains the FRB/US series on long-run inflation expectations (PTR) as a measure of the perception of policymakers' target rate of inflation, and thus PTR ends up being an important determinant of medium-run VAR-based inflation expectations in the wage-price system. Under this type of expectations, the system has a long-run unemployment sacrifice ratio of 5.8 under the assumption that PTR adjusts to movements in actual inflation at a speed of 10 percent per quarter.

The PAC approach specifies the dynamic behavior of non-consumer prices (PXNC) in relationship to the behavior of its target price level. The latter consists of: (1) a non-stationary component (QPXNC) that is built up from the level of trend unit labor costs in the adjusted-NFB sector and estimates of wedges between aggregate final sales prices and NFB prices and between non-consumer prices and final sales prices; and (2) a term to capture cyclical variation in the target price markup that depends on the gap between the unemployment rate and the NAIRU.

In the non-consumption price equation, adjustment dynamics are captured by three lags of non-consumer price inflation and the lagged gap between the actual price level and non-stationary component of the target price level. Expectations enter via ZPNC, which is a weighted average of expected future rates of growth of QPXNC, and ZLURNC, which is a weighted average of expected future unemployment gaps. The effective duration of expectations is dictated by the estimated nature of adjustment costs implicit in the structure of adjustment dynamics. The wage-price system is estimated with inflation neutrality restrictions that, in the non-consumer price equation, set the sum of coefficients on lagged inflation (.62) plus the "internal" coefficient sum on expected target price inflation (.38, in ZPNC) to unity. Without the neutrality restrictions, the equilibrium values of the unemployment rate and income shares would not be invariant to the rate of inflation.

Four additional terms appear in the equation. Two extend the PAC framework to account for the faster adjustment of consumption prices to energy and food price changes than to changes in other input prices. A third term (PIMOR) allows a faster passthrough of changes in nonoil import prices. The remaining term captures effects of the Nixon wage-price controls (DWPCP).

$$\begin{aligned} \text{del}(1 : \log(\text{PXNC})) &= 0.0561 * \log(\text{QPXNC}_{t-1}/\text{PXNC}_{t-1}) \\ &+ A2(L) \{ \text{sum } 0.646 \} * \text{del}(1 : \log(\text{PXNC}_{t-1})) \\ &+ 1.00 * \text{ZPNC} \end{aligned}$$

$$\begin{aligned}
 & - 0.0141 * \text{ZLURNC} \\
 & + 0.787 * (\text{UCES} * \text{del}(1 : \log(\text{PCER}))) \\
 & + 1.36 * \text{PIMOR} \\
 & - 0.00257 * \text{DWPCP} \\
 & + 0.633 * (\text{UCFS} * \text{del}(1 : \log(\text{PCFR})))
 \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.336
A2 ₁	0.236
A2 ₂	0.0741
A2SUM	0.646

Regression statistics

Sample period: 1966:q1 - 2004:q4

Estimation date: August 2006

Estimated by: John Roberts

g.3 PIPL: Rate of growth of PL

The model's wage-price sector contains three key structural equations, for compensation per hour (PIPL), PCE consumer prices (pcnia), and an aggregate price for household and business investment, government output excluding labor compensation, and exports (pxnc). The three equations are estimated simultaneously under the assumption that expectations are rational and that they share common estimates of the NAIRU and the equilibrium markup of the NFB price level over trend unit labor costs. The estimated system contains the three structural equations, which are specified using the polynomial adjustment cost framework, and a set of auxiliary equations (some of which are VARs) for other endogenous variables in the system, including the gap between a demographically adjusted measure of the unemployment rate and the NAIRU, and the federal funds rate. These auxiliary equations are not part of FRB/US, although their structures are implicit in the formulas for the expectations variables that appear in the main price and wage equations under VAR-based expectations. Notably, the auxiliary funds rate equation contains the FRB/US series on long-run inflation expectations (PTR) as a measure of the perception of policymakers' target rate of inflation, and thus PTR ends up being an important determinant of medium-run VAR-based inflation expectations in the wage-price system. Under this type of expectations, the system has a long-run unemployment sacrifice ratio of 5.8 under the assumption that PTR adjusts to movements in actual inflation at a speed of 10 percent per quarter.

The PAC approach specifies the dynamic behavior of hourly compensation (PL) in relationship to the behavior of its target level. The latter consists of: (1) a non-stationary component (QPL) that is proportional to the price of output adjusted for trend unit labor costs in the adjusted-NFB sector; and (2) a term to capture cyclical variation in the target wage markup that depends on the gap between the unemployment rate and the NAIRU.

In the wage inflation equation (PIPL), adjustment dynamics are captured by three lags of wage inflation and the lagged gap between the actual wage level and non-stationary component of the target wage level. Expectations enter via ZPL, which is a weighted average of expected future rates of growth of QPL, and ZLURL, which is a weighted average of expected future unemployment gaps. The effective duration of

expectations is dictated by the estimated nature of adjustment costs implicit in the structure of adjustment dynamics. The wage-price system is estimated with inflation neutrality restrictions that, in the hourly compensation equation, set the sum of coefficients on lagged wage inflation (.57) plus the "internal" coefficient sum on expected target price inflation (.43, in ZPL) to unity. Without the neutrality restrictions, the equilibrium values of the unemployment rate and income shares would not be invariant to the rate of inflation.

The remaining terms in the equation capture effects of the Nixon wage-price controls (DWPCW), the minimum wage (PLMIN), and employers' social insurance premiums as a share of total compensation (TSIEN/(LHP*PL)).

$$\begin{aligned}
 \text{PIPL} = & 0.0650 * \log(\text{QPL}_{t-1}/\text{PL}_{t-1}) \\
 & + \text{A2(L) } \{\text{sum } 0.597 \} * \text{PIPL}_{t-1} \\
 & + 1.00 * \text{ZPL} \\
 & - 0.0143 * \text{ZLURL} \\
 & - 0.00672 * \text{DWPCW} \\
 & + 0.825 * (\text{del}(1 : \log(\text{TSIEN}/(\text{LHP} * \text{PL}))) * \text{TSIEN}_{t-1} / (.01 * \text{PL}_{t-1} * \text{LHP}_{t-1})) \\
 & + 0.153 * ((\text{del}(1 : \log(\text{PLMIN})) - .25 * \text{del}(4 : \log(\text{PL}_{t-1}))) * \text{PLMIN}_{t-1} / (.01 * \text{PL}_{t-1}))
 \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.201
A2 ₁	0.240
A2 ₂	0.156
A2SUM	0.597

Regression statistics

Sample period: 1966:q1 - 2005:q4

Estimation date: August 2006

Estimated by: John Roberts

g.4 PL: Compensation per hour, nonfarm business

$$\log(\text{PL}) = \log(\text{PL}_{t-1}) + \text{PIPL}$$

g.5 QPCNIA: Desired level of consumption price, trending component

$$\log(\text{QPCNIA}) = \log(\text{QPXP}) + \log(\text{UQPC})$$

g.6 QPXNC: Desired level of nonconsumption price, trending component

$$\begin{aligned}\log(\text{QPXNC}) &= \log(\text{PXNC}) \\ &+ 2.99 * \log(\text{QPXP/PXP}) \\ &- 1.99 * \log(\text{QPCNIA/PCNIA})\end{aligned}$$

g.7 QPL: Desired level of compensation per hour, trending component

The trending component of the target level of hourly compensation (QPL) is defined by a condition that is just a rearrangement of the relationship used to define the target price level (QPXG). Given the definitions of these two targets, the percentage wage gap, $\log(\text{QPL/PL})$, is the negative of the percentage price gap, $\log(\text{QPXG/PXG})$.

$$\log(\text{QPL}) = \log(\text{PL}) + 1.00 * \log(\text{PXG/QPXG})$$

g.8 QPXP: Desired price level of adjusted final sales, trending component

The target price of adjusted final sales is defined as what the actual price of adjusted final sales would equal if the price of adjusted nonfarm business output (PXG) were at its target (QPXG). In the equation, this is implemented by dividing what nominal adjusted final sales would be in this case by real adjusted final sales.

$$\text{QPXP} = 100 * (\text{XPN} + (.01 * \text{QPXG} * \text{XG-XGN}) / \text{UXGN}) / \text{XP}$$

g.9 QPXG: Desired price level of private output ex. energy, housing, and farm

The key long-run relationship in the wage-price block is contained in the equation for the target output price (QPXG). The target price is proportional to trend unit labor costs.

$$\log(\text{QPXG}) = 0.466 + 1.00 * \log(\text{PL/LPRDT})$$

Regression statistics

Estimation date: August 2006

Estimated by: John Roberts

g.10 UQPC: Trend ratio of PCNIA to PXP

$$\log(\text{UQPC}) - \log(\text{UQPCT}) = 0.00866 - 0.536 * ((\text{EMON}/\text{ECNIA}) * \text{LOG}(\text{PMO}/\text{PCNIA}))$$

g.11 UQPCT: Stochastic I(2) component of trend ratio of PCNIA to PXP

$$\log(\text{UQPCT}) = 0.00 + \log(\text{UQPCT}_{t-1}) + \text{HUQPCT}$$

g.12 HUQPCT: Drift term in stochastic component of trend ratio of PCNIA to PXP

$$\text{HUQPCT} = 0.00 + 1.00 * \text{HUQPCT}_{t-1}$$

g.13 DPGAP: Price inflation aggregation discrepancy

The price inflation aggregation discrepancy (DPGAP) equals the rate of increase of the price for adjusted final sales excluding consumption less the weighted sum of rates of price increase for the non-consumption components of adjusted final sales.

$$\begin{aligned} \text{DPGAP} = & \text{PIPXNC}/400 - (\\ & .5 * (\text{EHN}/(\text{XPN} - \text{ECNIA}) + \text{EHN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PHR} * \text{PXP})) \\ & + .5 * (\text{EPDCN}/(\text{XPN} - \text{ECNIA}) + \text{EPDCN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PPDCR} * \text{PXP})) \\ & + .5 * (\text{EPDON}/(\text{XPN} - \text{ECNIA}) + \text{EPDON}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PPDOR} * \text{PXP})) \\ & + .5 * (\text{EPSN}/(\text{XPN} - \text{ECNIA}) + \text{EPSN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PPSR} * \text{PXP})) \\ & + .5 * (\text{EGFON}/(\text{XPN} - \text{ECNIA}) + \text{EGFON}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PGFOR} * \text{PXP})) \\ & + .5 * (\text{EGFIN}/(\text{XPN} - \text{ECNIA}) + \text{EGFIN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PGFIR} * \text{PXP})) \\ & + .5 * (\text{EGSON}/(\text{XPN} - \text{ECNIA}) + \text{EGSON}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PGSOR} * \text{PXP})) \\ & + .5 * (\text{EGSIN}/(\text{XPN} - \text{ECNIA}) + \text{EGSIN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PGSIR} * \text{PXP})) \\ & + .5 * (\text{EXN}/(\text{XPN} - \text{ECNIA}) + \text{EXN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIA}_{t-1})) \\ & * \text{del}(1:\log(\text{PXR} * \text{PXP})) \end{aligned}$$

g.14 DPADJ: Price inflation aggregation adjustment

The adjustment factor for non-consumption prices equals the value in the prior quarter plus the price aggregation discrepancy in the prior quarter. Thus, component prices are adjusted to offset any aggregation discrepancy with only a one-quarter lag.

$$\text{DPADJ} - \text{DPADJ}(-1) = 1.00 * \text{DPGAP}_{t-1}$$

g.15 PGFIR: Price index for federal gov. investment, cw (relative to PXP)

$$\log(\text{PGFIR}) - \log(\text{PGFIR}(-1)) = 0.00 + \text{PIPXNC}/400 + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.16 PGFOR: Price index for federal government consumption ex. emp. comp., cw (relative to PXP)

$$\log(\text{PGFOR}) - \log(\text{PGFOR}(-1)) = 0.00 + \text{PIPXNC}/400 + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.17 PGSIR: Price index for S&L government investment (relative to PXP)

$$\log(\text{PGSIR}) - \log(\text{PGSIR}(-1)) = 0.00 + \text{PIPXNC}/400 + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.18 PGSOR: Price index for S&L government consumption ex. emp. comp., cw (relative to PXP)

$$\log(\text{PGSOR}) - \log(\text{PGSOR}(-1)) = 0.00 + \text{PIPXNC}/400 + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.19 PHR: Price index for residential investment, cw (relative to PXP)

$$\log(\text{PHR}) - \log(\text{PHR}(-1)) = 0.00 + \text{PIPXNC}/400 + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.20 PPDCR: Price index for investment in computers, software, communication equip., cw (relative to PXP)

$$\log(\text{PPDCR}) - \log(\text{PPDCR}(-1)) = 0.00 + \frac{\text{PIPXNC}}{400} + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.21 PPDOR: Price index for E&S investment, ex. computers, software, communication, cw (relative to PXP)

$$\log(\text{PPDOR}) - \log(\text{PPDOR}(-1)) = 0.00 + \frac{\text{PIPXNC}}{400} + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.22 PPSR: Price index for nonresidential structures, cw (relative to PXP)

$$\log(\text{PPSR}) - \log(\text{PPSR}(-1)) = 0.00 + \frac{\text{PIPXNC}}{400} + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.23 PXR: Price index for exports, cw (relative to PXP)

$$\log(\text{PXR}) - \log(\text{PXR}(-1)) = 0.00 + \frac{\text{PIPXNC}}{400} + \text{DPADJ} - \text{del}(1:\log(\text{PXP}))$$

g.24 POILR: Price of imported oil, relative to price index for bus. sector output

Real oil prices error-correct to their long-run trend, POILRT.

$$\begin{aligned} \text{del}(1 : \log(\text{POILR})) &= -0.199 * \log(\text{POILR}_{t-1}/\text{POILRT}_{t-1}) \\ &\quad - 0.00443 \\ &\quad + 0.366 * \text{del}(1 : \log(\text{POILR}_{t-1})) \\ &\quad + 0.350 * \text{del}(1 : \log(\text{POILRT})) \end{aligned}$$

Regression statistics

R ² :	.23688
Sum of squared residuals:	1.9107
Standard error of regression:	.10928
Durbin-H statistic:	1.9739
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

g.25 POIL: Price of imported oil (\$ per barrel)

$$\text{POIL} = \text{POILR} * \text{PXB}$$

g.26 PMP: Price index for petroleum imports

The chain-weight price index for imported petroleum products (PMP) is proportional to the per barrel price of imported crude oil (POIL).

$$\text{PMP} = \text{UPMP} * \text{POIL}$$

g.27 PCENGR: Price index for aggregate energy consumption (relative to PXB)

The growth rate of the relative price of crude energy -- which includes oil, coal, and natural gas -- follows a simple error-correction specification in which the real price of oil (POILR) is the key long-run driving variable. Coefficient estimates indicate that a 1 percent change in oil prices leads to a .9 percent change in overall crude energy prices in the long run.

$$\begin{aligned} \text{del}(1 : \log(\text{PCENGR})) &= 0.0418 \\ &- 0.0527 * \text{del}(1 : \log(\text{PCENGR}_{t-1})) \\ &- 0.0259 * \log(\text{PCENGR}_{t-1}) \\ &+ 0.0296 * \log(\text{POILR}_{t-1}) \\ &+ 0.756 * \text{del}(1 : \log(\text{POILR})) \end{aligned}$$

Regression statistics

R ² :	.91252
Sum of squared residuals:	.13267
Standard error of regression:	.028886
Durbin-Watson statistic:	1.619
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

g.28 PCENG: Price index for aggregate energy consumption

$$\text{PCENG} = \text{PCENGR} * \text{PXB}$$

g.29 PCER: Price index for personal consumption expenditures on energy (relative to PCXFE)

Growth in consumer energy prices (expressed relative to core consumer price inflation) is determined in an error-correction format, in which the long run level of consumer energy prices is determined by the price of crude energy (PCENG). According to the estimated coefficients, a 1 percentage point change in crude energy prices leads to only a .4 percentage point change in consumer energy prices in the long run. The underlying reason for such a low pass-thru is that prices at the consumer level are influenced by a variety of factors other than crude energy costs, including retail and wholesale distribution costs, the capital cost of electricity generation, and motor fuel excise taxes.

$$\begin{aligned} \text{del}(1 : \log(\text{PCER})) &= -0.111 * \log(\text{PCER}_{t-1}) \\ &+ 0.0431 * \log(\text{PCENG}_{t-1}/\text{PCXFE}_{t-1}) \\ &+ 0.00786 \\ &+ 0.135 * \text{del}(1 : \log(\text{PCER}_{t-1})) \\ &+ 0.207 * \text{del}(1 : \log(\text{PCENG}/\text{PCXFE})) \\ &+ 0.0437 * \text{del}(1 : \log(\text{POIL}/\text{PCXFE})) \end{aligned}$$

Regression statistics

R ² :	.76074
Sum of squared residuals:	.039739
Standard error of regression:	.015859
Durbin-Watson statistic:	2.127
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

g.30 PCFR: Price index for personal consumption expenditures on food (relative to PCXFE)

Growth in relative consumer food prices is modeled using a simple error-correction specification, where the level of prices in the long run is equal to an estimated trend, PCFRT, defined historically by H-P filtering the observed series. This equation is primarily used in stochastic simulations.

$$\begin{aligned} \text{del}(1 : \log(\text{PCFR})) &= -0.167 * \log(\text{PCFR}_{t-1}/\text{PCFRT}_{t-1}) \\ &- 5.17\text{E-}05 \\ &+ \text{B1(L) } \{\text{sum } 0.816 \} * \text{del}(1 : \log(\text{PCFR}_{t-1})) \\ &+ 0.212 * \text{del}(1 : \log(\text{PCFRT})) \end{aligned}$$

Distributed lag coefficients

Name	Value
B1 ₀	0.415
B1 ₁	-0.00825
B1 ₂	0.409

B1SUM	0.816
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Regression statistics

R ² :	.46403
Sum of squared residuals:	.004236
Standard error of regression:	.0051778
Durbin-Watson statistic:	1.9549
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

g.31 UCES: Energy share of nominal consumption expenditures

Growth in the nominal energy share of consumption is modeled using an error-correction specification. The long run share is a function of the relative price of consumer energy (PCER), the real share of energy in gross output (CENG/XG), and a time trend (T47). In the short run, growth in the share is affected by the lagged difference between the actual share and its long-term level, lagged growth in the share, current growth in relative energy prices, and current growth in the energy intensity of overall production.

$$\begin{aligned} \text{del}(1 : \log(\text{UCES})) = & -0.484 * \log(\text{UCES}_{t-1}) \\ & + 0.420 * \log(\text{PCER}_{t-1}) \\ & + 0.243 * \log(\text{CENG}_{t-1}/\text{XG}_{t-1}) \\ & - 0.000625 * \text{T47} \\ & - 0.540 \\ & - 0.0435 * \text{del}(1 : \log(\text{UCES}_{t-1})) \\ & + 0.766 * \text{del}(1 : \log(\text{PCER})) \\ & + 0.268 * \text{del}(1 : \log(\text{CENG}/\text{XG})) \end{aligned}$$

Regression statistics

R ² :	.76291
Sum of squared residuals:	.0356
Standard error of regression:	.015106
Durbin-Watson statistic:	2.0619
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

g.32 UCFS: Food share of nominal consumption expenditures

Growth in the nominal food share of consumption is modeled using an error-correction specification. The long run share is a function of the relative price of consumer food (PCFR) and a time trend (T47). In the short run, growth in the share is affected by the lagged difference between the actual share and its long-term level,

lagged growth in the share, and current growth in relative food prices, broken down into its trend (PCFRT) and non-trend (PCFR/PCFRT) components.

$$\begin{aligned} \text{del}(1 : \log(\text{UCFS})) &= -0.102 * \log(\text{UCFS}_{t-1}) \\ &+ 0.0694 * \log(\text{PCFR}_{t-1}) \\ &- 0.000364 * T47 \\ &- 0.124 \\ &+ 0.00564 * \text{del}(1 : \log(\text{UCFS}_{t-1})) \\ &+ 0.929 * \text{del}(1 : \log(\text{PCFRT})) \\ &+ 0.374 * \text{del}(1 : \log(\text{PCFR}/\text{PCFRT})) \end{aligned}$$

Regression statistics

R ² :	.2293
Sum of squared residuals:	.0073748
Standard error of regression:	.0068537
Durbin-Watson statistic:	1.9642
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

g.33 PCXFE: Price index for personal consumption expenditures ex. food and energy, cw (NIA definition)

$$\begin{aligned} \text{del}(1:\log(\text{PCXFE})) &= \text{del}(1:\log(\text{PCNIA})) \\ &- \text{del}(1:\log(\text{UPCNIA})) \\ &- (\text{mave}(2 : \text{UCFS}_t)) * \text{del}(1:\log(\text{PCFR})) \\ &- (\text{mave}(2 : \text{UCES}_t)) * \text{del}(1:\log(\text{PCER})) \end{aligned}$$

g.34 PCPI: Consumer price index,total

The overall CPI equals the product of the PCE chain-weight price index and a proportionality factor. This factor has two components, one to account for the effect of different weights on energy in the two price indices, and the other to account for all other differences.

$$\text{PCPI} = \text{UPCPI} * \text{EXP}(.025 * \text{LOG}(\text{PCER})) * \text{PCNIA}$$

g.35 PCPIX: Consumer price index,excluding food and energy

$$\text{PCPIX} = \text{UPCPIX} * \text{PCXFE}$$

g.36 PMO: Price index for imports ex. petroleum, cw

Growth in non-oil import prices is modeled using a Kalman filter specification in which the level of non-oil import prices (PMO) gradually converges to a steady-state target. The latter has two elements: a stochastic random walk (QPMO) and a weighted average of aggregate foreign and domestic prices. Empirical work suggests that the pass-through of changes in the exchange rate (FPXM) or foreign prices (FPCM) into dollar-denominated import prices is incomplete. In accordance with this evidence, in FRB/US only 64 percent of any movement in FPCM or FPXM is allowed to pass through to PMO in the long run. This pass-thru relationship is defined in relative terms using the price of US business output, which accounts for the presence of PXB in the equilibrium formula. The PMO equation also contains the contemporaneous rates of foreign and domestic price inflation with the two coefficients restricted to sum to one.

QPMO is a random walk with constant drift:

$$\log(\text{QPMO}) = \log(\text{QPMO}(-1)) - .003220$$

The standard error of the additive errors term in the PMO equation is .00376, and the standard error of the error in the random walk equation for QPMO is .0172.

$$\begin{aligned} \text{del}(1 : \log(\text{PMO})) = & -0.00336[2.1] \\ & + 0.439 [4.6] * (\log(\text{QPMO}) + .64*\log(\text{FPCM}_{t-1}/\text{FPXM}_{t-1}) + .36*\log(\text{PXB}_{t-1}) \\ & - \log(\text{PMO}_{t-1})) \\ & + 0.307 [9.5] * \text{del}(1 : \log(\text{FPCM}/\text{FPXM})) \\ & + 0.693 [21.1] * \text{del}(1 : \log(\text{PXB})) \end{aligned}$$

Regression statistics

Sample period: 1965:q1 - 2005:q1

Estimation date: July 2005

g.37 QPMO: Random walk component of non-oil import prices

In the long run, the level of non-oil import prices is determined by two factors -- a weighted average of foreign consumer prices expressed in dollars and domestic output prices; and a stochastic trend component that takes account of permanent movements in the relative price of imported goods with respect to the prices of both foreign consumption and domestic output. The stochastic trend component, QPMO, is derived from Kalman filter estimation of the dynamic non-oil import price equation; estimation suggested that QPMO is subject to significant I(1), but not I(2), shocks.

$$\log(\text{QPMO}) = \log(\text{QPMO}_{t-1}) - 0.00336$$

g.38 PGDP: Price index for GDP, cw

$$\text{PGDP} = 100 * \frac{\text{XGDPN}}{\text{XGDP}}$$

g.39 PGFL: Price index for federal government employee compensation, cw

The price index for federal employee compensation (PGFL) is proportional to the economy-wide compensation rate (PL). They are linked by the exogenous conversion factor UPGFL, adjusted for trend labor productivity. Because the national accounts assume that there is no productivity growth in the government sector, the dummy variable DGLPRD is set to 0 over history. In long-run simulations, however, DGLPRD is set to 1.0 to ensure that the government shares of employment and GDP are stationary.

$$\log(\text{PGFL}) = \log(\text{UPGFL}) + \log(\text{PL}) - \text{DGLPRD} * \log(\text{LPRDT})$$

g.40 PGSL: Price index for S&L government employee compensation, cw

The price index for state and local employee compensation (PGSL) is proportional to the economy-wide compensation rate (PL). They are linked by the exogenous conversion factor UPGSL, adjusted for trend labor productivity. Because the national accounts assume that there is no productivity growth in the government sector, the dummy variable DGLPRD is set to 0 over history. In long-run simulations, however, DGLPRD is set to 1.0 to ensure that the government shares of employment and GDP are stationary.

$$\log(\text{PGSL}) = \log(\text{UPGSL}) + \log(\text{PL}) - \text{DGLPRD} * \log(\text{LPRDT})$$

g.41 PKPDCR: Price index for stock of computers, software, communication equip., cw (relative to PXP)

The relative price index for the stock of computer equipment (PKPDCR) is proportional to the relative price index for computer investment (PPDCR).

$$\text{PKPDCR} = \text{UPKPDC} * \text{PPDCR}$$

g.42 PLMIN: Minimum wage

The minimum wage (PLMIN) equals the product of the exogenous real minimum wage (PLMINR) and compensation per hour (PL).

$$\text{PLMIN} = \text{PLMINR} * .01 * \text{PL}$$

g.43 PXB: Price index for business sector output, cw

$$\text{PXB} = 100 * \frac{\text{XBN}}{\text{XB}}$$

g.44 PXG: Price index for nonfarm, nonhousing business output plus oil imports (net of IBT)

$$\text{PXG} = 100 * \frac{\text{XGN}}{\text{XG}}$$

g.45 PXGV: Price deflator for government output

The chain-weight price index for government output equals the product of two factors: the ratio of nominal to real government expenditures, and an exogenous scale factor (UPXGV). The latter controls for the effects of chain-aggregation, as well as the approximation error created by the equation's neglect of the non-compensation component of government output -- that, is the consumption of fixed capital.

$$\text{PXGV} = \text{UPXGV} * 100 * \frac{(\text{EGFLN} + \text{EGSLN})}{(\text{EGFL} + \text{EGSL})}$$

g.46 PXNFB: BLS NFB price

BLS NFB price.

$$\text{PXNFB} = 100 * \frac{\text{XNFBN}}{\text{XNFB}}$$

g.47 PXP: Price index for final sales plus imports less gov. labor

$$\begin{aligned} \text{del}(1 : \log(\text{PXP})) = & \\ & .5 * \left(\frac{\text{ECNIAN}}{\text{XPN}} + \frac{\text{ECNIAN}_{t-1}}{\text{XPN}_{t-1}} \right) * \text{del}(1 : \log(\text{PCNIA})) \\ & + .5 * \left(\frac{\text{XPN} - \text{ECNIAN}}{\text{XPN}} + \frac{\text{XPN}_{t-1} - \text{ECNIAN}_{t-1}}{\text{XPN}_{t-1}} \right) * \text{del}(1 : \log(\text{PXNC})) \end{aligned}$$

g.48 HGPDOR: Trend growth rate of PPDCR

$$\begin{aligned} \text{HGPDOR} &= 0.900 * \text{HGPDOR}_{t-1} \\ &+ 0.100 * 400 * \log(\text{PPDCR}/\text{PPDCR}_{t-1}) \end{aligned}$$

g.49 HGPDOR: Trend growth rate of PPDOR

$$\begin{aligned} \text{HGPDOR} &= 0.900 * \text{HGPDOR}_{t-1} \\ &+ 0.100 * 400 * \log(\text{PPDOR}/\text{PPDOR}_{t-1}) \end{aligned}$$

g.50 HGPKIR: Trend growth rate of PKIR

$$\begin{aligned} \text{HGPKIR} &= 0.900 * \text{HGPKIR}_{t-1} \\ &+ 0.100 * 400 * \log(\text{PKIR}/\text{PKIR}_{t-1}) \end{aligned}$$

g.51 HGPMOR: Trend growth rate of PMOR

$$\begin{aligned} \text{HGPMOR} &= 0.900 * \text{HGPMOR}_{t-1} \\ &+ 0.100 * 400 * (\log(\text{PMO}/\text{PXP}_{t-1}) - \log(\text{PMO}_{t-1}/\text{PXP}_{t-2})) \end{aligned}$$

g.52 HGPPSR: Trend growth rate of PPSR

$$\begin{aligned} \text{HGPPSR} &= 0.900 * \text{HGPPSR}_{t-1} \\ &+ 0.100 * 400 * \log(\text{PPSR}/\text{PPSR}_{t-1}) \end{aligned}$$

g.53 DLQXP: del(log(qxp))

$$\text{DLQXP} = \text{del}(1: \log(\text{QXP}))$$

g.54 PICNGR: Weighted growth rate of relative energy price

$$\text{PICNGR} = (\text{del}(1 : \log(\text{PCENG}/\text{PXP}_{t-1})) * \text{mave}(2 : \text{PCENG}_t * \text{CENG}_t / (\text{PXP}_t * \text{XP}_t)))$$

g.55 PICNIA: Inflation rate, personal consumption expenditures, cw

$$\text{PICNIA} = 400 * \text{del}(1 : \log(\text{PCNIA}))$$

g.56 PICXFE: Inflation rate, personal consumption expenditures, ex. food and energy, cw

$$\text{PICXFE} = 400 * \text{del}(1 : \log(\text{PCXFE}))$$

g.57 PIGDP: Inflation rate, GDP, cw

$$\text{PIGDP} = 400 * \text{del}(1 : \log(\text{PGDP}))$$

g.58 PIMOR: Weighted growth rate of relative nonpetroleum import price

PIMOR is the relative import price term that enters the main price equations. It is equal to the difference between the current and trend growth rates of relative nonoil import prices, weighted by the expenditure share of nonoil imports.

$$\text{PIMOR} = (\text{del}(1 : \log(\text{PMO}/\text{PXP}_{t-1})) - \text{HGPMOR}_{t-1}/400) * \text{EMON}_{t-1}/\text{XPN}_{t-1}$$

g.59 PIPXNC: Inflation rate, price of adjusted final sales excluding consumption (annual rate)

$$\text{PIPXNC} = 400 * \text{del}(1 : \log(\text{PXNC}))$$

g.60 PIXB: $400 * \text{del}(\log(\text{pxb}))$

$$\text{PIXB} = 400 * \text{del}(1 : \log(\text{PXB}))$$

g.61 PCOR: Price index for non-durable goods and non-housing services, cw (relative to PCNIA)

The relative price of non-durable goods and non-housing services (PCOR) is chain disaggregated from PCNIA using the relative prices for durable goods (PCDR) and housing services (PCHR).

$$\begin{aligned} \log(\text{PCOR}) - \log(\text{PCOR}(-1)) = & \\ & (-.5 * .01 * (\text{PCDR} * \text{PCNIA} * \text{ECD} / \text{ECNIA} \\ & + \text{PCDR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECD}_{t-1} / \text{ECNIA}_{t-1})) \\ & / (.5 * .01 * (\text{PCOR} * \text{PCNIA} * \text{ECO} / \text{ECNIA} \\ & + \text{PCOR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECO}_{t-1} / \text{ECNIA}_{t-1})) \\ & * \text{del}(1 : \log(\text{PCDR})) \\ & - .5 * .01 * (\text{PCHR} * \text{PCNIA} * \text{ECH} / \text{ECNIA} \\ & + \text{PCHR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECH}_{t-1} / \text{ECNIA}_{t-1}) \\ & * \text{del}(1 : \log(\text{PCHR})) \\ & / (.5 * .01 * (\text{PCOR} * \text{PCNIA} * \text{ECO} / \text{ECNIA} \\ & + \text{PCOR}_{t-1} * \text{PCNIA}_{t-1} * \text{ECO}_{t-1} / \text{ECNIA}_{t-1})) \end{aligned}$$

g.62 PCHR: Price index for housing services, cw (relative to PCNIA)

The growth rate of the relative (to PCNIA) price of housing services (PCHR) is assumed to follow a first order autoregression. The constant is equal to the drift times one minus the lag coefficient.

$$\begin{aligned} \text{del}(1 : \log(\text{PCHR})) = & 0.00106 \\ & + 0.580 * \text{del}(1 : \log(\text{PCHR}_{t-1})) \end{aligned}$$

Regression statistics

Adjusted R2:	.3369
Sum of squared residuals:	.001843
Standard error of regression:	.003919
Durbin-Watson statistic:	2.1290
Sample period:	1975:q1 - 2005:q4
Estimation date:	August 25, 2006

g.63 PICX4: Four-quarter percent change core in PCE prices

$$\text{PICX4} = 100 * (\text{PCXFE} / \text{PCXFE}_{t-4} - 1)$$

g.64 PCDR: Price index for consumer durables, cw (relative to to PCNIA)

The growth rate of the relative (to PCNIA) price of consumer durable goods (PCDR) is assumed to follow a second order autoregression. The constant is equal to the drift times one minus the sum of the lag coefficients.

$$\begin{aligned} \text{del}(1:\log(\text{PCDR})) &= -0.00283 \\ &+ 0.382 * \text{del}(1:\log(\text{PCDR}_{t-1})) \\ &+ 0.184 * \text{del}(1:\log(\text{PCDR}_{t-2})) \end{aligned}$$

Regression statistics

Adjusted R2:	.2559
Sum of squared residuals:	.002053
Standard error of regression:	.004119
Durbin-Watson statistic:	2.034
Sample period:	1975:q1 - 2005:q4
Estimation date:	August 25, 2006

g.65 PIC4: Four-quarter percent change in PCE prices

$$\text{PIC4} = 100 * (\text{PCNIA} / \text{PCNIA}_{t-4} - 1)$$



The bulk of the government sector consists of identities that: (1) relate nominal purchases, transfers, and grants to associated constant-dollar variables and price indexes; (2) link tax receipts to associated tax rates and tax bases; and (3) compute the budget surplus and stock of debt. In constructing these identities, the

government sector is disaggregated into its federal and state and local components.

Aside from these identities, the sector also contains a number of simple reduced-form behavioral equations. For example, there are a several dynamic error-correction equations that link growth in spending on various types of goods and services to trend spending in these categories. Other estimated behavioral equations in the government sector account for the average interest rate paid on government debt, the cyclical component of transfer payments, and short-run fluctuations in a variety of tax rates.

Finally, the sector includes a pair of equations that determine the overall stance of fiscal policy, as defined by the government debt-to-GDP ratio on both the federal and state/local levels. These equations work by adjusting personal income tax rates to ensure that actual debt ratios gradually converge to specified target values.

h.1 EGF: Federal government consumption and gross investment, cw 2000\$

Total federal government expenditures are approximated by the Divisia aggregate of its components.

$$\begin{aligned} \log(\mathbf{EGF}) &= \log(\mathbf{EGF}_{t-1}) \\ &+ .5 * (\mathbf{EGFON}/\mathbf{EGFN} + \mathbf{EGFON}_{t-1}/\mathbf{EGFN}_{t-1}) * \text{del}(1:\log(\mathbf{EGFO})) \\ &+ .5 * (\mathbf{EGFIN}/\mathbf{EGFN} + \mathbf{EGFIN}_{t-1}/\mathbf{EGFN}_{t-1}) * \text{del}(1:\log(\mathbf{EGFI})) \\ &+ .5 * (\mathbf{EGFLN}/\mathbf{EGFN} + \mathbf{EGFLN}_{t-1}/\mathbf{EGFN}_{t-1}) * \text{del}(1:\log(\mathbf{EGFL})) \end{aligned}$$

h.2 EGFI: Federal government gross investment, cw 2000\$

Federal government investment expenditures error-correct to their long-run trend, EGFI_T.

$$\begin{aligned} \text{del}(1 : \log(\mathbf{EGFI})) &= -0.00527 \\ &- 0.184 * \log(\mathbf{EGFI}_{t-1}/\mathbf{EGFIT}_{t-1}) \\ &+ \mathbf{A2(L)} \{ \text{sum } -0.425 \} * \text{del}(1 : \log(\mathbf{EGFI}_{t-1})) \\ &+ 2.01 * \text{del}(1 : \log(\mathbf{EGFIT})) \\ &+ \mathbf{A4(L)} \{ \text{sum } 0.00222 \} * \mathbf{XGAP2}_t \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	-0.247
A2 ₁	-0.178
A2SUM	-0.425
A4 ₀	0.0105
A4 ₁	-0.00824
A4SUM	0.00222

Regression statistics

R^2 : .26868
 Sum of squared residuals: .5154
 Standard error of regression: .057296
 Durbin Watson statistic: 1.9641
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.3 EGFIN: Federal government gross investment, current \$

$$EGFIN = .01 * PXP * PGFIR * EGFI$$

h.4 EGFIT: Federal government gross investment, cw 2000\$, trend

$$\begin{aligned}
 \text{del}(1 : \log(EGFIT)) &= -0.463 \\
 &- 0.100 * \log(.01 * PGFIR_{t-1} * PXP_{t-1} * EGFIT_{t-1} / XGDPT_{t-1}) \\
 &+ 1.00 * (\underline{HGGDPT} + \underline{HGGDPT}_{t-1} + \underline{HGGDPT}_{t-2} + \underline{HGGDPT}_{t-3}) / 1600
 \end{aligned}$$

h.5 EGFL: Federal government employee compensation, cw 2000\$

Federal government employee compensation error-corrects to its long-run trend, EGFLT.

$$\begin{aligned}
 \text{del}(1 : \log(EGFL)) &= 0.000523 \\
 &- 0.0799 * \log(EGFL_{t-1} / \underline{EGFLT}_{t-1}) \\
 &+ A2(L) \{ \text{sum } 0.156 \} * \text{del}(1 : \log(EGFL_{t-1})) \\
 &+ 1.34 * \text{del}(1 : \log(\underline{EGFLT})) \\
 &+ A4(L) \{ \text{sum } 0.000209 \} * \underline{XGAP2}_t
 \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.258
A2 ₁	-0.101
A2SUM	0.156
A4 ₀	-0.000499
A4 ₁	0.000708
A4SUM	0.000209

Regression statistics

R ² :	.40518
Sum of squared residuals:	.010968
Standard error of regression:	.0083581
Durbin-Watson statistic:	2.0224
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

h.6 EGFLN: Federal government employee compensation, current \$

$$EGFLN = .01 * \text{PGFL} * \text{EGFL}$$

h.7 EGFLT: Federal government employee compensation, cw 2000\$, trend

$$\begin{aligned} \text{del}(1 : \log(EGFLT)) &= -0.369 \\ &- 0.100 * \log(.01 * \text{PGFL}_{t-1} * \text{EGFLT}_{t-1} / \text{XGDPTN}_{t-1}) \\ &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600 \end{aligned}$$

h.8 EGFN: Federal government consumption and gross investment, current \$

$$EGFN = \text{EGFLN} + \text{EGFIN} + \text{EGFON}$$

h.9 EGFO: Federal government consumption ex. employee comp., cw 2000\$

Federal government consumption expenditure ex employee compensation error-corrects to its long-run trend, EGFOT.

$$\begin{aligned} \text{del}(1 : \log(EGFO)) &= -0.00260 \\ &- 0.171 * \log(EGFO_{t-1} / \text{EGFOT}_{t-1}) \\ &+ A2(L) \{ \text{sum } -0.342 \} * \text{del}(1 : \log(EGFO_{t-1})) \\ &+ 1.78 * \text{del}(1 : \log(\text{EGFOT})) \\ &+ A4(L) \{ \text{sum } 0.000790 \} * \text{XGAP}_t \end{aligned}$$

Distributed lag coefficients

Name	Value
A20	-0.235
A21	-0.107
A2SUM	-0.342
A40	-0.000385
A41	0.00117
A4SUM	0.000790

Regression statistics

R^2 : .26426
 Sum of squared residuals: .11755
 Standard error of regression: .027363
 Durbin Watson statistic: 2.0276
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.10 EGFON: Federal government consumption ex. employee comp., current \$

$$\text{EGFON} = .01 * \text{PXP} * \text{PGFOR} * \text{EGFO}$$

h.11 EGFOT: Federal government consumption ex. employee comp., cw 2000\$, trend

$$\begin{aligned}
 \text{del}(1 : \log(\text{EGFOT})) &= -0.346 \\
 &- 0.100 * \log(.01 * \text{PGFOR}_{t-1} * \text{PXP}_{t-1} * \text{EGFOT}_{t-1} / \text{XGDPTN}_{t-1}) \\
 &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600
 \end{aligned}$$

h.12 EGS: S&L government consumption and gross investment, cw 2000\$

Total state and local government expenditures are approximated by the Divisia aggregate of its components.

$$\begin{aligned}
 \log(\text{EGS}) &= \log(\text{EGS}_{t-1}) \\
 &+ .5 * (\text{EGSON}/\text{EGSN} + \text{EGSON}_{t-1}/\text{EGSN}_{t-1}) * \text{del}(1:\log(\text{EGSO})) \\
 &+ .5 * (\text{EGSIN}/\text{EGSN} + \text{EGSIN}_{t-1}/\text{EGSN}_{t-1}) * \text{del}(1:\log(\text{EGSI})) \\
 &+ .5 * (\text{EGSLN}/\text{EGSN} + \text{EGSLN}_{t-1}/\text{EGSN}_{t-1}) * \text{del}(1:\log(\text{EGSL}))
 \end{aligned}$$

h.13 EGSi: S&L government gross investment, cw 2000\$

State and local government investment spending error-corrects to its long-run trend, EGSIT.

$$\begin{aligned} \text{del}(1 : \log(\text{EGSi})) &= -0.00393 \\ &- 0.203 * \log(\text{EGSi}_{t-1} / \text{EGSIT}_{t-1}) \\ &+ \text{A2(L)} \{ \text{sum } -0.0735 \} * \text{del}(1 : \log(\text{EGSi}_{t-1})) \\ &+ 1.48 * \text{del}(1 : \log(\text{EGSIT})) \\ &+ \text{A4(L)} \{ \text{sum } 0.00230 \} * \text{XGAP2}_t \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.0336
A2 ₁	-0.107
A2SUM	-0.0735
A4 ₀	0.00768
A4 ₁	-0.00538
A4SUM	0.00230

Regression statistics

R²: .22484
 Sum of squared residuals: .14762
 Standard error of regression: .030664
 Durbin-Watson statistic: 2.0186
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.14 EGSIN: S&L government gross investment, current \$

$$\text{EGSIN} = .01 * \text{PXP} * \text{PGSIR} * \text{EGSI}$$

h.15 EGSIT: S&L government gross investment, cw 2000\$, trend

$$\begin{aligned} \text{del}(1 : \log(\text{EGSIT})) &= -0.379 \\ &- 0.100 * \log(.01 * \text{PGSIR}_{t-1} * \text{PXP}_{t-1} * \text{EGSIT}_{t-1} / \text{XGDPT}_{t-1}) \\ &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600 \end{aligned}$$

h.16 EGSL: S&L government employee compensation, cw 2000\$

State and local government employee compensation error-corrects to its long-run trend, EGSLT.

$$\begin{aligned} \text{del}(1 : \log(\text{EGSL})) &= 0.000811 \\ &- 0.125 * \log(\text{EGSL}_{t-1} / \text{EGSLT}_{t-1}) \\ &+ \text{A2(L)} \{ \text{sum } 0.131 \} * \text{del}(1 : \log(\text{EGSL}_{t-1})) \\ &+ 0.661 * \text{del}(1 : \log(\text{EGSLT})) \\ &+ \text{A4(L)} \{ \text{sum } 0.000422 \} * \text{XGAP2}_t \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.151
A2 ₁	-0.0206
A2SUM	0.131
A4 ₀	-0.000704
A4 ₁	0.00113
A4SUM	0.000422

Regression statistics

R²: .58548
 Sum of squared residuals: .0016981
 Standard error of regression: .0032887
 Durbin-Watson statistic: 2.0287
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.17 EGSLN: S&L government employee compensation, current \$

$$\text{EGSLN} = .01 * \text{PGSL} * \text{EGSL}$$

h.18 EGSLT: S&L government employee compensation, cw 2000\$, trend

$$\begin{aligned} \text{del}(1 : \log(\text{EGSLT})) &= -0.269 \\ &- 0.100 * \log(.01 * \text{PGSL}_{t-1} * \text{EGSLT}_{t-1} / \text{XGDPTN}_{t-1}) \\ &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600 \end{aligned}$$

h.19 EGSN: S&L government consumption and gross investment, current \$

$$\text{EGSN} = \text{EGSLN} + \text{EGSIN} + \text{EGSON}$$

h.20 EGSO: S&L government consumption ex. employee comp., cw 2000\$

State and local government consumption expenditure ex employee compensation error-corrects to its long-run trend, EGSOT.

$$\begin{aligned} \text{del}(1 : \log(\text{EGSO})) &= -0.000486 \\ &- 0.0813 * \log(\text{EGSO}_{t-1} / \text{EGSOT}_{t-1}) \\ &+ \text{A2(L) } \{ \text{sum } 0.703 \} * \text{del}(1 : \log(\text{EGSO}_{t-1})) \\ &+ 0.310 * \text{del}(1 : \log(\text{EGSOT})) \\ &+ \text{A4(L) } \{ \text{sum } 3.62\text{E-}05 \} * \text{XGAP2}_t \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.522
A2 ₁	0.180
A2SUM	0.703
A4 ₀	-0.00136
A4 ₁	0.00140
A4SUM	3.62E-05

Regression statistics

R²: .59926
 Sum of squared residuals: .010701
 Standard error of regression: .0082557
 Durbin-Watson statistic: 1.9935
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.21 EGSON: S&L government consumption ex. employee comp., current \$

$$\text{EGSON} = .01 * \text{PXP} * \text{PGSOR} * \text{EGSO}$$

h.22 EGSOT: S&L government consumption ex. employee comp., cw 2000\$, trend

$$\begin{aligned} \text{del}(1 : \log(\text{EGSOT})) &= -0.371 \\ &- 0.100 * \log(.01 * \text{PGSOR}_{t-1} * \text{PXP}_{t-1} * \text{EGSOT}_{t-1} / \text{XGDPTN}_{t-1}) \\ &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600 \end{aligned}$$

h.23 GFDBTN: Federal government debt stock, current \$

$$\begin{aligned} \text{GFDBTN} &= \text{UGFDBT} * (\text{GFDBTN}_{t-1} - .25 * \text{GFSRPN} + .25 * \text{EGFIN} \\ &- .25 * \text{JYGFGN} - .25 * \text{JYGFEN}) \end{aligned}$$

h.24 GFINTN: Federal government net interest payments, current \$

$$\text{GFINTN} = \text{RGFINT} * \text{GFDBTN}_{t-1}$$

h.25 GFS: Federal government grants-in-aid to S&L government, deflated by PCNIA

$$\begin{aligned} \text{del}(1 : \log(\text{GFS})) &= -0.361 \\ &- 0.100 * \log(\text{GFSN}_{t-1} / \text{XGDPTN}_{t-1}) \\ &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600 \end{aligned}$$

h.26 GFSN: Federal government grants-in-aid to S&L government, current \$

$$\text{GFSN} = .01 * \text{PGDP} * \text{GFS}$$

h.27 GFSRPN: Federal government budget surplus, current \$

$$\begin{aligned} \text{GFSRPN} &= \text{TFPN} + \text{TFCIN} + \text{TFIBN} + \text{TFSIN} \\ &- \text{EGFLN} - \text{EGFON} - \text{GFTN} - \text{GFINTN} \\ &- \text{GFSUBN} - \text{GFSN} \end{aligned}$$

h.28 GFSUB: Federal government subsidies less surplus, deflated by PCNIA

$$\begin{aligned} \text{del}(1 : \log(\text{GFSUB})) &= -0.550 \\ &- 0.100 * \log(\text{GFSUBN}_{t-1}/\text{XGDPTN}_{t-1}) \\ &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600 \end{aligned}$$

h.29 GFSUBN: Federal government subsidies less surplus, current \$

$$\text{GFSUBN} = .01 * \text{PGDP} * \text{GFSUB}$$

h.30 GFT: Federal government net transfer payments, deflated by PCNIA

Real federal transfers equals the sum of the cyclical and trend transfer ratios (GFTRD and GFTRT) multiplied by potential GDP.

$$\text{GFT} = (\text{GFTRD} + \text{GFTRT}) * \text{XGDPT}$$

h.31 GFTN: Federal government net transfer payments, current \$

$$\text{GFTN} = .01 * \text{PCNIA} * \text{GFT}$$

h.32 GFTRD: Deviation of ratio of federal transfers to GDP from trend ratio

The deviation of the ratio of real federal transfers to real GDP from its trend is estimated to vary countercyclically. Historically, the trend ratio (GFTRT) is estimated by H-P filtering the actual ratio.

$$\begin{aligned} \text{GFTRD} &= 0.000140 \\ &+ 0.639 * \text{GFTRD}_{t-1} \\ &- 0.000211 * \text{XGAP2} \end{aligned}$$

Regression statistics

R ² :	.53383
Sum of squared residuals:	7.6419E-4

Standard error of regression: .0021787
 Durbin-Watson statistic: 2.1263
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.33 GSDBTN: S&L government debt stock, current \$

$$\text{GSDBTN} = \text{UGSDBT} * (\text{GSDBTN}_{t-1} - .25 * \text{GSSRPN} + .25 * \text{EGSIN} - .25 * \text{JYGSGN} - .25 * \text{JYGSEN})$$

h.34 GSINTN: S&L government net interest payments, current \$

State and local net interest payments combine the interest paid on the financial liabilities of these entities with the interest received by their pension funds. It is a negative number. Because FRB/US includes only the debt position excluding the social insurance funds, the equation for net interest assumes that state and local governments pay the same rate of interest as does the federal government (RGFINT) on debt excluding social insurance funds (GSDBTN), and that the interest receipts of the social insurance funds are an exogenous fraction (UGSINT) of business sector output (XBN).

$$\text{GSINTN} = \text{RGFINT} * \text{GSDBTN}_{t-1} + \text{UGSINT} * \text{XBN}$$

h.35 GSSRPN: S&L government budget surplus, current \$

$$\text{GSSRPN} = \text{TSPN} + \text{TSCIN} + \text{TSIBN} + \text{TSSIN} + \text{GFSN} - \text{EGSLN} - \text{EGSON} - \text{GSTN} - \text{GSINTN} - \text{GSSUBN}$$

h.36 GSSUB: S&L government subsidies less surplus, deflated by PCNIA

$$\text{GSSUB} = \text{UGSSUB} * \text{XGDPT}$$

h.37 GSSUBN: S&L government subsidies less surplus, current \$

$$\text{GSSUBN} = .01 * \text{PGDP} * \text{GSSUB}$$

h.38 GST: S&L government net transfer payments, deflated by PCNIA

$$\text{GST} = (\text{GSTRD} + \text{GSTRT}) * \text{XGDPT}$$

h.39 GSTN: S&L government net transfer payments, current \$

$$\text{GSTN} = .01 * \text{PCNIA} * \text{GST}$$

h.40 GSTRD: Deviation of ratio of S&L transfers to GDP from trend ratio

Real state and local transfer payments relative to potential GDP are assumed to deviate from their trend rate of growth when aggregate output deviates from its trend. When the economy is cyclically strong (XGAP2 greater than zero), transfer payments are below trend.

$$\begin{aligned} \text{GSTRD} &= 2.90\text{E-}05 \\ &+ 0.749 * \text{GSTRD}_{t-1} \\ &- 3.88\text{E-}05 * \text{XGAP2} \end{aligned}$$

Regression statistics

R ² :	.62526
Sum of squared residuals:	5.323E-5
Standard error of regression:	5.75E-4
Durbin-Watson statistic:	2.419
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

h.41 RGFINT: Ratio of federal government net interest payments to lagged stock of debt

The average rate of interest on federal government debt (RGFINT) is measured historically as the ratio of interest paid to the lagged stock of debt outstanding. Its equation is specified in a partial adjustment format, with an estimated adjustment speed of about 8 percent per quarter. The steady-state average interest rate equals an average of the yields on treasury bills (RTB) and 5-year bonds (RG5).

$$\begin{aligned}
 \text{del}(1 : \text{RGFINT}) &= 0.0442 * (\text{RG5}_{t-1}/100 - \text{RGFINT}_{t-1}) \\
 &+ 0.0620 * (\text{RTB}_{t-1}/100 - \text{RG5}_{t-1}/100) \\
 &+ 0.000803 \\
 &- 0.171 * \text{del}(1 : \text{RGFINT}_{t-1}) \\
 &+ 0.200 * \text{del}(1 : \text{RG5}_{t-1}/100) \\
 &+ 0.0442 * \text{del}(1 : \text{RTB}/100)
 \end{aligned}$$

Regression statistics

R ² :	.59022
Sum of squared residuals:	3.9306E-4
Standard error of regression:	.0015772
Durbin-Watson statistic:	2.2633
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

h.42 TFCIN: Federal corporate income tax accruals, current \$

$$\text{TFCIN} = \text{TRFCI} * \text{YNICPN}$$

h.43 TFIBN: Federal indirect business tax receipts, current \$

$$\text{TFIBN} = \text{TRFIB} * \text{ECNIAN}$$

h.44 TFPN: Federal personal income tax and nontax receipts, current \$

$$\text{TFPN} = \text{TRFP} * (\text{YPN} - \text{GFTN} - \text{GSTN})$$

h.45 TFSIN: Federal social insurance tax receipts

$$\text{TFSIN} = \text{TRFSI} * \text{YNILN}$$

h.46 TRFCI: Average federal corporate income tax rate

The average federal corporate income tax rate varies with the statutory marginal rate (TRFCIM), the investment tax credit (TAPDTC and TAPDTC), the cyclical state of the economy (XGAP2), and the rate of inflation (PICNIA). The latter captures two effects of higher inflation: it boosts taxable capital gains on inventory stocks and lowers the value of historical cost depreciation allowances.

$$\begin{aligned} \text{TRFCI} = & 0.00753 \\ & + 0.714 * \text{TRFCI}_{t-1} \\ & + 0.152 * \text{TRFCIM} \\ & - 0.219 * (.01 * \text{PXP} * (\text{EPDO} * \text{PPDOR} * .01 * \text{TAPDTC} + \text{EPDC} * \text{PPDCR} * .01 * \text{TAPDTC}) / \text{YNICPN}) \\ & + 0.00173 * \text{XGAP2} \\ & + 0.00383 * \text{PICNIA} \end{aligned}$$

Regression statistics

R ² :	.94779
Sum of squared residuals:	.025613
Standard error of regression:	.012732
Durbin-Watson statistic:	1.7905
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

h.47 TRFP: Average federal tax rate for personal income tax and nontax receipts

The average federal personal income tax rate varies procyclically and adjusts gradually to eliminate deviations between the average and trend (TRFPT) tax rate.

$$\begin{aligned} \text{TRFP} = & 1.00 * \text{TRFPT} \\ & + \text{A2(L)} \{ \text{sum } 0.918 \} * (\text{TRFP}_{t-1} - \text{TRFPT}_{t-1}) \\ & + 0.000344 * \text{XGAP2}_{t-1} \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.568
A2 ₁	0.349
A2SUM	0.918

Regression statistics

R ² :	.76586
Sum of squared residuals:	.0041008
Standard error of regression:	.0050025
Durbin Watson statistic:	1.9659
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

h.48 TRFPT: Average federal tax rate for personal income tax, trend

The equation for TRFPT (the trend component of the average federal personal income tax rate) has three settings. The trend tax rate is exogenous if DFPEX is set to 1; the trend rate adjusts to deviations of the debt ratio from its target is DFDBT is 1, and it adjusts to deviations of the surplus ratio from its target if DFSRP is 1.

$$\begin{aligned}
 \text{TRFPT} = & \text{DFPEX} * \text{TRFPTX} \\
 & + \text{DFPDBT} * (\text{TRFPT}_{t-1} \\
 & + 0.0500 \text{ [(const.)]} * (\text{GFDBTN}_{t-1} / \text{XGDPN}_{t-1} - \text{GFDRT}_{t-1}) \\
 & + 0.500 \text{ [(const.)]} * \text{del}(1 : \text{GFDBTN}_{t-1} / \text{XGDPN}_{t-1} - \text{GFDRT}_{t-1}) \\
 & + \text{DFPSRP} * (\text{TRFPT}_{t-1} \\
 & - 0.100 \text{ [(const.)]} * ((\text{GFSRPN}_{t-1} - \text{EGFIN}_{t-1} + \text{JYGFGN}_{t-1} \\
 & + \text{JYGFEN}_{t-1}) / \text{XGDPN}_{t-1} - \text{GFSRT}_{t-1}))
 \end{aligned}$$

h.49 TRSCI: Average S&L corporate income tax rate

The average state and local corporate income tax rate varies countercyclically, moves in tandem with the average federal rate, and adjusts gradually to eliminate deviations between the average rate and its trend (TRSCIT).

$$\begin{aligned}
 \text{TRSCI} = & 0.759 * \text{TRSCI}_{t-1} \\
 & + \text{A2(L)} \{ \text{sum } 0.241 \} * \text{TRSCIT}_t \\
 & + \text{A3(L)} \{ \text{sum } -6.87\text{E-}05 \} * \text{XGAP2}_t \\
 & + 0.124 * \text{del}(1 : \text{TRFCI})
 \end{aligned}$$

Distributed lag coefficients

Name	Value
A20	1.24
A21	-0.995
A2SUM	0.241
A30	-0.000623
A31	0.000555
A3SUM	-6.87E-05

Regression statistics

R^2 : .96544
 Sum of squared residuals: 8.5847E-4
 Standard error of regression: .0023217
 Durbin-Watson statistic: 2.2474
 Sample period: 1965:q1 - 2005:q4

Estimation date: August 2006

h.50 TRSIB: Average S&L indirect business tax rate

The average state and local corporate indirect business tax rate varies countercyclically, and adjusts gradually to eliminate deviations between the average rate and its trend (TRSIBT).

$$\begin{aligned} \text{TRSIB} = & 0.914 * \text{TRSIB}_{t-1} \\ & + \text{A2(L) } \{\text{sum } 0.0863 \} * \text{TRSIBT}_t \\ & - 4.24\text{E-}05 * \text{XGAP2} \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	1.39
A2 ₁	-1.30
A2SUM	0.0863

Regression statistics

R²: .99177
 Sum of squared residuals: 6.8019E-5
 Standard error of regression: 6.4811E-4
 Durbin-Watson statistic: 1.9554
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.51 TRSP: Average S&L tax rate for personal income tax and nontax receipts

The average state and local personal income tax rate varies countercyclically, moves in tandem with the average federal rate (TRFP), and adjusts gradually to eliminate deviations between the average and trend (TRSPT) tax rates.

$$\begin{aligned} \text{TRSP} = & 0.621 * \text{TRSP}_{t-1} \\ & + \text{A2(L) } \{\text{sum } 0.379 \} * \text{TRSPT}_t \\ & + 6.71\text{E-}06 * \text{XGAP2}_{t-1} \\ & + 0.0252 * \text{del}(1 : \text{TRFP}) \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.920
A2 ₁	-0.541

A2SUM	0.379
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Regression statistics

R^2 : .98065
 Sum of squared residuals: 8.1125E-5
 Standard error of regression: 7.1201E-4
 Durbin-Watson statistic: 2.0796
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

h.52 TRSPT: Trend S&L personal income tax rate

The equation for TRSPT (the trend component of the average state and local personal income tax rate) has three settings. The trend tax rate is exogenous if DFPEX is set to 1; the trend rate adjusts to deviations of the debt ratio from its target is DFDBT is 1, and it adjusts to deviations of the surplus ratio from its target if DFSRP is 1.

$$\begin{aligned}
 \text{TRSPT} = & \text{DFPEX} * \text{TRSPTX} \\
 & + \text{DFPDBT} * (\text{TRSPT}_{t-1} \\
 & + 0.0500 [(\text{const.})] * (\text{GSDBTN}_{t-1}/\text{XGDPN}_{t-1} - \text{GSDRT}_{t-1}) \\
 & + 0.500 [(\text{const.})] * \text{del}(1 : \text{GSDBTN}_{t-1}/\text{XGDPN}_{t-1} - \text{GSDRT}_{t-1}) \\
 & + \text{DFPSRP} * (\text{TRSPT}_{t-1} \\
 & - 0.250 [(\text{const.})] * ((\text{GSSRPN}_{t-1} - \text{EGSIN}_{t-1} + \text{JYGSGN}_{t-1} \\
 & + \text{JYGSEN}_{t-1})/\text{XGDPN}_{t-1} - \text{GSSRT}_{t-1}))
 \end{aligned}$$

h.53 TRSSI: Average S&L social insurance tax rate

The average state and local social insurance tax rate varies countercyclically, and adjusts gradually to eliminate deviations between the average rate and its trend (TRSSIT).

$$\begin{aligned}
 \text{TRSSI} = & \text{A1(L)} \{ \text{sum } 0.936 \} * \text{TRSSI}_{t-1} \\
 & + \text{A2(L)} \{ \text{sum } 0.0639 \} * \text{TRSSIT}_t \\
 & - 2.79\text{E-}06 * \text{XGAP2}
 \end{aligned}$$

Distributed lag coefficients

Name	Value
A10	1.12
A11	-0.185
A1SUM	0.936
A20	1.18

A2 ₁	-1.12
A2 _{SUM}	0.0639

Regression statistics

R ² :	.98748
Sum of squared residuals:	8.0804E-7
Standard error of regression:	7.1025E-5
Durbin Watson statistic:	1.9883
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

h.54 TSCIN: S&L corporate income tax accruals, current \$

$$\text{TSCIN} = \text{TRSCI} * \text{YNICPN}$$

h.55 TSIBN: S&L indirect business tax receipts, current \$

$$\text{TSIBN} = \text{TRSIB} * \text{ECNIAN}$$

h.56 TSIEN: Employer social insurance taxes, current \$

$$\text{TSIEN} = \text{UTSIE} * (\text{TFSIN} + \text{TSSIN})$$

h.57 TSPN: S&L personal income tax and nontax receipts, current \$

$$\text{TSPN} = \text{TRSP} * (\text{YPN} - \text{GFTN} - \text{GSTN})$$

h.58 TSSIN: S&L social insurance tax receipts, current \$

$$\text{TSSIN} = \text{TRSSI} * \text{YNILN}$$

h.59 YGFSN: Federal government saving

$$\text{YGFSN} = \text{GFSRPN} + \text{JYGFGN} + \text{JYGFEN}$$

h.60 YGSSN: State and Local government saving

$$\text{YGSSN} = \text{GSSRPN} + \text{JYGSGN} + \text{JYGSN}$$



Financial Sector

The financial sector of FRB/US can be sub-divided into three blocks of equations: equations determining the stance of monetary policy, defined as the value of the nominal federal funds rate; equations for other interest rates based on arbitrage relationships; and a set of identities for household wealth, including equations that relate the value of the stock market to real bond yields and expected growth in dividends.

In the monetary policy block, there are five options for setting the federal funds rate: (1) The funds rate follows a pre-determined path. (2) Policy is defined by a policy reaction function which is estimated over the period 1963 to 1994 and is identical to that embedded in the construction of VAR expectations. (3) Policy is modeled as a version of the Taylor rule. (4) Policy is defined by a policy reaction function estimated over the 1980-1995 period. (5) The funds rate is set according to a generalized policy rule that can be used, among other things, to target either inflation or the price level. These five options are mutually exclusive, although it is possible to switch from one option to another in multi-period simulations by manipulating a group of exogenous "switches" (DMPEX, DMPVAR, DMPTAY, DMTP79 and DMPGEN).

In the block of equations that determine other interest rates, the most important are those for yields on 5- and 10-year government bonds and for the yield on corporate bonds. These equations are based on the expectations theory of the term structure, whereby the yield on a long-term bond equals a weighted average of expected rates on short-term assets over the maturity of the long-term bond plus a term premium. A weighted average (with weights declining about 2 percent per quarter), rather than a simple average, of expected future rates is computed, because the value of a coupon bond depends on both the level and the time-ordering of expected short-term rates. In these equations, term/risk premiums are modeled as having four components: a constant, an element that varies inversely with the expected cyclical state of the economy, an element that captures low-frequency shifts in the slope, and an unexplained component which is serially correlated. (An

alternative interpretation of the latter component is that it represents errors in the model's proxies for expectations.)

Aside from the three main bond rate variables, the second block of equations also contains estimated equations for several other interest rates, including yields on Treasury bills, home mortgages, new car loans, and M2 deposits. Unlike the bond rate equations, however, these expressions do not directly use any expectational variables. In addition, the block also contains an equation for M2.

The final block of the sector determines the value of household net worth, as measured by the Federal Reserve's Flow-of-Funds accounts. Household net worth is divided into two components, corporate equity and other. The former is determined using the standard Gordon formula, in which stock prices depend on the current level of dividends, expected future growth in dividends, the real interest rate, and an equity premium; historical estimates of the latter are derived by inverting the formula. Household net worth excluding corporate equity equals the accumulated flow of household saving plus cumulated capital gains.

i.1 RFFTAY: Value of eff. federal funds rate given by the Taylor reaction function

RFFTAY is a version of the Taylor Rule. According to the equation, the nominal funds rate is set equal to the sum of the equilibrium real funds rate as perceived by policymakers (RSTAR) and a four-quarter moving average of actual inflation. This value is then adjusted in response to deviations of actual inflation from the target rate of inflation (PITARG) and deviations of the level of output from potential (XGAP2).

$$\begin{aligned} \text{RFFTAY} = & \text{RSTAR} \\ & + \text{mave}(4 : \text{PICXFE}_t) \\ & + 0.500 * (\text{mave}(4 : \text{PICXFE}_t) - \text{PITARG}) \\ & + 1.00 * \text{XGAP2} \end{aligned}$$

i.2 RFFP87: Value of eff. federal funds rate given by the post-87 estimated reaction function

RFFP87 is a version of the Taylor Rule estimated over the period 1987 to 2000. In estimation, the core inflation terms are aggregated and a constant intercept is used in place of the equilibrium real funds rate as perceived by policymakers (RSTAR) and the target rate of core inflation (PITARG). The estimated value of the intercept (.40032) is consistent with RSTAR equal to 2.5 percent and PITARG equal to 1.5 percent.

$$\begin{aligned} \text{RFFP87} = & 0.705 * \text{RFFP87}_{t-1} \\ & + 0.295 * (\text{RSTAR} + \text{mave}(4 : \text{PICXFE}_t)) \\ & + 0.220 * (\text{mave}(4 : \text{PICXFE}_t) - \text{PITARG}) \\ & + 0.315 * \text{XGAP2} \end{aligned}$$

i.3 RFFGEN: Value of eff. federal funds rate given by the generalize reaction function

The equation for RFFGEN expresses a generalized description of a monetary policy reaction function. By altering the rule's coefficients, policy can target either inflation or the price level in the long-run. Similarly, parameters can be manipulated to allow the federal funds rate to respond (as desired) to transitory movements in past interest rates, inflation, prices, the output gap and the deviation of unemployment from the NAIRU. The default coefficient setting for RFFGEN makes the equation equivalent to the Taylor rule.

$$\begin{aligned}
 \text{RFFGEN} &= 0.00 \\
 &+ A1(L) \text{ {sum 0.00} } * \text{RFFE}_{t-1} \\
 &+ A2(L) \text{ {sum 1.50} } * \text{PICNIA}_t \\
 &+ A3(L) \text{ {sum 0.500} } * \text{XGAP2}_t \\
 &+ A4(L) \text{ {sum 0.00} } * \text{LUR}_t \\
 &+ A5(L) \text{ {sum 0.00} } * \text{PCNIA}_t \\
 &+ B1(L) \text{ {sum 1.00} } * \text{RSTAR}_t \\
 &+ B2(L) \text{ {sum -0.500} } * \text{PITARG}_t \\
 &+ B4(L) \text{ {sum 0.00} } * \text{LURNAT}_t \\
 &+ B5(L) \text{ {sum 0.00} } * \text{PCSTAR}_t \\
 &+ B6(L) \text{ {sum 0.00} } * \text{PICXFE}_t
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	0.00	A34	0.00	B12	0.00	B4SUM	0.00
A11	0.00	A3SUM	0.500	B13	0.00	B50	0.00
A12	0.00	A40	0.00	B14	0.00	B51	0.00
A13	0.00	A41	0.00	B1SUM	1.00	B52	0.00
A1SUM	0.00	A42	0.00	B20	-0.500	B53	0.00
A20	0.375	A43	0.00	B21	0.00	B54	0.00
A21	0.375	A44	0.00	B22	0.00	B5SUM	0.00
A22	0.375	A4SUM	0.00	B23	0.00	B60	0.00
A23	0.375	A50	0.00	B24	0.00	B61	0.00
A24	0.00	A51	0.00	B2SUM	-0.500	B62	0.00
A2SUM	1.50	A52	0.00	B40	0.00	B63	0.00
A30	0.500	A53	0.00	B41	0.00	B64	0.00
A31	0.00	A54	0.00	B42	0.00		
A32	0.00	A5SUM	0.00	B43	0.00		
A33	0.00	B10	1.00	B44	0.00		
		B11	0.00				

i.4 RFFE: Federal funds rate (effective ann. yield)

The equation for the effective federal funds rate determines which of six monetary policy options is used in simulations of the model. To simulate with an exogenous nominal funds rate, one sets the policy switch variable DMPEX to 1, assigns a path for the exogenous funds rate (RFFFIX), and sets the other five policy switches to zero. Similarly, to simulate with an exogenous real funds rate, one sets DMPRR to 1, assigns a path for the exogenous real funds rate (RRFIX), and sets the remaining policy switches (DPMxxx) to zero.

Alternatively, the funds rate can be determined by one of the policy reaction functions. Which specific rule is used depends on the settings of the three policy dummy variables -- DMPTAY, DMPP87, and DMPGEN. A setting of zero turns off the corresponding policy rule, a setting of 1 turns it on. Finally, the equation specification sets a lower limit on the nominal funds rate. Setting RFFMIN to zero imposes the zero lower bound; setting RFFMIN to a large negative number effectively eliminates the constraint.

$$\begin{aligned} \mathbf{RFFE} = & \text{MAX}(\text{DMPEX} * 100 * ((1+\text{RFFFIX}/36000)**365-1) \\ & + \text{DMPRR} * (\text{RRFIX} + \text{mave}(4 : \text{PICXFE}_t)) \\ & + \text{DMPTAY} * \text{RFFTAY} \\ & + \text{DMPP87} * \text{RFFP87} \\ & + \text{DMPALT} * 100 * ((1+\text{RFFALT}/36000)**365-1) \\ & + \text{DMPGEN} * \text{RFFGEN}, \text{RFFMIN}) \end{aligned}$$

i.5 RFF: Federal funds rate

$$\mathbf{RFF} = 36000 * ((1+.01 * \text{RFFE})**(1/365) - 1)$$

i.6 RRFEE: Real federal funds rate (effective ann. yield)

The real federal funds rate (RRFEE) is defined as the nominal effective funds rate (RFFE) minus a 4-quarter moving average of core consumer price inflation (PICXFE).

$$\mathbf{RRFEE} = \text{RFFE} - \text{mave}(4 : \text{PICXFE}_t)$$

i.7 RTB: 3-month Treasury bill rate

$$\mathbf{RTB} = 36000/90 * (1-(.01 * \text{RTBE}+1)**(-90/365))$$

i.8 RTBE: 3-month Treasury bill rate (effective ann. yield)

In the long run, the yield on 3-month Treasury bills equals the federal funds rate, less a fixed factor that adjusts for the default risk associated with the latter. Lags of RTBE are included in the equation to control for the sluggish adjustment of Treasury yields to the funds rate.

$$\begin{aligned} \mathbf{RTBE} = & -0.0740 \\ & + \text{B1(L)} \{ \text{sum } 0.885 \} * \text{RTBE}_{t-1} \end{aligned}$$

$$+ B2(L) \{ \text{sum } 0.115 \} * RFFE_t$$

Distributed lag coefficients

Name	Value
B1 ₀	0.759
B1 ₁	0.126
B1SUM	0.885
B2 ₀	0.783
B2 ₁	-0.668
B2SUM	0.115

Regression statistics

R ² :	.9865
Sum of squared residuals:	21.468
Standard error of regression:	.3663
Durbin-Watson statistic:	2.205
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

i.9 RG5: 5-year Treasury note rate

$$RG5 = ((.01 * RG5E + 1)^{*.5} - 1) * 200$$

i.10 RG5E: 5-year Treasury note rate (effective ann. yield)

The yield on the five-year Treasury is equal to a weighted average of the values of the federal funds rates expected over the next 5 years (ZRFF5) plus a term premium (RG5P). The latter is not exogenous but is assumed to vary with the expected state of the economy.

$$RG5E = ZRFF5 + RG5P$$

i.11 RG5P: 5-year Treasury note rate. term premium

The term premium on 5-year Treasury bonds varies with the expected state of the business cycle, as proxied by the weighted forward average of the expected future output gap (ZGAP05). The weights used to calculate ZGAP05 match those used to calculate ZRFF5, and decline geometrically at a rate of .98 per quarter over the coming 5 years. The bond premium also has an exogenous component that is captured by the intercept

Finally, there is an unexplained stochastic component of the bond premium that is serially correlated.

$$\begin{aligned} \mathbf{RG5P} &= 0.529 \text{ [(1.3)]} \\ &- 0.323 \text{ [(-3.6)]} * \mathbf{ZGAP05} \\ &+ 0.864 \text{ [(17.7)]} * (\mathbf{RG5P}_{t-1} - 0.529 \text{ [(const)]} - -0.323 \text{ [(const)]} * \mathbf{ZGAP05}_{t-1}) \end{aligned}$$

Regression statistics

R ² :	.85899
Sum of squared residuals:	30.075
Standard error of regression:	.54569
Durbin-Watson statistic:	1.76
Sample period:	1980:q1 - 2005:q4
Estimation date:	October 2006

i.12 RG10: 10-year Treasury bond rate

$$\mathbf{RG10} = ((.01 * \mathbf{RG10E} + 1)^{*.5} - 1) * 200$$

i.13 RG10E: 10-year Treasury bond rate (effective ann. yield)

The yield on 10-year Treasury bonds is equal to a weighted average of the values of the federal funds rates expected over the next 10 years (ZRFF10) plus a term premium (RG10P). The latter is not exogenous but is assumed to vary with the expected state of the economy.

$$\mathbf{RG10E} = \mathbf{ZRFF10} + \mathbf{RG10P}$$

i.14 RG10P: 10-year Treasury bond rate, term premium

The term premium on 10-year Treasury bonds varies with the expected state of the business cycle, as proxied by the weighted forward average of the expected future output gap (ZGAP10). The weights used to calculate ZGAP10 match those used to calculate ZRFF10, and decline geometrically at a rate of .98 per quarter over the coming 10 years. The bond premium also has an exogenous component that is captured by the intercept. Finally, there is an unexplained stochastic component of the bond premium that is serially correlated.

$$\begin{aligned} \mathbf{RG10P} &= 0.733 \text{ [(2.1)]} \\ &- 0.554 \text{ [(-3.2)]} * \mathbf{ZGAP10} \\ &+ 0.854 \text{ [(16.8)]} * (\mathbf{RG10P}_{t-1} - 0.733 \text{ [(const.)]} - -0.554 \text{ [(const.)]} * \mathbf{ZGAP10}_{t-1}) \end{aligned}$$

Regression statistics

R ² :	.82644
Sum of squared residuals:	26.347
Standard error of regression:	.51074
Durbin-Watson statistic:	1.68
Sample period:	1980:q1 - 2005:q4
Estimation date:	October 2006

i.15 RBAA: Moody's BAA corporate bond rate

$$RBAA = (((0.01 * \underline{RBAAE} + 1) ** .5 - 1) * 200)$$

i.16 RBAAE: Moody's BAA corporate bond rate (effective ann. yield)

The yield on long-term BAA corporate bonds is equal to a weighted average of the values of the federal funds rates expected over the next 10 years (ZRFF10) plus a term premium (RBAAP). The latter is not exogenous but is assumed to vary with the expected state of the economy.

$$RBAAE = \underline{ZRFF10} + \underline{RBAAP}$$

i.17 RBAAP: Moody's BAA corporate bond rate, risk/term premium

The combined risk/term premium on BAA bonds varies with the expected state of the business cycle, as proxied by the weighted forward average of the expected future output gap (ZGAP10). The weights used to calculate ZGAP10 match those used to calculate ZRFF10, and decline geometrically at a rate of .98 per quarter over the coming 10 years. The bond premium also has an exogenous component that is captured by the intercept. Finally, there is an unexplained stochastic component of the bond premium that is serially correlated.

$$\begin{aligned} RBAAP = & 3.03 \text{ [(7.02)]} \\ & - 0.612 \text{ [(-4.1)]} * \underline{ZGAP10} \\ & + 0.901 \text{ [(22.7)]} * (RBAAP_{t-1} - 3.03 \text{ [(const.)]} - 0.612 \text{ [(const.)]} * \underline{ZGAP10}_{t-1}) \end{aligned}$$

Regression statistics

R ² :	.89728
Sum of squared residuals:	19.161
Standard error of regression:	.43556

Durbin-Watson statistic: 1.3446
 Sample period: 1980:q1 - 2005:q4
 Estimation date: October 2006

i.18 RCB: Moody's AAA corporate bond rate

$$RCB = (((0.01 * RCBE + 1) ** .5 - 1) * 200)$$

i.19 RCBE: Moody's AAA corporate bond rate (effective ann. yield)

The yield on long-term AAA corporate bonds is equal to a weighted average of the values of the federal funds rates expected over the next 30 years (ZRFF30) plus a term premium (RCBP). The latter is not exogenous but is assumed to vary with the expected state of the economy.

$$RCBE = ZRFF30 + RCBP$$

i.20 RCBP: Moody's AAA corporate bond rate, risk/term premium

The combined risk/term premium on corporate bonds varies with the expected state of the business cycle, as proxied by the weighted forward average of the expected future output gap (ZGAP30). The weights used to calculate ZGAP30 match those used to calculate ZRFF30, and decline geometrically at a rate of .98 per quarter over the coming 30 years. The corporate bond premium also has an exogenous component that is captured by the intercept. Finally, there is an unexplained stochastic component of the bond premium that is serially correlated.

$$RCBP = 1.90 [(7.9)] \\ - 0.945 [(-3.8)] * ZGAP30 \\ + 0.826 [(16.4)] * (RCBP_{t-1} - 1.90 [(const.)] - 0.945 [(const.)] * ZGAP30_{t-1})$$

Regression statistics

R²: .80980
 Sum of squared residuals: 18.48
 Standard error of regression: .42775
 Durbin-Watson Statistic: 1.64
 Sample period: 1980:q1 - 2005:q4
 Estimation date: August 2006

i.21 RCAR: New car loan rate at finance companies

In the long run, the rate on new car loans equals the yield on 5-year Treasury bonds, plus an exogenous risk premium. This risk premium declined over the 1960s and 1970s, but appears to have been stable since 1980; this effect is captured using the dummy variable D79A and time trend T47. The lagged value of the auto loan rate is included in the equation to capture the sluggish adjustment of bank loan rates to movements in market interest rates.

$$\begin{aligned} \text{RCAR} = & 2.84 \\ & - 1.82 * \text{D79A} \\ & - 0.0111 * ((1-\text{D79A})*\text{T47}) \\ & + 0.629 * \text{RCAR}_{t-1} \\ & + \text{A4(L) } \{ \text{sum } 0.371 \} * \text{RG5}_t \end{aligned}$$

Distributed lag coefficients

Name	Value
A4 ₀	0.225
A4 ₁	0.146
A4SUM	0.371

Regression statistics

R ² :	.98073
Sum of squared residuals:	19.755
Standard error of regression:	.35248
Durbin-Watson statistic:	1.7594
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

i.22 RME: Interest rate on conventional mortgages (effective ann. yield)

In the long run, the mortgage rate equals the yield on BAA bonds, plus a combined term/risk premium. This premium has a fixed component captured by the intercept, but another component moves with the slope of the yield curve: When the yield curve is steep mortgage rates are modestly lower than they otherwise would be, all else equal. The lagged value of the mortgage rate is included in the equation to capture the sluggish adjustment of these loan rates to movements in market interest rates.

$$\begin{aligned} \text{RME} = & 0.199 \\ & + 0.767 * \text{RME}_{t-1} \\ & + \text{A2(L) } \{ \text{sum } 0.233 \} * \text{RBAAE}_t \\ & - 0.0683 * (\text{RBAAE} - \text{RTBE}) \end{aligned}$$

Distributed lag coefficients

Name	Value
A2 ₀	0.973
A2 ₁	-0.740
A2SUM	0.233

Regression statistics

R ² :	.99135
Sum of squared residuals:	12.572
Standard error of regression:	.28031
Durbin-Watson statistic:	1.8095
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

i.23 DELRFF: Federal funds rate, first diff

$$\text{DEL RFF} = \text{RFF} - \text{RFF}_{t-1}$$

i.24 REQ: Real expected rate of return on equity

The rate of return on equity equals the effective nominal corporate bond rate, minus the average rate of inflation expected to prevail over the coming 30 years, plus an equity premium. The latter varies over time, and is the residual in the theoretical identity linking the dividend-price ratio, the nominal yield on bonds, expected inflation, and the expected growth rate of real dividends.

$$\text{REQ} = \text{RCBE} - \text{ZPIC30} + \text{REQP}$$

i.25 REQP: Real expected rate of return on equity, premium component

The equity premium is estimated to be serially correlated but stationary; its long-run value is about 4.1 percentage points.

$$\text{REQP} = 0.270 + 0.934 * \text{REQP}_{t-1}$$

Regression statistics

R ² :	.87571
Sum of squared residuals:	59.494
Standard error of regression:	.60601

Durbin-Watson statistic: 2.1784
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

i.26 WPSN: Household stock market wealth, current \$

The equation for the market value of equities held by households (WPSN) is derived from the standard Gordon model for valuing a firm's share price. Aggregating across firms, this model implies that WPSN equals the current level of corporate cash payments, scaled up by the difference between the expected real rate of return on equity (REQ) and the expected real growth rate of dividends (ZDIVGR). Corporate cash payments are approximated by the NIPA measure of dividends, YNIDN, less a one-time \$24 billion cash payout by Microsoft in late 2004, YMSDN. (Because this latter payment merely represents a conversion of a portion of Microsoft's net assets from equity to cash, and not a change in the corporate earnings stream, it should not be capitalized.)

$$\log(\text{WPSN}) = \log(\text{YNIDN} - \text{YMSDN}) \\ - \log(.01 * \text{REQ} - .01 * \text{ZDIVGR})$$

i.27 WPS: Household stock market wealth, real

$$\text{WPS} = \frac{\text{WPSN}}{(.01 * \text{PCNIA})}$$

i.28 RCGAIN: Rate of capital gain on the non-equity portion of household wealth

The rate of capital gain on non-equity household wealth, after adjusting for inflation, depends on the rate of real price appreciation of consumer durable goods and housing. (Note: relative price gains on these two types of assets are weighted by their share in non-equity wealth.) Also, real capital gains on other assets vary procyclically.

$$\begin{aligned} \text{RCGAIN} = & 0.00 \\ & + 0.418 * \text{RCGAIN}_{t-1} \\ & + 0.582 * (\text{mave}(4 : \text{PICXFE}_t)) \\ & + 1.11 * (400 * \text{del}(1 : \log(\text{PHR})) * (.01 * \text{PHR}_{t-1} * \text{PXP}_{t-1} * \text{KH}_{t-1} / \text{WPON}_{t-1})) \\ & + 0.403 * (400 * \text{del}(1 : \log(\text{PCDR})) * (.01 * \text{PCDR}_{t-1} * \text{PCNIA}_{t-1} * \text{KCD}_{t-1} / \text{WPON}_{t-1})) \\ & + 0.163 * \text{XGAP2} \end{aligned}$$

Regression statistics

R²: .5707

Sum of squared residuals: 722.07
 Standard error of regression: 2.1243
 Durbin-Watson statistic: 2.0345
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

i.29 WPON: Household property wealth ex. stock market, current \$

The change in the non-equity portion of household net worth has three components -- NIPA personal savings, net investment in consumer durable goods, and capital gains on houses and other assets.

$$\begin{aligned} \text{WPON} = & \text{WPON}_{t-1} * \exp(\text{RCGAIN}/400) \\ & + .25 * (\text{YDN-ECNIAN-YHIBN}) \\ & + .25 * (.01 * \text{PCDR} * \text{PCNIA} * (\text{ECD-JKCD})) \end{aligned}$$

i.30 WPO: Household property wealth ex. stock market, real

$$\text{WPO} = \text{WPON} / (.01 * \text{PCNIA})$$

i.31 RFFALT: Federal funds rate given by MA rule

$$\begin{aligned} \text{RFFALT} = & 0.265 \\ & + 1.14 * \text{RFF}_{t-1} \\ & - 0.352 * \text{RFF}_{t-2} \\ & + 0.601 * \text{XGAP2} \\ & - 0.397 * \text{XGAP2}_{t-1} \\ & + 0.325 * (\text{mave}(4 : \text{PICXFE}_t)) \end{aligned}$$

Foreign Activity

In essence, the foreign activity sector is an estimated small-scale reduced-form forecasting model for the G10 economies. The system contains five primary equations: an "IS" curve equation, in which the level of foreign output relative to trend is a function of the real long-term interest rate abroad; an inflation equation, based on a simple Phillips curve specification augmented to control for the effects of oil price shocks; a monetary policy reaction function that determines the short-term rate of interest in the G10 economies; and a reduced-form yield curve equation that makes foreign bond rates a function of the long-run level of short-term interest rates. In estimating this system, coefficient restrictions were imposed to ensure long-run stability.

In addition to the G10 forecasting system, the foreign activity sector also contains equations for the level of consumer prices in the G39 economies, as well as the exchange value of dollar vis-a-vis the currencies of the same countries. Aggregate indices for both foreign consumer prices and the exchange rate are constructed using chain-aggregation, in which the weights are based on either bilateral export or import shares in U.S. trade.

j.1 FXGAP: Foreign output gap (world, bilateral export weights)

The foreign output gap is expressed as a reduced-form IS curve. The gap depends on lags of the foreign output gap, the real long-term foreign interest rate (FRL10-FPI10T), the domestic output gap (XGAP2), and dummy shift variable that controls for an apparent increase in the foreign equilibrium real rate after 1980. The equation is also coded to allow the user to build in a link between US and foreign equilibrium real rate, if desired. However, in estimation this link is suppressed by constraining the coefficient on the US equilibrium rate (RRTR) to be zero. (When freely estimated, this coefficient is insignificantly different from zero.)

$$\begin{aligned} \text{FXGAP} = & 0.0231 \\ & + \text{B1(L)} \{ \text{sum } 0.828 \} * \text{FXGAP}_{t-1} \\ & - 0.0704 * (\text{FRL10}_{t-1} - \text{FPI10T}_{t-1}) \\ & + 0.0363 * \text{XGAP2}_{t-1} \\ & + 0.00 * \text{RRTR}_{t-1} \\ & + 0.279 * \text{del}(1 : \text{T801}) \end{aligned}$$

Distributed lag coefficients

Name	Value
B10	1.19
B11	-0.360
B1SUM	0.828

Regression statistics

R ² :	.84505
Sum of squared residuals:	31.917
Standard error of regression:	.44945
Durbin-Watson statistic:	1.9954
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

j.2 FGDP: Foreign aggregate GDP (world, bilateral export weights)

The level of foreign GDP is determined via the identity that links it to the level of potential foreign output (FGDPT) and the foreign output gap (FXGAP).

$$\text{FGDP} = \text{FGDPT} * \exp(\text{FXGAP}/100)$$

j.3 FGDPT: Foreign aggregate GDP (world, bilateral export weights), trend

$$\begin{aligned} \text{del}(1 : \log(\text{FGDPT})) &= -0.458 \\ &- 0.100 * \log(\text{FGDPT}_{t-1}/\text{XGDPT}_{t-1}) \\ &+ 1.00 * (\text{HGGDPT} + \text{HGGDPT}_{t-1} + \text{HGGDPT}_{t-2} + \text{HGGDPT}_{t-3}) / 1600 \end{aligned}$$

j.4 FPI10: Foreign consumer price inflation (G10)

Foreign CPI inflation, as measured on a G-10 basis, is determined via a simple Phillips curve in which the change in inflation from its 4-quarter moving average is a function of the foreign output gap, plus current and lagged changes in the relative price of oil.

$$\begin{aligned} \text{FPI10} &= 1.000 * (\text{mave}(4 : \text{FPI10}_{t-1})) \\ &+ 0.249 * \text{FXGAP}_{t-1} \\ &+ \text{B3(L)} \{ \text{sum } 6.32 \} * \text{del}(1 : \log(\text{POILR}_t)) \end{aligned}$$

Distributed lag coefficients

Name	Value
B3 ₀	5.24
B3 ₁	1.08
B3SUM	6.32

Regression statistics

R^2 : .82633
 Sum of squared residuals: 321.16
 Standard error of regression: 1.4111
 Durbin Watson statistic: 1.7113
 Sample period: 1965:q1 - 2005:q4
 Estimation date: August 2006

j.5 FPI10T: Foreign consumer price inflation, trend (G10)

The trend component of foreign inflation adjusts at 5 percent per quarter to movements in actual foreign inflation.

$$\text{FPI10T} = 0.950 \text{ [const.] * FPI10T}_{t-1} \\ + 0.0500 \text{ [const.] * FPI10}$$

j.6 FPIC: Foreign consumer price inflation (G39, bilateral export trade weights)

In the long run, foreign consumer price inflation as measured on a G-29 basis moves one for one with foreign inflation as measured on a G-10 basis. The estimated coefficients indicate that G-29 inflation on average is 7.5 percentage points higher than G10 inflation (i.e., $1.261/.168 = 7.5$).

$$\text{FPIC} = 2.44 \\ + 0.659 * \text{FPI10} \\ + 0.341 * \text{FPIC}_{t-1}$$

Regression statistics

R ² :	.40508
Sum of squared residuals:	3138.5
Standard error of regression:	4.4015
Durbin-Watson statistic:	2.1066
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

j.7 FPC: Foreign aggregate consumer price (G39, import/export trade weights)

$$\text{FPC} = \text{FPC}_{t-1} * \exp(\text{FPIC}/400)$$

j.8 FPCM: Foreign aggregate consumer price (G39, bilateral non-oil import trade weights)

$$\text{FPCM} = \text{UFPCM} * \text{FPC}$$

j.9 FRS10: Foreign short-term interest rate (G10)

Foreign short-term interest rates (FRS10) are set using the standard version of the Taylor rule.

$$\begin{aligned} \text{FRS10} &= 0.00 \\ &+ 1.00 * \text{FRSTAR}_{t-1} \\ &+ 1.00 * (\text{mave}(4 : \text{FPI10}_t)) \\ &+ 0.500 * (\text{mave}(4 : \text{FPI10}_t) - \text{FPITRG}) \\ &+ 1.00 * \text{FXGAP} \end{aligned}$$

j.10 FRSTAR: Equilibrium real short-term interest rate used in foreign Taylor rule

The estimate of the foreign equilibrium real short-term interest rate used in the foreign Taylor rule is updated each period by 5 percent of the gap between the ex post real short rate and the prior estimate.

$$\begin{aligned} \text{FRSTAR} &= 0.950 * \text{FRSTAR}_{t-1} \\ &+ 0.0500 * (\text{FRS10} - \text{mave}(4 : \text{FPI10}_t)) \end{aligned}$$

j.11 FRL10: Foreign long-term interest rate (G10)

Foreign long-term interest rates (FRL10) are modeled using a reduced-form error-correction specification in which long rates converge to the foreign short-term interest rate plus a constant premium.

$$\begin{aligned} \text{FRL10} - \text{FRL10}(-1) &= 0.0402 [t] \\ &- 0.0823 [(-3.1)] * (\text{FRL10}_{t-1} - \text{FRS10}_{t-1}) \\ &+ 0.161 [t] * (\text{FRL10}_{t-1} - \text{FRL10}_{t-2}) \\ &+ 0.407 [t] * (\text{FRS10} - \text{FRS10}_{t-1}) \\ &+ 0.215 [t] * (\text{FXGAP} - \text{FXGAP}_{t-1}) \end{aligned}$$

Regression statistics

R ² :	.50708
Sum of squared residuals:	7.0689
Standard error of regression:	.26721
Durbin-Watson statistic:	1.6338
Sample period:	1980:q1 - 2005:q4
Estimation date:	September 2006

j.12 FPXR: Real exchange rate (G39, import/export trade weights)

The real exchange rate is determined via an open interest parity condition, in which a 1 percentage point

increase in the spread between domestic and foreign real long-term interest rates causes the dollar to appreciate 6 percent, on the assumption that the average duration of long-term interest rates is about 6 years. The value of the dollar is also assumed to be influenced by country risk, which is proxied by the ratio of net foreign assets to GDP. Finally, the equation is written as an identity through the use of a multiplicative residual, FPXRR.

$$\begin{aligned} \log(\text{FPXR}) - \log(\text{FPXRR}) = & \\ & 0.0600 * (\text{RG10E} - \text{ZPI10F} - \text{FRL10} + \text{FPI10T}) \\ & + 0.200 * (\text{FNIN} / \text{XGDPN}) \end{aligned}$$

Regression statistics

R ² :	1
Sum of squared residuals:	2.1176E-29
Standard error of regression:	3.9253E-16
Durbin Watson statistic:	2.0905
Sample period:	1965:q1 - 1998:q4
Estimation date:	February 2000

j.13 FPXRR: Real exchange rate residual

The unexplained component of the exchange rate error-corrects to its long-run exogenous trend (FPXRRT). This equation is primarily used in stochastic simulations.

$$\begin{aligned} \text{del}(1 : \log(\text{FPXRR})) = & 0.183 * \log(\text{FPXRRT}_{t-1} / \text{FPXRR}_{t-1}) \\ & + 0.0732 * \text{del}(1 : \log(\text{FPXRR}_{t-1})) \\ & + 0.927 * \text{del}(1 : \log(\text{FPXRRT})) \end{aligned}$$

Regression statistics

R ² :	.16992
Sum of squared residuals:	.15222
Standard error of regression:	.030648
Durbin Watson statistic:	2.0078
Sample period:	1965:q1 - 2005:q4
Estimation date:	August 2006

j.14 FPX: Nominal exchange rate (G39, import/export trade weights)

$$\text{FPX} = \text{FPXR} * \text{FPC} / \text{PCPI}$$

j.15 FPXM: Nominal exchange rate (G39, bilateral import trade weights)

$$\text{FPXM} = \text{UFPXM} * \text{FPX} * \text{FPCM} / \text{FPC}$$

Expectations

This sector contains the equations that are used for expectational variables when the assumption of "VAR" expectations is employed. Each equation defines the expectation of a weighted average of a variable over future quarters as a linear function of an observable information set. Two types of parameters determine the coefficient values in the expectations equations: the coefficients of the estimated VAR model used to generate forecasts that proxy for expectations; and discounting weights that specify the horizon of each expectation. Thus these equations are best thought of as formulas expressing the discounted present value of a particular variable as a function of an information set.

In these formulas, the information set always includes a core set of macro variables: actual consumer price inflation (PICNIA) and the value expected to prevail in the long run (PTR); the actual federal funds rate (RFFE) and the value expected to prevail in the long run (RTR); and the output gap (XGAP). (By definition, the latter is assumed to be zero in the long run.) The structure of the core VAR model is such that interest rate and inflation expectations converge to long-run expectations as the forecast horizon lengthens. The long-run expectations are modeled as random walks in the core VAR. For many expectational variables, the information set also includes one or more sector-specific variables. Expectations in most financial equations assume that current-period data are in the information set, while those in most nonfinancial equations assume that only lagged data are in the information set.

For expectations appearing in PAC equations, the discounting weights depend on a general discount factor (.98 per quarter) and on the estimated adjustment cost parameters as given by the error-correction coefficient and coefficients on lags of the dependent variable. In most cases, the effective forward horizon of these expectations is only a few years. Note that the sum of the discounting weights in PAC expectations is not unity; the actual sum of the PAC discounting weights is given in the definition of each expectational variable.

Financial equations for long-term interest rates and the stock market do not contain adjustment costs. In these instances, the discounting weights depend on the maturity and duration of the financial instrument. In the bond rate equations, the sum of the discounting weights is unity and the forward horizon is finite. In the stock market equation, the sum of the discounting weights is not unity and the forward horizon is infinite.

z.1 DLQEC: del(log(qec))

$$\mathbf{DLQEC} = \text{del}(1 : \log(\mathbf{QEC}))$$

z.2 DLQECD: del(log(qecd))

$$\mathbf{DLQECD} = \text{del}(1 : \log(\mathbf{QECD}))$$

z.3 DLQEH: del(log(qeh))

$$\mathbf{DLQEH} = \text{del}(1 : \log(\mathbf{QEH}))$$

z.4 DLQLHP: del(log(qlhp))

$$\mathbf{DLQLHP} = \text{del}(1 : \log(\mathbf{QLHP}))$$

z.5 DLQPC: del(log(qpcnia))

$$\mathbf{DLQPC} = \text{del}(1 : \log(\mathbf{QPCNIA}))$$

z.6 DLQPL: del(log(qpl))

$$\mathbf{DLQPL} = \text{del}(1 : \log(\mathbf{QPL}))$$

z.7 DLQPX: del(log(qpxnc))

$$\mathbf{DLQPX} = \text{del}(1 : \log(\mathbf{QPXNC}))$$

z.8 DLQYDV: del(log(qynidn/pxg))

$$\mathbf{DLQYDV} = \text{del}(1 : \log(\underline{\text{QYNIDN/PXG}}))$$

z.9 DLVPDC: del(log(vpdc))

$$\mathbf{DLVPDC} = \text{del}(1 : \log(\underline{\text{VPDC}}))$$

z.10 DLVPDO: del(log(vpdo))

$$\mathbf{DLVPDO} = \text{del}(1 : \log(\underline{\text{VPDO}}))$$

z.11 DLVPS: del(log(vps))

$$\mathbf{DLVPS} = \text{del}(1 : \log(\underline{\text{VPS}}))$$

z.12 DLXB: del(log(xb))

$$\mathbf{DLXB} = \text{del}(1 : \log(\underline{\text{XB}}))$$

z.13 DLYNID: del(log(ynidn/pxg))

$$\mathbf{DLYNID} = \text{del}(1 : \log(\underline{\text{YNIDN/PXG}}))$$

z.14 HGYNID: 400*del(log(ynidn/pxg))

$$\mathbf{HGYNID} = 400 * \text{del}(1 : \log(\mathbf{YNIDN/PXG}))$$

z.15 HPRDTP: Expected growth rate of trend labor productivity for PXP equation

$$\mathbf{HPRDTP} = 0.00 * \mathbf{HPRDTP}_{t-1} \\ + 1.00 * \mathbf{HLPRDT}/400$$

z.16 HPRDTW: Expected growth rate of trend labor productivity for PIPL equation

$$\mathbf{HPRDTW} = 0.963 * \mathbf{HPRDTW}_{t-1} \\ + 0.0370 * \mathbf{HLPRDT}/400$$

Regression statistics

Estimation date: August 2006

Estimated by: John Roberts

z.17 PTR: 10-year expected inflation (Hoey/Philadelphia survey)

Long-run expectations close a fixed percentage each quarter of the gap between last period's actual rate of inflation (PICNIA) and the previous expectation.

$$\mathbf{PTR} = \mathbf{PTR}_{t-1} \\ + 0.100 * (\mathbf{PICNIA} - \mathbf{PTR}_{t-1})$$

z.18 RRTR: Expected long-run real federal funds rate

The expected long-run value of the real federal funds rate (RRTR) is assumed each quarter to close 3 percent of the gap between the current ex post real funds rate and last quarter's estimate of RRTR.

$$\mathbf{RRTR} = 0.970 * \mathbf{RRTR}_{t-1} \\ + 0.0300 * \mathbf{RRFFE}$$

z.19 RSTAR: Equilibrium real federal funds rate (for monetary policy reaction functions)

The estimate of the equilibrium real federal funds rate used in the monetary policy rules is updated each period by 5 percent of the gap between the ex post real short rate and the prior estimate, if the switch DRSTAR is set to 1.

$$\begin{aligned} \text{RSTAR} &= \text{RSTAR}_{t-1} \\ &+ 0.0500 * ((\text{RRFFE} - \text{RSTAR}_{t-1}) * \text{DRSTAR}) \end{aligned}$$

z.20 RTR: Expected average federal funds rate 10-30 years ahead

$$\text{RTR} = \text{RRTR} + \text{PTR}$$

z.21 ZDIVGR: Expected growth rate of real dividends, for WPSN eq. (weight: 1.0)

$$\begin{aligned} \text{ZDIVGR} &= 2.17 \\ &+ \text{A1(L) } \{\text{sum } -0.00493\} * \text{PICNIA}_t \\ &+ \text{A2(L) } \{\text{sum } -0.0552\} * \text{RFFE}_t \\ &+ 0.0552 * \text{RTR} \\ &+ 0.00493 * \text{PTR} \\ &+ \text{A5(L) } \{\text{sum } -0.152\} * \text{XGAP}_t \\ &+ \text{A6(L) } \{\text{sum } 0.0116\} * (400 * \text{del}(1 : \log((\text{YNIDN}_t - \text{YMSDN}_t) / (.01 * \text{PXG}_t)))) \\ &+ 0.988 * \text{HGGDPT} \end{aligned}$$

Distributed lag coefficients

Name	Value
A10	0.00621
A11	-0.000198
A12	-0.0109
A13	-4.99E-05

Name	Value
A1SUM	-0.00493
A20	0.0465
A21	-0.0130
A22	-0.0654
A23	-0.0233

Name	Value
A2SUM	-0.0552
A50	-0.173
A51	0.00394
A52	-0.00490
A53	0.0220

Name	Value
A5SUM	-0.152
A60	0.0191
A61	-0.00358
A62	-0.00409
A63	0.000143
A6SUM	0.0116

z.22 ZECD: Expected growth rate of target durable consumption, for ECD eq. (weight: 1.05)

The weighted average growth rate of expected future target outlays on consumer durable goods, ZECD, is computed using (1) forecasts from a small scale VAR model (2) combined with the PAC weights implied by

the estimated coefficients of the dynamic ECD equation. The equation shown below is the reduced-form representation of this expectational computation.

$$\begin{aligned}
 \text{ZECD} = & 0.00110 \\
 & + \text{B1(L)} \{ \text{sum } -0.00230 \} * \text{PICNIA}_{t-1} \\
 & + \text{B2(L)} \{ \text{sum } 0.000431 \} * \text{RFFE}_{t-1} \\
 & + \text{B3(L)} \{ \text{sum } -0.000322 \} * \text{XGAP2}_{t-1} \\
 & + 0.00230 * \text{PTR}_{t-1} \\
 & - 0.000431 * \text{RTR}_{t-1} \\
 & + \text{B6(L)} \{ \text{sum } -0.000134 \} * \text{YHGAP}_{t-1} \\
 & + \text{B7(L)} \{ \text{sum } 0.000123 \} * \text{YHTGAP}_{t-1} \\
 & + \text{B8(L)} \{ \text{sum } 0.000822 \} * \text{YHPGAP}_{t-1} \\
 & + 1.03 * (\text{HGGDPT}_{t-1}/400) \\
 & - 0.767 * (\text{HGPCDR}_{t-1}/400) \\
 & + \text{B11(L)} \{ \text{sum } -0.00163 \} * \text{del}(1 : \log(\text{QECD}_{t-1}))
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
B1 ₀	-0.000787	B2 ₃	0.000481	B6 ₂	-0.000142	B8 ₁	0.000316
B1 ₁	-0.000620	B2SUM	0.000431	B6 ₃	0.000150	B8 ₂	9.11E-05
B1 ₂	-0.000513	B3 ₀	0.000372	B6SUM	-0.000134	B8 ₃	0.000437
B1 ₃	-0.000381	B3 ₁	-0.000289	B7 ₀	2.48E-05	B8SUM	0.000822
B1SUM	-0.00230	B3 ₂	-0.000573	B7 ₁	3.16E-05	B11 ₀	0.0206
B2 ₀	-0.00165	B3 ₃	0.000168	B7 ₂	2.87E-05	B11 ₁	0.00542
B2 ₁	0.00210	B3SUM	-0.000322	B7 ₃	3.78E-05	B11 ₂	-0.0146
B2 ₂	-0.000494	B6 ₀	0.000222	B7SUM	0.000123	B11 ₃	-0.0131
		B6 ₁	-0.000365	B8 ₀	-2.23E-05	B11SUM	-0.00163

z.23 ZEH: Expected growth rate of desired residential investment, for EH eq. (weight: .53)

The weighted average growth rate of expected future target housing investment, ZEH, is computed using (1) forecasts from a small-scale VAR model combined with (2) the PAC weights implied by the estimated coefficients of the dynamic housing equation. The equation shown below is the reduced-form representation of this expectational computation.

$$\begin{aligned}
 \text{ZEH} = & 0.00937 \\
 & + \text{B1(L)} \{ \text{sum } -0.00149 \} * \text{PICNIA}_{t-1} \\
 & + \text{B2(L)} \{ \text{sum } 0.00151 \} * \text{RFFE}_{t-1} \\
 & + \text{B3(L)} \{ \text{sum } -0.00117 \} * \text{XGAP2}_{t-1} \\
 & + 0.00149 * \text{PTR}_{t-1} \\
 & - 0.00305 * \text{RTR}_{t-1} \\
 & + \text{B6(L)} \{ \text{sum } 0.00128 \} * \text{YHGAP}_{t-1} \\
 & + \text{B7(L)} \{ \text{sum } -0.000264 \} * \text{YHTGAP}_{t-1} \\
 & + \text{B8(L)} \{ \text{sum } 0.000813 \} * \text{YHPGAP}_{t-1} \\
 & + 0.560 * (\text{HGGDPT}_{t-1}/400)
 \end{aligned}$$

$$+ B10(L) \{ \text{sum } -0.0636 \} * \text{del}(1 : \log(QEH_{t-1}))$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
B10	-0.000549	B23	0.000298	B62	0.000394	B81	0.000401
B11	-0.000375	B2SUM	0.00151	B63	0.000610	B82	-0.000161
B12	-0.000511	B30	0.000636	B6SUM	0.00128	B83	0.000508
B13	-5.84E-05	B31	-0.00127	B70	-0.000228	B8SUM	0.000813
B1SUM	-0.00149	B32	-0.000832	B71	2.78E-05	B100	-0.0130
B20	8.14E-05	B33	0.000298	B72	-4.92E-05	B101	-0.0189
B21	0.00106	B3SUM	-0.00117	B73	-1.44E-05	B102	-0.0219
B22	6.61E-05	B60	0.000597	B7SUM	-0.000264	B103	-0.00980
		B61	-0.000324	B80	6.48E-05	B10SUM	-0.0636

z.24 ZGAP05: Expected output gap, for RG5E eq. (weight: 1.0)

$$\begin{aligned} \text{ZGAP05} &= 5.47\text{E-}13 \\ &+ A1(L) \{ \text{sum } -0.373 \} * \text{PICNIA}_t \\ &+ A2(L) \{ \text{sum } -0.227 \} * \text{RFFE}_t \\ &+ 0.227 * \text{RTR} \\ &+ 0.373 * \text{PTR} \\ &+ A5(L) \{ \text{sum } 0.405 \} * \text{XGAP}_t \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A10	-0.326	A1SUM	-0.373	A2SUM	-0.227
A11	-0.0781	A20	-0.422	A50	0.506
A12	-0.0210	A21	0.0644	A51	0.0571
A13	0.0526	A22	0.0251	A52	-0.0911
		A23	0.105	A53	-0.0666
				A5SUM	0.405

z.25 ZGAP10: Expected output gap, for RG10E eq. (weight: 1.0)

$$\begin{aligned} \text{ZGAP10} &= 5.91\text{E-}13 \\ &+ A1(L) \{ \text{sum } -0.195 \} * \text{PICNIA}_t \\ &+ A2(L) \{ \text{sum } -0.0789 \} * \text{RFFE}_t \\ &+ 0.0789 * \text{RTR} \\ &+ 0.195 * \text{PTR} \\ &+ A5(L) \{ \text{sum } 0.195 \} * \text{XGAP}_t \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A1 ₀	-0.162	A1 _{SUM}	-0.195	A2 _{SUM}	-0.0789
A1 ₁	-0.0413	A2 ₀	-0.181	A5 ₀	0.263
A1 ₂	-0.0140	A2 ₁	0.0297	A5 ₁	0.0155
A1 ₃	0.0223	A2 ₂	0.0254	A5 ₂	-0.0494
		A2 ₃	0.0472	A5 ₃	-0.0343
				A5 _{SUM}	0.195

z.26 ZGAP30: Expected output gap, for RCBE eq. (weight: 1.0)

$$\begin{aligned}
 \text{ZGAP30} &= 5.95\text{E-}13 \\
 &+ \text{A1(L) } \{\text{sum } -0.113 \} * \text{PICNIA}_t \\
 &+ \text{A2(L) } \{\text{sum } -0.0482 \} * \text{RFFE}_t \\
 &+ 0.0482 * \text{RTR} \\
 &+ 0.113 * \text{PTR} \\
 &+ \text{A5(L) } \{\text{sum } 0.114 \} * \text{XGAP}_t
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A1 ₀	-0.0941	A1 _{SUM}	-0.113	A2 _{SUM}	-0.0482
A1 ₁	-0.0238	A2 ₀	-0.107	A5 ₀	0.152
A1 ₂	-0.00790	A2 ₁	0.0174	A5 ₁	0.00989
A1 ₃	0.0132	A2 ₂	0.0138	A5 ₂	-0.0283
		A2 ₃	0.0277	A5 ₃	-0.0198
				A5 _{SUM}	0.114

z.27 ZGAPC2: Expected output gap, for ECD eq. (weight: .35)

The weighted average of expected future output gaps for the ECD equation, ZGAPC2, is computed using (1) forecasts from a small-scale VAR model combined with (2) the PAC weights implied by the estimated coefficients of the dynamic consumer durables equation. The equation shown below is the reduced-form representation of this expectational computation.

$$\begin{aligned}
 \text{ZGAPC2} &= \text{B1(L) } \{\text{sum } -0.0430 \} * \text{PICNIA}_{t-1} \\
 &+ \text{B2(L) } \{\text{sum } -0.0396 \} * \text{RFFE}_{t-1} \\
 &+ \text{B3(L) } \{\text{sum } 0.119 \} * \text{XGAP2}_{t-1} \\
 &+ 0.0430 * \text{PTR}_{t-1} \\
 &+ 0.0396 * \text{RTR}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
B1 ₀	-0.0342	B1SUM	-0.0430	B2SUM	-0.0396
B1 ₁	-0.00943	B2 ₀	-0.0504	B3 ₀	0.151
B1 ₂	-0.00483	B2 ₁	-0.0108	B3 ₁	-0.00561
B1 ₃	0.00549	B2 ₂	0.0235	B3 ₂	-0.0205
		B2 ₃	-0.00199	B3 ₃	-0.00533
				B3SUM	0.119

z.28 ZLHP: Expected growth rate of desired aggregate hours (weight: .58)

ZLHP is calculated as weighted average of VAR and AR expectations. Let zlhpar be the former and zlhpar be the latter. ZLHP is defined as,

$$ZLHP = 0.126 \text{ zlhpar} + 0.874 \text{ zlhpar},$$

where the weights were estimated as part of the estimation of the lhp equation.

$$\begin{aligned}
 ZLHP = & -1.66E-16 \\
 & + A1(L) \{\text{sum } -0.000177\} * \text{PICNIA}_{t-1} \\
 & + A2(L) \{\text{sum } -8.21E-05\} * \text{RFFE}_{t-1} \\
 & + 8.21E-05 * \text{RTR}_{t-1} \\
 & + 0.000177 * \text{PTR}_{t-1} \\
 & + A5(L) \{\text{sum } -3.18E-05\} * \text{XGAP}_{t-1} \\
 & + 0.0788 * (\text{del}(1 : \log(\text{XG}_{t-1})) - \text{HLPRDT}_{t-1}/400) \\
 & + 0.709 * ((\text{HGX}_{t-1} - \text{HLPRDT}_{t-1})/400)
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A1 ₀	-0.000122	A1SUM	-0.000177	A2SUM	-8.21E-05
A1 ₁	-3.95E-05	A2 ₀	-0.000175	A5 ₀	6.56E-05
A1 ₂	-1.86E-05	A2 ₁	-1.69E-05	A5 ₁	-2.79E-05
A1 ₃	2.67E-06	A2 ₂	8.61E-05	A5 ₂	-6.35E-05
		A2 ₃	2.41E-05	A5 ₃	-5.96E-06
				A5SUM	-3.18E-05

z.29 ZLURC: Expected unemployment rate, for PCNIA eq.

ZLURC is a discounted sum of expected future unemployment gaps. It enters the PCNIA equation.

$$ZLURC = -9.31E-07$$

$$\begin{aligned}
 &+ A1(L) \{ \text{sum } 0.532 \} * \text{PIPL}_{t-1} \\
 &+ A2(L) \{ \text{sum } 0.0136 \} * \text{del}(1 : \log(\text{PXP}_{t-1})) \\
 &+ A3(L) \{ \text{sum } 4.30 \} * (\text{PICNIA}_{t-1}/400) \\
 &+ A4(L) \{ \text{sum } 0.187 \} * \text{del}(1 : \log(\text{PXNC}_{t-1})) \\
 &+ A5(L) \{ \text{sum } 0.000104 \} * \text{del}(1 : \log(\text{PXG}_{t-1})) \\
 &- 5.04 * (\text{PTR}_{t-1}/400) \\
 &- 0.158 * (\log(\text{PCNIA}_{t-1}/\text{QPCNIA}_{t-1})) \\
 &+ 0.0221 * (\log(\text{PXNC}_{t-1}/\text{QPXNC}_{t-1})) \\
 &+ 3.85 * \text{HPRDTW}_{t-1} \\
 &- 4.38 * \text{HPRDTP}_{t-1} \\
 &+ A11(L) \{ \text{sum } 0.0208 \} * ((\text{LUR}_{t-1} - \text{LURNAT}_{t-1})) \\
 &+ A12(L) \{ \text{sum } 0.925 \} * (\text{RFFE}_{t-1}/400) \\
 &- 0.925 * (\text{RTR}_{t-1}/400) \\
 &- 0.0441 * (\text{UCFS}_{t-1} * \text{del}(1 : \log(\text{PCFR}_{t-1}))) \\
 &+ 3.26E-06 * (\text{UCES}_{t-1} * \text{del}(1 : \log(\text{PCER}_{t-1}))) \\
 &+ 0.730 * \text{UQPXP}_{t-1} \\
 &+ 1.10 * \text{HUQPCT}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A1 ₀	0.284	A3 ₁	0.986	A5 ₁	-0.00721	A11SUM	0.0208
A1 ₁	0.180	A3 ₂	1.30	A5 ₂	-0.00326	A12 ₀	1.42
A1 ₂	0.0684	A3 ₃	0.392	A5 ₃	0.00413	A12 ₁	-0.0148
A1SUM	0.532	A3SUM	4.30	A5SUM	0.000104	A12 ₂	-0.455
A2 ₀	-0.0102	A4 ₀	0.119	A11 ₀	0.0473	A12 ₃	-0.0250
A2 ₁	0.0161	A4 ₁	0.0551	A11 ₁	-0.0286	A12SUM	0.925
A2 ₂	0.00769	A4 ₂	0.0129	A11 ₂	0.000526		
A2SUM	0.0136	A4SUM	0.187	A11 ₃	0.00163		
A3 ₀	1.63	A5 ₀	0.00644				

z.30 ZLURL: Expected unemployment rate, for PL eq.

ZLURL is a discounted sum of expected future unemployment gaps. It enters the PIPL equation.

$$\begin{aligned}
 \text{ZLURL} &= -1.01E-06 \\
 &+ A1(L) \{ \text{sum } 0.557 \} * \text{PIPL}_{t-1} \\
 &+ A2(L) \{ \text{sum } 0.0157 \} * \text{del}(1 : \log(\text{PXP}_{t-1})) \\
 &+ A3(L) \{ \text{sum } 5.78 \} * (\text{PICNIA}_{t-1}/400) \\
 &+ A4(L) \{ \text{sum } 0.186 \} * \text{del}(1 : \log(\text{PXNC}_{t-1})) \\
 &+ A5(L) \{ \text{sum } 9.49E-05 \} * \text{del}(1 : \log(\text{PXG}_{t-1})) \\
 &- 6.54 * (\text{PTR}_{t-1}/400) \\
 &- 0.180 * (\log(\text{PCNIA}_{t-1}/\text{QPCNIA}_{t-1})) \\
 &+ 0.0231 * (\log(\text{PXNC}_{t-1}/\text{QPXNC}_{t-1})) \\
 &+ 3.35 * \text{HPRDTW}_{t-1}
 \end{aligned}$$

$$\begin{aligned}
 & - 3.91 * \text{HPRDTP}_{t-1} \\
 & + A11(L) \{ \text{sum } 0.0314 \} * ((\text{LUR}_{t-1} - \text{LURNAT}_{t-1})) \\
 & + A12(L) \{ \text{sum } 1.37 \} * (\text{RFFE}_{t-1}/400) \\
 & - 1.37 * (\text{RTR}_{t-1}/400) \\
 & - 0.0511 * (\text{UCFS}_{t-1} * \text{del}(1 : \log(\text{PCFR}_{t-1}))) \\
 & + 2.54E-07 * (\text{UCES}_{t-1} * \text{del}(1 : \log(\text{PCER}_{t-1}))) \\
 & + 0.623 * \text{UQPXP}_{t-1} \\
 & + 1.13 * \text{HUQPCT}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	0.295	A31	1.29	A51	-0.00837	A11SUM	0.0314
A11	0.189	A32	1.83	A52	-0.00380	A120	2.11
A12	0.0723	A33	0.525	A53	0.00478	A121	-0.0178
A1SUM	0.557	A3SUM	5.78	A5SUM	9.49E-05	A122	-0.683
A20	-0.0120	A40	0.118	A110	0.0712	A123	-0.0376
A21	0.0186	A41	0.0549	A111	-0.0430	A12SUM	1.37
A22	0.00905	A42	0.0129	A112	0.000775		
A2SUM	0.0157	A4SUM	0.186	A113	0.00245		
A30	2.14	A50	0.00748				

z.31 ZLURNC: Expected unemployment rate, for PXNC eq.

ZLURNC is a discounted sum of expected future unemployment gaps. It enters the PXNC equation.

$$\begin{aligned}
 \text{ZLURNC} = & -8.81E-07 \\
 & + A1(L) \{ \text{sum } 0.491 \} * \text{PIPL}_{t-1} \\
 & + A2(L) \{ \text{sum } 0.0138 \} * \text{del}(1 : \log(\text{PXP}_{t-1})) \\
 & + A3(L) \{ \text{sum } 5.05 \} * (\text{PICNIA}_{t-1}/400) \\
 & + A4(L) \{ \text{sum } 0.164 \} * \text{del}(1 : \log(\text{PXNC}_{t-1})) \\
 & + A5(L) \{ \text{sum } 8.39E-05 \} * \text{del}(1 : \log(\text{PXG}_{t-1})) \\
 & - 5.72 * (\text{PTR}_{t-1}/400) \\
 & - 0.159 * (\log(\text{PCNIA}_{t-1}/\text{QPCNIA}_{t-1})) \\
 & + 0.0204 * (\log(\text{PXNC}_{t-1}/\text{QPXNC}_{t-1})) \\
 & + 2.97 * \text{HPRDTW}_{t-1} \\
 & - 3.46 * \text{HPRDTP}_{t-1} \\
 & + A11(L) \{ \text{sum } 0.0265 \} * ((\text{LUR}_{t-1} - \text{LURNAT}_{t-1})) \\
 & + A12(L) \{ \text{sum } 1.18 \} * (\text{RFFE}_{t-1}/400) \\
 & - 1.18 * (\text{RTR}_{t-1}/400) \\
 & - 0.0450 * (\text{UCFS}_{t-1} * \text{del}(1 : \log(\text{PCFR}_{t-1}))) \\
 & + 4.07E-07 * (\text{UCES}_{t-1} * \text{del}(1 : \log(\text{PCER}_{t-1}))) \\
 & + 0.553 * \text{UQPXP}_{t-1} \\
 & + 0.995 * \text{HUQPCT}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	0.261	A31	1.14	A51	-0.00737	A11SUM	0.0265
A11	0.167	A32	1.58	A52	-0.00334	A120	1.82
A12	0.0638	A33	0.457	A53	0.00421	A121	-0.0218
A1SUM	0.491	A3SUM	5.05	A5SUM	8.39E-05	A122	-0.585
A20	-0.0105	A40	0.104	A110	0.0605	A123	-0.0321
A21	0.0164	A41	0.0485	A111	-0.0368	A12SUM	1.18
A22	0.00796	A42	0.0114	A112	0.000687		
A2SUM	0.0138	A4SUM	0.164	A113	0.00209		
A30	1.87	A50	0.00658				

z.32 ZPC: Expected growth rate of desired price level, for PCNIA eq.

ZPC is a discounted sum of expected future log changes in QPCNIA, which is the nonstationary component of the price target in the PCNIA equation.

$$\begin{aligned}
 \text{ZPC} = & -4.67\text{E-}08 \\
 & + A1(L) \{ \text{sum } 0.0653 \} * \text{PIPL}_{t-1} \\
 & + A2(L) \{ \text{sum } 0.00203 \} * \text{del}(1 : \log(\text{PXP}_{t-1})) \\
 & + A3(L) \{ \text{sum } -0.00183 \} * (\text{PICNIA}_{t-1}/400) \\
 & + A4(L) \{ \text{sum } 0.0193 \} * \text{del}(1 : \log(\text{PXNC}_{t-1})) \\
 & + A5(L) \{ \text{sum } 6.58\text{E-}05 \} * \text{del}(1 : \log(\text{PXG}_{t-1})) \\
 & + 0.316 * (\text{PTR}_{t-1}/400) \\
 & + 0.0257 * (\log(\text{PCNIA}_{t-1}/\text{QPCNIA}_{t-1})) \\
 & + 0.00252 * (\log(\text{PXNC}_{t-1}/\text{QPXNC}_{t-1})) \\
 & + 0.335 * \text{HPRDTW}_{t-1} \\
 & - 0.400 * \text{HPRDTP}_{t-1} \\
 & + A11(L) \{ \text{sum } -0.000197 \} * ((\text{LUR}_{t-1} - \text{LURNAT}_{t-1})) \\
 & + A12(L) \{ \text{sum } -0.0139 \} * (\text{RFFE}_{t-1}/400) \\
 & + 0.0139 * (\text{RTR}_{t-1}/400) \\
 & - 0.00820 * (\text{UCFS}_{t-1} * \text{del}(1 : \log(\text{PCFR}_{t-1}))) \\
 & + 7.76\text{E-}07 * (\text{UCES}_{t-1} * \text{del}(1 : \log(\text{PCER}_{t-1}))) \\
 & + 0.0579 * \text{UQPXP}_{t-1} \\
 & + 0.125 * \text{HUQPCT}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	0.0339	A31	0.000883	A51	-0.00134	A11SUM	-0.000197
A11	0.0225	A32	-0.00485	A52	-0.000681	A120	-0.0210
A12	0.00885	A33	0.00361	A53	0.000767	A121	0.00131
A1SUM	0.0653	A3SUM	-0.00183	A5SUM	6.58E-05	A122	0.00551
A20	-0.00227	A40	0.0122	A110	-0.000505	A123	0.000299

A2 ₁	0.00285	A4 ₁	0.00576	A11 ₁	0.000337	A12SUM	-0.0139
A2 ₂	0.00145	A4 ₂	0.00137	A11 ₂	-1.01E-05		
A2SUM	0.00203	A4SUM	0.0193	A11 ₃	-1.95E-05		
A3 ₀	-0.00146	A5 ₀	0.00132				

z.33 ZPI10: Expected cons. price infl., for RCCH and RG10E eqs. (10-yr mat., weight: 1.0)

$$\begin{aligned}
 \text{ZPI10} = & B1(L) \{ \text{sum } 0.0828 \} * \text{PICNIA}_{t-1} \\
 & + B2(L) \{ \text{sum } -0.152 \} * \text{RFFE}_{t-1} \\
 & + 0.152 * \text{RTR}_{t-1} \\
 & + 0.917 * \text{PTR}_{t-1} \\
 & + B5(L) \{ \text{sum } 0.108 \} * \text{XGAP}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
B1 ₀	0.0268	B1SUM	0.0828	B2SUM	-0.152
B1 ₁	0.0221	B2 ₀	-0.120	B5 ₀	0.0430
B1 ₂	0.0232	B2 ₁	-0.0117	B5 ₁	0.0308
B1 ₃	0.0107	B2 ₂	-0.0336	B5 ₂	0.0177
		B2 ₃	0.0129	B5 ₃	0.0163
				B5SUM	0.108

z.34 ZPI10F: FL Expected cons. price infl., for RCCH and RG10E eqs. (10-yr mat., weight: 1.0)

$$\text{ZPI10F} = \text{ZPI10}$$

z.35 ZPI5: Expected cons. price infl., for RG5E eq. (5-yr mat., weight: 1.0)

$$\begin{aligned}
 \text{ZPI5} = & B1(L) \{ \text{sum } 0.148 \} * \text{PICNIA}_{t-1} \\
 & + B2(L) \{ \text{sum } -0.274 \} * \text{RFFE}_{t-1} \\
 & + 0.274 * \text{RTR}_{t-1} \\
 & + 0.852 * \text{PTR}_{t-1} \\
 & + B5(L) \{ \text{sum } 0.221 \} * \text{XGAP}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
B10	0.0539	B1SUM	0.148	B2SUM	-0.274
B11	0.0390	B20	-0.211	B50	0.108
B12	0.0393	B21	-0.0299	B51	0.0484
B13	0.0158	B22	-0.0516	B52	0.0326
		B23	0.0186	B53	0.0317
				B5SUM	0.221

z.36 ZPIB5: Expected output price infl., for RPD eq. (5-yr dur., weight: 1.0)

$$\begin{aligned}
 \text{ZPIB5} &= 1.02\text{E-}12 \\
 &+ A1(L) \{ \text{sum } 0.137 \} * \text{PICNIA}_{t-1} \\
 &+ A2(L) \{ \text{sum } -0.331 \} * \text{RFFE}_{t-1} \\
 &+ 0.331 * \text{RTR}_{t-1} \\
 &+ 0.711 * \text{PTR}_{t-1} \\
 &+ A5(L) \{ \text{sum } 0.250 \} * \text{XGAP}_{t-1} \\
 &+ A6(L) \{ \text{sum } 0.152 \} * (400 * \text{del}(1 : \log(\text{PXB}_{t-1})))
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	0.0557	A1SUM	0.137	A2SUM	-0.331	A5SUM	0.250
A11	0.0321	A20	-0.248	A50	0.129	A60	0.0628
A12	0.0483	A21	-0.0494	A51	0.0639	A61	0.0392
A13	0.00136	A22	-0.0543	A52	0.0330	A62	0.0154
		A23	0.0203	A53	0.0244	A63	0.0344
						A6SUM	0.152

z.37 ZPIC30: Expected cons. price infl., for RCBE and WPSN eqs. (30-yr mat., weight: 1.0)

$$\begin{aligned}
 \text{ZPIC30} &= 2.37\text{E-}12 \\
 &+ A1(L) \{ \text{sum } 0.0657 \} * \text{PICNIA}_t \\
 &+ A2(L) \{ \text{sum } -0.0856 \} * \text{RFFE}_t \\
 &+ 0.0856 * \text{RTR} \\
 &+ 0.934 * \text{PTR} \\
 &+ A5(L) \{ \text{sum } 0.0616 \} * \text{XGAP}_t
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A10	0.0345	A1SUM	0.0657	A2SUM	-0.0856

A1 ₁	0.0124	A2 ₀	-0.0671	A5 ₀	0.0252
A1 ₂	0.0129	A2 ₁	-0.00692	A5 ₁	0.0171
A1 ₃	0.00588	A2 ₂	-0.0186	A5 ₂	0.00999
		A2 ₃	0.00711	A5 ₃	0.00926
				A5SUM	0.0616

z.38 ZPL: Expected growth rate of desired comp. per hour, for PL eq.

ZPL is a discounted sum of expected future log changes in QPL, the nonstationary component of the wage target in the PIPL equation.

$$\begin{aligned}
 \text{ZPL} = & -1.16\text{E-}07 \\
 & + A1(L) \{\text{sum } 0.0300\} * \text{PIPL}_{t-1} \\
 & + A2(L) \{\text{sum } -0.00724\} * \text{del}(1 : \log(\text{PXP}_{t-1})) \\
 & + A3(L) \{\text{sum } 0.0434\} * (\text{PICNIA}_{t-1}/400) \\
 & + A4(L) \{\text{sum } 0.0404\} * \text{del}(1 : \log(\text{PXNC}_{t-1})) \\
 & + A5(L) \{\text{sum } -0.000160\} * \text{del}(1 : \log(\text{PXG}_{t-1})) \\
 & + 0.296 * (\text{PTR}_{t-1}/400) \\
 & + 0.00194 * (\log(\text{PCNIA}_{t-1}/\text{QPCNIA}_{t-1})) \\
 & - 0.0101 * (\log(\text{PXNC}_{t-1}/\text{QPXNC}_{t-1})) \\
 & + 0.587 * \text{HPRDTW}_{t-1} \\
 & - 0.214 * \text{HPRDTP}_{t-1} \\
 & + A11(L) \{\text{sum } -0.000207\} * ((\text{LUR}_{t-1} - \text{LURNAT}_{t-1})) \\
 & + A12(L) \{\text{sum } -0.0143\} * (\text{RFFE}_{t-1}/400) \\
 & + 0.0143 * (\text{RTR}_{t-1}/400) \\
 & + 0.0250 * (\text{UCFS}_{t-1} * \text{del}(1 : \log(\text{PCFR}_{t-1}))) \\
 & + 4.87\text{E-}08 * (\text{UCES}_{t-1} * \text{del}(1 : \log(\text{PCER}_{t-1}))) \\
 & + 0.0354 * \text{UQPXP}_{t-1} \\
 & - 0.259 * \text{HUQPCT}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A1 ₀	0.0159	A3 ₁	0.0134	A5 ₁	0.00407	A11SUM	-0.000207
A1 ₁	0.0102	A3 ₂	0.00376	A5 ₂	0.00198	A12 ₀	-0.0217
A1 ₂	0.00388	A3 ₃	0.0102	A5 ₃	-0.00234	A12 ₁	0.00132
A1SUM	0.0300	A3SUM	0.0434	A5SUM	-0.000160	A12 ₂	0.00574
A2 ₀	0.00627	A4 ₀	0.0253	A11 ₀	-0.000528	A12 ₃	0.000312
A2 ₁	-0.00895	A4 ₁	0.0122	A11 ₁	0.000352	A12SUM	-0.0143
A2 ₂	-0.00457	A4 ₂	0.00293	A11 ₂	-1.04E-05		
A2SUM	-0.00724	A4SUM	0.0404	A11 ₃	-2.03E-05		
A3 ₀	0.0161	A5 ₀	-0.00387				

z.39 ZPNC: Expected growth rate of desired price level, for PXNC eq.

ZPNC is a discounted sum of expected future log changes in QPXNC, the nonstationary component of the price target in the PXNC equation.

$$\begin{aligned}
 \text{ZPNC} = & -2.89\text{E-}07 \\
 & + \text{A1(L) } \{\text{sum } 0.0719 \} * \text{PIPL}_{t-1} \\
 & + \text{A2(L) } \{\text{sum } 0.00247 \} * \text{del}(1 : \log(\text{PXP}_{t-1})) \\
 & + \text{A3(L) } \{\text{sum } -0.00397 \} * (\text{PICNIA}_{t-1}/400) \\
 & + \text{A4(L) } \{\text{sum } 0.0199 \} * \text{del}(1 : \log(\text{PXNC}_{t-1})) \\
 & + \text{A5(L) } \{\text{sum } 4.69\text{E-}05 \} * \text{del}(1 : \log(\text{PXG}_{t-1})) \\
 & + 0.264 * (\text{PTR}_{t-1}/400) \\
 & + 0.0233 * (\log(\text{PCNIA}_{t-1}/\text{QPCNIA}_{t-1})) \\
 & + 0.00271 * (\log(\text{PXNC}_{t-1}/\text{QPXNC}_{t-1})) \\
 & + 0.285 * \text{HPRDTW}_{t-1} \\
 & - 0.356 * \text{HPRDTP}_{t-1} \\
 & + \text{A11(L) } \{\text{sum } -0.000198 \} * ((\text{LUR}_{t-1} - \text{LURNAT}_{t-1})) \\
 & + \text{A12(L) } \{\text{sum } -0.0135 \} * (\text{RFFE}_{t-1}/400) \\
 & + 0.0136 * (\text{RTR}_{t-1}/400) \\
 & - 0.00978 * (\text{UCFS}_{t-1} * \text{del}(1 : \log(\text{PCFR}_{t-1}))) \\
 & - 6.33\text{E-}07 * (\text{UCES}_{t-1} * \text{del}(1 : \log(\text{PCER}_{t-1}))) \\
 & + 0.0509 * \text{UQXPX}_{t-1} \\
 & - 0.924 * \text{HUQPCT}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	0.0371	A31	0.000325	A51	-0.00161	A11SUM	-0.000198
A11	0.0249	A32	-0.00535	A52	-0.000801	A120	-0.0205
A12	0.00986	A33	0.00318	A53	0.000916	A121	0.00124
A1SUM	0.0719	A3SUM	-0.00397	A5SUM	4.69E-05	A122	0.00546
A20	-0.00277	A40	0.0126	A110	-0.000504	A123	0.000297
A21	0.00343	A41	0.00594	A111	0.000335	A12SUM	-0.0135
A22	0.00181	A42	0.00139	A112	-9.87E-06		
A2SUM	0.00247	A4SUM	0.0199	A113	-1.94E-05		
A30	-0.00213	A50	0.00154				

z.40 ZRFF10: Expected federal funds rate, for RG10E eq. (10-yr mat., weight: 1.0)

$$\begin{aligned}
 \text{ZRFF10} = & 9.05\text{E-}13 \\
 & + \text{A1(L) } \{\text{sum } -0.0537 \} * \text{PICNIA}_t \\
 & + \text{A2(L) } \{\text{sum } 0.155 \} * \text{RFFE}_t \\
 & + 0.845 * \text{RTR} \\
 & + 0.0537 * \text{PTR}
 \end{aligned}$$

$$+ A5(L) \{ \text{sum } 0.0807 \} * \underline{XGAP}_t$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A1 ₀	-0.000984	A1SUM	-0.0537	A2SUM	0.155
A1 ₁	-0.0115	A2 ₀	0.127	A5 ₀	0.176
A1 ₂	-0.0186	A2 ₁	-0.0345	A5 ₁	-0.0724
A1 ₃	-0.0226	A2 ₂	0.0899	A5 ₂	-0.0220
		A2 ₃	-0.0276	A5 ₃	-0.00123
				A5SUM	0.0807

z.41 ZRFF30: Expected federal funds rate, for RCBE eq. (30-yr mat., weight: 1.0)

$$\begin{aligned} \text{ZRFF30} &= -2.80\text{E-}14 \\ &+ A1(L) \{ \text{sum } -0.0296 \} * \underline{PICNIA}_t \\ &+ A2(L) \{ \text{sum } 0.0874 \} * \underline{RFFE}_t \\ &+ 0.913 * \underline{RTR} \\ &+ 0.0296 * \underline{PTR} \\ &+ A5(L) \{ \text{sum } 0.0469 \} * \underline{XGAP}_t \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A1 ₀	0.000232	A1SUM	-0.0296	A2SUM	0.0874
A1 ₁	-0.00638	A2 ₀	0.0723	A5 ₀	0.101
A1 ₂	-0.0105	A2 ₁	-0.0200	A5 ₁	-0.0412
A1 ₃	-0.0130	A2 ₂	0.0511	A5 ₂	-0.0122
		A2 ₃	-0.0159	A5 ₃	-0.000433
				A5SUM	0.0469

z.42 ZRFF5: Expected federal funds rate, for RG5E eq. (5-yr mat., weight: 1.0)

$$\begin{aligned} \text{ZRFF5} &= -6.44\text{E-}14 \\ &+ A1(L) \{ \text{sum } -0.0646 \} * \underline{PICNIA}_t \\ &+ A2(L) \{ \text{sum } 0.239 \} * \underline{RFFE}_t \\ &+ 0.761 * \underline{RTR} \\ &+ 0.0646 * \underline{PTR} \\ &+ A5(L) \{ \text{sum } 0.167 \} * \underline{XGAP}_t \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
A10	0.0174	A1SUM	-0.0646	A2SUM	0.239
A11	-0.0135	A20	0.208	A50	0.315
A12	-0.0284	A21	-0.0694	A51	-0.122
A13	-0.0400	A22	0.151	A52	-0.0304
		A23	-0.0505	A53	0.00421
				A5SUM	0.167

z.43 ZVPDC: Expected growth rate of des. capital-output ratio, for EPDCeq. (weight: .68)

$$\begin{aligned}
 \text{ZVPDC} &= 3.12\text{E-}16 \\
 &+ \text{A1(L) } \{\text{sum } -0.00229\} * \text{PICNIA}_{t-1} \\
 &+ \text{A2(L) } \{\text{sum } 0.000771\} * \text{RFFE}_{t-1} \\
 &- 0.000771 * \text{RTR}_{t-1} \\
 &+ 0.00229 * \text{PTR}_{t-1} \\
 &+ \text{A5(L) } \{\text{sum } 1.21\text{E-}05\} * \text{XGAP}_{t-1} \\
 &+ \text{A6(L) } \{\text{sum } -6.74\text{E-}15\} * \text{del}(1 : \log(\text{XB}_{t-1})) \\
 &+ \text{A7(L) } \{\text{sum } -0.0334\} * \text{del}(1 : \log(\text{VPDC}_{t-1})) \\
 &+ 0.393 * \text{HGVPDC}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	-0.000697	A21	0.000146	A52	0.000829	A63	-1.25E-15
A11	-0.000967	A22	-0.000769	A53	-0.000217	A6SUM	-6.74E-15
A12	-0.000587	A23	0.000147	A5SUM	1.21E-05	A70	0.00519
A13	-3.46E-05	A2SUM	0.000771	A60	-1.89E-15	A71	-0.0104
A1SUM	-0.00229	A50	-0.000844	A61	6.01E-16	A72	-0.0213
A20	0.00125	A51	0.000244	A62	-4.20E-15	A73	-0.00694
						A7SUM	-0.0334

z.44 ZVPDO: Expected growth rate of des. capital-output ratio, for EPDOeq. (weight: .68)

$$\begin{aligned}
 \text{ZVPDO} &= -1.05\text{E-}16 \\
 &+ \text{A1(L) } \{\text{sum } 0.000728\} * \text{PICNIA}_{t-1} \\
 &+ \text{A2(L) } \{\text{sum } 0.000624\} * \text{RFFE}_{t-1} \\
 &- 0.000624 * \text{RTR}_{t-1} \\
 &- 0.000728 * \text{PTR}_{t-1} \\
 &+ \text{A5(L) } \{\text{sum } -0.000157\} * \text{XGAP}_{t-1} \\
 &+ \text{A6(L) } \{\text{sum } 7.09\text{E-}16\} * \text{del}(1 : \log(\text{XB}_{t-1})) \\
 &+ \text{A7(L) } \{\text{sum } 0.0294\} * \text{del}(1 : \log(\text{VPDO}_{t-1}))
 \end{aligned}$$

$$+ 0.617 * \text{HGVPDO}_{t-1}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A1 ₀	0.000476	A2 ₁	0.000316	A5 ₂	-2.18E-05	A6 ₃	6.68E-16
A1 ₁	-2.63E-05	A2 ₂	-0.000122	A5 ₃	0.000201	A6 _{SUM}	7.09E-16
A1 ₂	0.000197	A2 ₃	0.000189	A5 _{SUM}	-0.000157	A7 ₀	0.00863
A1 ₃	8.11E-05	A2 _{SUM}	0.000624	A6 ₀	2.28E-16	A7 ₁	0.00444
A1 _{SUM}	0.000728	A5 ₀	-0.000342	A6 ₁	3.50E-16	A7 ₂	0.00640
A2 ₀	0.000240	A5 ₁	6.71E-06	A6 ₂	-5.37E-16	A7 ₃	0.00994
						A7 _{SUM}	0.0294

z.45 ZVPS: Expected growth rate of des. capital-output ratio, for EPS eq. (weight: .68)

$$\text{ZVPS} = 5.12\text{E-}17$$

$$\begin{aligned}
 &+ A1(L) \{\text{sum } 0.000562\} * \text{PICNIA}_{t-1} \\
 &+ A2(L) \{\text{sum } -6.49\text{E-}05\} * \text{RFFE}_{t-1} \\
 &+ 6.49\text{E-}05 * \text{RTR}_{t-1} \\
 &- 0.000562 * \text{PTR}_{t-1} \\
 &+ A5(L) \{\text{sum } -0.000321\} * \text{XGAP}_{t-1} \\
 &+ A6(L) \{\text{sum } 2.55\text{E-}16\} * \text{del}(1 : \log(\text{XB}_{t-1})) \\
 &+ A7(L) \{\text{sum } -0.0189\} * \text{del}(1 : \log(\text{VPS}_{t-1})) \\
 &+ 0.525 * \text{HGVPS}_{t-1}
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A1 ₀	0.000254	A2 ₁	0.000124	A5 ₂	6.29E-05	A6 ₃	1.80E-16
A1 ₁	-5.63E-06	A2 ₂	-0.000174	A5 ₃	2.09E-05	A6 _{SUM}	2.55E-16
A1 ₂	0.000164	A2 ₃	3.62E-07	A5 _{SUM}	-0.000321	A7 ₀	-0.000655
A1 ₃	0.000150	A2 _{SUM}	-6.49E-05	A6 ₀	6.28E-16	A7 ₁	-0.00854
A1 _{SUM}	0.000562	A5 ₀	-0.000312	A6 ₁	6.95E-16	A7 ₂	-0.00449
A2 ₀	-1.57E-05	A5 ₁	-9.25E-05	A6 ₂	-1.25E-15	A7 ₃	-0.00526
						A7 _{SUM}	-0.0189

z.46 ZXBC: Expected growth rate of business output, for EPDCeq. (weight: .68)

$$\text{ZXBC} = -5.74\text{E-}16$$

$$\begin{aligned}
 &+ A1(L) \{\text{sum } 3.59\text{E-}06\} * \text{PICNIA}_{t-1} \\
 &+ A2(L) \{\text{sum } 4.50\text{E-}05\} * \text{RFFE}_{t-1} \\
 &- 4.50\text{E-}05 * \text{RTR}_{t-1}
 \end{aligned}$$

$$\begin{aligned}
 & - 3.59E-06 * PTR_{t-1} \\
 & + A5(L) \{sum -7.68E-05\} * XGAP_{t-1} \\
 & + A6(L) \{sum 0.360\} * del(1 : log(XB_{t-1})) \\
 & + A7(L) \{sum 7.46E-17\} * del(1 : log(VPDC_{t-1})) \\
 & + 8.59E-17 * HGX/400
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A1 ₀	1.17E-05	A2 ₁	3.52E-05	A5 ₂	0.000135	A6 ₃	0.0250
A1 ₁	2.75E-07	A2 ₂	0.000496	A5 ₃	2.26E-05	A6SUM	0.360
A1 ₂	-7.04E-05	A2 ₃	0.000224	A5SUM	-7.68E-05	A7 ₀	3.27E-17
A1 ₃	6.20E-05	A2SUM	4.50E-05	A6 ₀	0.166	A7 ₁	6.07E-17
A1SUM	3.59E-06	A5 ₀	-0.000455	A6 ₁	0.114	A7 ₂	-5.88E-18
A2 ₀	-0.000711	A5 ₁	0.000221	A6 ₂	0.0546	A7 ₃	-1.29E-17
						A7SUM	7.46E-17

z.47 ZXBO: Expected growth rate of business output, for EPDOeq. (weight: .68)

$$\begin{aligned}
 ZXBO = & -8.08E-16 \\
 & + A1(L) \{sum 0.000829\} * PICNIA_{t-1} \\
 & + A2(L) \{sum 0.000103\} * RFFE_{t-1} \\
 & - 0.000103 * RTR_{t-1} \\
 & - 0.000829 * PTR_{t-1} \\
 & + A5(L) \{sum -6.71E-05\} * XGAP_{t-1} \\
 & + A6(L) \{sum 0.647\} * del(1 : log(XB_{t-1})) \\
 & + 1.74E-16 * HGX/400
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A1 ₀	0.000134	A1SUM	0.000829	A2SUM	0.000103	A5SUM	-6.71E-05
A1 ₁	0.000254	A2 ₀	-0.00121	A5 ₀	-0.000733	A6 ₀	0.265
A1 ₂	0.000242	A2 ₁	0.000215	A5 ₁	0.000401	A6 ₁	0.207
A1 ₃	0.000199	A2 ₂	0.000627	A5 ₂	0.000201	A6 ₂	0.115
		A2 ₃	0.000467	A5 ₃	6.41E-05	A6 ₃	0.0592
						A6SUM	0.647

z.48 ZXBS: Expected growth rate of business output, for EPS eq. (weight: .68)

$$\begin{aligned}
 ZXBS = & -7.49E-16 \\
 & + A1(L) \{sum 0.000586\} * PICNIA_{t-1}
 \end{aligned}$$

$$\begin{aligned}
 &+ A2(L) \text{ (sum } 7.09E-05) * RFFE_{t-1} \\
 &- 7.09E-05 * RTR_{t-1} \\
 &- 0.000586 * PTR_{t-1} \\
 &+ A5(L) \text{ (sum } -9.17E-05) * XGAP_{t-1} \\
 &+ A6(L) \text{ (sum } 0.506) * \text{del}(1 : \log(XB_{t-1})) \\
 &+ 1.31E-16 * HGX/400
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A10	6.47E-05	A1SUM	0.000586	A2SUM	7.09E-05	A5SUM	-9.17E-05
A11	0.000182	A20	-0.000973	A50	-0.000592	A60	0.206
A12	0.000180	A21	0.000167	A51	0.000311	A61	0.163
A13	0.000159	A22	0.000501	A52	0.000148	A62	0.0907
		A23	0.000376	A53	4.15E-05	A63	0.0472
						A6SUM	0.506

z.49 ZYH: Expected level of real after-tax household income, for QEC eq. (weight: 1.0)

Permanent household income is approximated by the product of four factors: (1) potential output XGDPT; (2) the trend ratio of of household income to potential GDP, ZYHST; (3) the weighted average of expected future log deviations of actual GDP from its potential; and (4) the weighted average of expected future log deviations of the actual ratio of household income to GDP from its trend ZYHST. In the case of the last two factors, the expectations are derived from a small-scale VAR forecasting system using time t information; forward averages through infinity for these forecasts are then computed using weights that decline geometrically, based on a discount rate of 20 percent per year. The equation shown below is the reduced-form representation of this expectational system.

$$\begin{aligned}
 \log(ZYH) = & B1(L) \text{ (sum } 0.000398) * PICNIA_t \\
 & + B2(L) \text{ (sum } -3.25E-05) * RFFE_t \\
 & + B3(L) \text{ (sum } 0.00296) * XGAP2_t \\
 & - 0.000398 * PTR \\
 & + 3.25E-05 * RTR \\
 & + B6(L) \text{ (sum } 0.00301) * YHGAP_t \\
 & + \log(ZYHST * XGDPT)
 \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
B10	-0.000586	B1SUM	0.000398	B2SUM	-3.25E-05	B3SUM	0.00296
B11	0.000349	B20	-0.00131	B30	0.00419	B60	0.00248
B12	0.000160	B21	0.000208	B31	0.000388	B61	0.000555
B13	0.000476	B22	0.000768	B32	-0.000756	B62	-0.000105
		B23	0.000300	B33	-0.000864	B63	7.88E-05
						B6SUM	0.00301

z.50 ZYHP: Expected level of real after-tax property income, for QEC eq. (weight: 1.0)

The property component of permanent household income is approximated by the product of six factors: (1) potential output XGDPT; (2) the trend ratio of household income to potential GDP, ZYHST; (3) the trend share of property income in total household income, ZYHPST; (4) the weighted average of expected future log deviations of actual GDP from its potential; (5) the weighted average of expected future log deviations of the actual ratio of household income to GDP from its trend ZYHST; and (6) the weighted average of expected future log deviations of the actual property share from its trend. In the case of the last three factors, the expectations are derived from a small-scale VAR forecasting system using time t information; forward averages through infinity for these forecasts are then computed using weights that decline geometrically, based on a discount rate of 20 percent per year. The equation shown below is the reduced-form representation of this expectational system.

$$\begin{aligned} \log(\text{ZYHP}) = & B1(L) \{ \text{sum } 0.00366 \} * \text{PICNIA}_t \\ & + B2(L) \{ \text{sum } -0.000614 \} * \text{RFFE}_t \\ & + B3(L) \{ \text{sum } 0.00129 \} * \text{XGAP2}_t \\ & - 0.00366 * \text{PTR} \\ & + 0.000614 * \text{RTR} \\ & + B6(L) \{ \text{sum } 0.00274 \} * \text{YHGAP}_t \\ & + B7(L) \{ \text{sum } 0.00194 \} * \text{YHPGAP}_t \\ & + \log(\text{ZYHPST} * \text{ZYHST} * \text{XGDPT}) \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
B1 ₀	0.000783	B2 ₁	-0.000557	B3 ₂	-0.000891	B6 ₃	-3.11E-05
B1 ₁	0.00138	B2 ₂	0.00114	B3 ₃	-0.000771	B6SUM	0.00274
B1 ₂	0.000750	B2 ₃	-0.000141	B3SUM	0.00129	B7 ₀	0.00203
B1 ₃	0.000745	B2SUM	-0.000614	B6 ₀	0.00247	B7 ₁	-0.000123
B1SUM	0.00366	B3 ₀	0.00259	B6 ₁	0.000450	B7 ₂	0.000116
B2 ₀	-0.00105	B3 ₁	0.000358	B6 ₂	-0.000140	B7 ₃	-8.05E-05
						B7SUM	0.00194

z.51 ZYHPST: Expected trend share of property income in household income

Each quarter, the estimated long-run share of property income in total income is assumed to close 5% of the gap between the actual share and last period's estimate.

$$\text{ZYHPST} = \text{ZYHPST}_{t-1} + 0.0500 \text{ [(const.)]} * (\text{YHPshr} - \text{ZYHPST}_{t-1})$$

z.52 ZYHST: Expected trend ratio of household income to GDP

Each quarter, the estimated trend ratio of household income to GDP is assumed to close 5% of the gap between the actual share and last period's estimate.

$$\text{ZYHST} = \text{ZYHST}_{t-1} + 0.0500 \text{ [(const.)]} * (\text{YHSHR} - \text{ZYHST}_{t-1})$$

z.53 ZYHT: Expected level of real transfer income, for QEC eq. (weight: 1.0)

The transfer component of permanent household income is approximated by the product of six factors: (1) potential output XGDPT; (2) the trend ratio of household income to potential GDP, ZYHST; (3) the trend share of transfer income in total household income, ZYHTST; (4) the weighted average of expected future log deviations of actual GDP from its potential; (5) the weighted average of expected future log deviations of the actual ratio of household income to GDP from its trend ZYHST; and (6) the weighted average of expected future log deviations of the actual transfer share from its trend. In the case of the last three factors, the expectations are derived from a small-scale VAR forecasting system using time t information; forward averages through infinity for these forecasts are then computed using weights that decline geometrically, based on a discount rate of 20 percent per year. The equation shown below is the reduced-form representation of this expectational system.

$$\begin{aligned} \log(\text{ZYHT}) = & B1(L) \text{ \{sum -0.00167\} } * \text{PICNIA}_t \\ & + B2(L) \text{ \{sum 0.000253\} } * \text{RFFE}_t \\ & + B3(L) \text{ \{sum 0.00772\} } * \text{XGAP2}_t \\ & + 0.00167 * \text{PTR} \\ & - 0.000253 * \text{RTR} \\ & + B6(L) \text{ \{sum 0.00260\} } * \text{YHGAP}_t \\ & + B7(L) \text{ \{sum 0.00299\} } * \text{YHTGAP}_t \\ & + \log(\text{ZYHTST} * \text{ZYHST} * \text{XGDPT}) \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
B10	-0.00111	B21	0.00105	B32	0.000373	B63	0.000194
B11	-0.000364	B22	0.000280	B33	-3.42E-05	B6SUM	0.00260
B12	-0.000284	B23	0.000240	B3SUM	0.00772	B70	0.00236
B13	8.73E-05	B2SUM	0.000253	B60	0.00178	B71	0.000594
B1SUM	-0.00167	B30	0.00578	B61	0.000339	B72	-0.000248
B20	-0.00131	B31	0.00160	B62	0.000284	B73	0.000291
						B7SUM	0.00299

z.54 ZYHTST: Expected trend share of transfer income in household income

Each quarter, the estimated long-run share of transfer income in total income is assumed to close 5% of the

gap between the actual share and last period's estimate.

$$ZYHTST = ZYHTST_{t-1} + 0.0500 [(const.) * (YHTSHR - ZYHTST_{t-1})]$$

z.55 ZYNID: Expected rate of growth of desired real dividends, for YNIDN eq. (weight: .48)

$$\begin{aligned} ZYNID = & 0.00269 \\ & + A1(L) \{sum\ 0.00124\} * PICNIA_{t-1} \\ & + A2(L) \{sum\ -0.000439\} * RFFE_{t-1} \\ & + 0.000439 * RTR_{t-1} \\ & - 0.00124 * PTR_{t-1} \\ & + A5(L) \{sum\ -0.00119\} * XGAP_{t-1} \\ & + A6(L) \{sum\ -0.0237\} * del(1 : log(QYNIDN_{t-1}/PXB_{t-1})) \\ & + 0.497 * (HGGDPT_{t-1}/400) \end{aligned}$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
A1 ₀	0.000309	A1SUM	0.00124	A2SUM	-0.000439	A5SUM	-0.00119
A1 ₁	0.000370	A2 ₀	-0.000225	A5 ₀	-0.00156	A6 ₀	-0.0106
A1 ₂	0.000328	A2 ₁	-0.000122	A5 ₁	0.000441	A6 ₁	-0.00888
A1 ₃	0.000230	A2 ₂	-0.000147	A5 ₂	-0.000267	A6 ₂	-0.00158
		A2 ₃	5.49E-05	A5 ₃	0.000197	A6 ₃	-0.00262
						A6SUM	-0.0237

z.56 ZECO: Expected growth rate of target non-durables and non-housing services, for ECO eq. (weight:.72)

The weighted average growth rate of expected future target "other" consumption, ZECO, is computed using forecasts from a small scale VAR model combined with the PAC weights implied by the estimated coefficients of the dynamic consumption equation. The equation shown below is the reduced-form representation of this expectational computation.

$$\begin{aligned} ZECO = & -1.35E-05 \\ & + B1(L) \{sum\ -0.000251\} * PICNIA_{t-1} \\ & + B2(L) \{sum\ 0.000160\} * RFFE_{t-1} \\ & + B3(L) \{sum\ -0.000218\} * XGAP2_{t-1} \\ & + 0.000251 * PTR_{t-1} \\ & - 0.000160 * RTR_{t-1} \\ & + B6(L) \{sum\ 9.07E-05\} * YHGAP_{t-1} \\ & + B7(L) \{sum\ -3.99E-05\} * YHTGAP_{t-1} \\ & + B8(L) \{sum\ -8.97E-05\} * YHPGAP_{t-1} \\ & + 0.728 * (HGGDPT_{t-1}/400) \end{aligned}$$

+ B10(L) {sum 0.00118 }

* (del(1 : log(QEC_{t-1})) - del(1 : log(PCOR_{t-1})))

Distributed lag coefficients

Name	Value
B1 ₀	-0.000199
B1 ₁	-8.74E-05
B1 ₂	-1.78E-06
B1 ₃	3.67E-05
B1SUM	-0.000251
B2 ₀	-1.84E-05
B2 ₁	0.000178
B2 ₂	-6.51E-05

Name	Value
B2 ₃	6.52E-05
B2SUM	0.000160
B3 ₀	-0.000105
B3 ₁	3.05E-05
B3 ₂	-5.19E-05
B3 ₃	-9.16E-05
B3SUM	-0.000218
B6 ₀	-8.75E-05
B6 ₁	8.75E-05

Name	Value
B6 ₂	0.000131
B6 ₃	-4.05E-05
B6SUM	9.07E-05
B7 ₀	2.82E-05
B7 ₁	-4.18E-05
B7 ₂	6.68E-06
B7 ₃	-3.30E-05
B7SUM	-3.99E-05
B8 ₀	-4.00E-05

Name	Value
B8 ₁	-6.38E-05
B8 ₂	1.47E-06
B8 ₃	1.27E-05
B8SUM	-8.97E-05
B10 ₀	0.00452
B10 ₁	-0.00408
B10 ₂	-0.00161
B10 ₃	0.00236
B10SUM	0.00118