FRB/US Equation Documentation

September 2014

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Introduction

This document lists the roughly 375 equations in the FRB/US macroeconomic model. Many of these equations are identities. The number of ``core" stochastic equations is around 50, of which about a third are based on formal models of optimization and contain explicit expectations of future economic conditions. Equations are grouped into 11 sectors, each of which is introduced by a brief discussion of its major features. Sector Z, which contains equations for expectations variables, has two forms: one for the backward-looking "VAR" representation of expectations and one for the forward-looking formulas associated with model-consistent expectations. Important equations are accompanied by a small amount of explanatory text. The rest of this introduction provides a brief overview of the equations in FRB/US.

Equations based on optimization

New Keynesian Phillips curve (NKPC). In the price-wage sector, the equations for core consumer price inflation and the ECI measure of hourly labor compensation are based on the NKPC framework.

PAC equations. The polynomial adjustment cost (PAC) approach underlies the other nonfinancial equations that are based on optimization. These include the equations for most components of consumption and investment, labor hours, and dividends. PAC is a specification that 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 (y) from a target path (y^*) plus adjustment costs associated with squared changes in the level, the growth rate, and higher-order time derivatives of the decision variable. Expressed as a decision rule, the PAC first-order condition has the following error-correction form.

(1) $$\Delta y_t = a_0(y^*_{t-1} - y_{t-1}) + \Sigma_{k=1,m-1} a_k \Delta y_{t-k} + E_{t-1}\Sigma_{j=0,\infty}\, d_j \Delta y^*_{t+j} + \varepsilon_t$$

Δ is the first difference operator, E_{t-1} represents expectations based on information available at t-1, and ε is an error term that is assumed to be serially uncorrelated. The equation decomposes the determinants of Δy into three elements:

- 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.

The d_j coefficients on leads of Δy^* are transformations of the a_k ($k = 0,\ldots,m-1$) coefficients on lags of y and a fixed discount factor. When m=1, PAC is equivalent to the case of quadratic adjustment costs. In estimating the FRB/US PAC equations, m is chosen on the basis of the number of lags of Δy that have statistically significant coefficients, which usually leads to residuals that are free of serial correlation. Based on this criterion, m is found to be either 2 or 3. (In some cases the target variable y^* is decomposed into separate stationary and non-stationary parts.)

For more information on PAC see Peter A. Tinsley, "Rational Error Correction," *Computational Economics* (2002). Information is also available here and here.

Permanent income. In the PAC equations for components of consumption and for residential investment, the target levels of spending depend on expectations of future income. An important characteristic of these expectations is that they are computed using a 25 percent annual rate of discount, a value that is based on micro evidence about individuals' income uncertainty.

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

Other equations

Error-correction and other behavioral equations. 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, inventories, 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 FRB/US, these relationships are closely approximated by identities that aggregate using Divisia indexes; the chain-aggregation formula is used for real GDP, because the value of its inventory investment component may be negative. 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.

Estimation

The large size of FRB/US makes it infeasible to estimate all of its equations simultaneously. Estimation of the optimization-based equations involves the estimation of a set of independent sub-models, each of which typically combines one of the structural equations with a condensed model of the overall economy that features a VAR. Projections of the VAR provide proxies for the explicit expectations terms in the structural equation. Each VAR model shares a *core* set of macro variables: the federal funds rate and the value expected to prevail in the long run, consumer price inflation and the value expected to prevail in the long run, and the output gap. 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. *Auxiliary* variables are added to individual VARs as needed to form proxies for expectations of variables not in the core set.

An iterated OLS approach is used to estimate the sub-models associated with most of the optimization-based equations. The only exceptions are the price and wage NKPC equations, which are estimated simultaneously using a mixture of maximum likelihood and Bayesian methods. The estimates other equations are obtained by standard OLS or, in a few cases, with the Kalman filter.

Expectations

FRB/US contains roughly 30 expectations variables, most of which appear in equations whose basis includes the assumption that some or all economic agents make decisions optimally. Most expectation are for the weighted sum of a variable over future quarters. The exceptions are in the price-wage block, where expectations are for one period ahead.

The first version of sector Z contains the identities that are used when the assumption of VAR expectations is employed. The form of each identity is determined by the structure and parameters of the sub-model that is used to estimate the structural equation in which the expectation appears. Two types of parameters determine the coefficient values in the typical

VAR-expectations equation: discounting weights that specify the horizon of each expectation and coefficients of the VAR system used to generate the forecasts that proxy for expectations in the estimation sub-model.

The second version of sector Z contains the identities that are used when the assumption of model-consistent expectations is employed. The coefficient values in the typical model-consistent expectations equation depend only on discounting weights.

The design of FRB/US permits simulations in which some expectations have VAR-based solutions and others have model-consistent solutions.

Conventions for naming variables.

In addition to the use of a standard set of prefixes (such as ``E'' for expenditure, "F" for foreign, ``G'' for government, "K" for capital stock, "P" for price, and ``R'' for interest rate), variable names in FRB/US follow several other conventions. Among prefixes, ``Q'' denotes the nonstationary component of the ``target'' or ``desired'' level of a variable (eg, QECO is the desired level of consumption variable ECO), "PI" denotes an annualized rate of inflation, "H" is used for the rate of growth of a non-price variable (which may or may not be expressed at an annual rate), "U" usually denotes an exogenous multiplicative factor, and ``Z'' refers to a variable that is an expectation. Among suffixes, "N" usually indicates a variable that is measured in current dollars, and "E" indicates that an interest rate is measured as a compound annual rate.

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 a set of 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 do not have t-statistics. Below the equation text and any distributed lag coefficients, standard estimation statistics are shown.

Household Expenditures

In FRB/US, optimizing households seek to maximize expected utility subject to lifetime resources. Because of risk aversion and uninsurable income uncertainty, consumption depends on the present value of expected future income discounted not at the real rate of interest, but at a higher rate that is fixed at 25 percent per annum. Heterogeneity across age groups in wealth holdings and the propensity to consume makes aggregate desired spending a function of both the level and composition of expected lifetime resources. Adjustment costs cause actual spending to deviate from desired spending.

The household optimization problem has two parts. The first is the calculation of desired spending in the absence of adjustment costs. The second applies the polynomial adjustment cost (PAC) framework to find the optimal path of actual spending given the desired path. Expectations play a role in both optimization steps.

This general paradigm applies to consumer spending on nondurable goods and non-housing services (actual = ECO, desired = QECO), investment in durable goods (ECD, QECD), and investment in residential structures (EH, QEH). The equation for ECO also allows for the presence of some rule-of-thumb or liquidity constrained households whose consumption moves in proportion to their income. The desired level of spending on each of the two categories of investment depends on a real rental rate in addition to lifetime resources. A final and relatively minor consumption category, consumption of housing services (ECH), is modeled as a simple reduced form.

The modeling of desired consumption centers on variable QEC, which is the desired level of spending associated with consumption of nondurable goods and services plus the service flow from the stock of durables (EC). QEC is measured historically as the fitted values of a regression of EC on constructed measures of discounted future income and Flow of Funds estimates of the net stock of tangible assets held by the household sector. The FRB/US equation for QEC is this regression equation with QEC substituted for EC as its dependent variable.

a.1 ECO: Consumer expenditures on non-durable goods and non-housing services, cw 2009$

Consumer spending on nondurables goods and non-housing services is a weighted average of the spending of optimizing households and rule-of-thumb (ROT) households. The consumption decisions of the former are modeled using the polynomial adjustment cost (PAC) framework. ROT consumption moves in proportion with the sum of labor and transfer income (YHL+YHT). The estimated fraction of ROT consumption is 0.18. The structure of the PAC component of the equation is based on equation (1) shown below in the PAC Overview section. To translate the general PAC specification into the form in which it appears in the ECO equation, associate log(ECO) with y, log(QECO) with y*, and ZECO with the expected weighted sum of future Δy^*. The order of adjustment costs (m) is 2.

PAC Overview: Let y denote the decision variable and y* its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

(1) $\Delta y_t^{pac} = a_0(y^*_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i \Delta y_{t-i} + E_{t-1}\sum_{i=0,\infty} d_i \Delta y^*_{t+i}$

The order of adjustment costs is given by parameter m. The forward weights, d_i {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see PAC Basics.

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$$\begin{aligned}\mathbf{\Delta(\log(ECO))} = {} & (0.109\ [3.75] * \log(QECO_{t-1}/ECO_{t-1}) \\ & + 0.461\ [4.75] * \Delta(\log(ECO_{t-1})) \\ & + 1.00 * ZECO) * (1-0.252\ [2.20]) \\ & + 0.252\ [2.20] * (\Delta(\log(YHL+YHT)))\end{aligned}$$

Regression statistics

Adjusted R^2:	0.350
S.E. of regression:	0.00421
Sum of squared residuals:	0.00317
Durbin-Watson statistic:	2.02
Sample period:	1968Q3 2013Q4
Estimation date:	August 2014
Estimation method:	Iterative Least Squares

a.2 ECD: Consumer expenditures on durable goods, cw 2009$

Household investment in consumer durables is modeled using the polynomial adjustment cost (PAC) framework, whose general structure is shown below in the PAC Overview section. To translate the general PAC specification into the form in which it appears in the ECD equation, associate log(ECD) with y, log(QECD) with y^{1*}, ZECO with the expected weighted sum of future Δy^{1*}, and 8.02*ZGAPC2/400 with the expected weighed sum of future y^{0*}. The order of adjustment costs (m) is 2.

PAC Overview: Let y denote the decision variable, and y^{1*} and y^{0*} be the nonstationary and stationary components of its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

(1) $\Delta y_t = a_0(y^{1*}_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i \Delta y_{t-i} + E_{t-1}\sum_{i=0,\infty} d_i \Delta y^{1*}_{t+i} + E_{t-1}\sum_{i=0,\infty} h_i y^{0*}_{t+i}$

The order of adjustment costs is given by parameter m. The forward weights, d_i and h_i, {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see Pac Basics.

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Δ(log(ECD)) = 0.155 [3.40] * log(QECD$_{t-1}$/ECD$_{t-1}$)
- 0.0586 [-0.82] * Δ(log(ECD$_{t-1}$))
+ 1.00 * ZECD
+ 9.04 [2.70] * ZGAPC2 / 400

Regression statistics

Adjusted R^2:	0.140
S.E. of regression:	0.0278
Sum of squared residuals:	0.136
Durbin-Watson statistic:	2.03
Sample period:	1969Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

a.3 EH: Residential investment expenditures, cw 2009$

Household investment in residential structures is modeled using the polynomial adjustment cost (PAC) framework, whose general structure is shown below in the PAC Overview section. To translate the general PAC specification into the form in which it appears in the EH equation, associate log(EH) with y, log(QEH) with y*, and ZEH with the expected weighted sum of future Δy*. The order of adjustment costs (m) is 3.

Besides the standard PAC terms, the equation also includes the first lag of the change in the nominal mortgage rate. This term is 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 coefficient on this term 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.

PAC Overview: Let y denote the decision variable and y* its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

(1) $\Delta y_t^{pac} = a_0(y^*_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i \Delta y_{t-i} + E_{t-1}\sum_{i=0,\infty} d_i \Delta y^*_{t+i}$

The order of adjustment costs is given by parameter m. The forward weights, d_i {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see Pac Basics.

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Δ(log(EH)) = 0.0118 [0.87] * $\log(QEH_{t-1}/EH_{t-1})$
+ 0.358 [5.24] * $\Delta(\log(EH_{t-1}))$
+ 0.216 [3.23] * $\Delta(\log(EH_{t-2}))$
+ 1.00 * ZEH
- 0.0514 [-6.67] * $\Delta(RME_{t-1})$
+ 0.0249 [2.57] * D83 * $\Delta(RME_{t-1})$

Regression statistics

Adjusted R^2:	0.500
S.E. of regression:	0.0337
Sum of squared residuals:	0.193
Durbin-Watson statistic:	2.12
Sample period:	1970Q2 2013Q4
Estimation date:	August 2014

Estimation method:	Least Squares

a.4 ECH: Consumer expenditures on housing services, cw 2009$

The equation for consumer spending on housing services has an error-correction form in which the equilibrium ratio of housing services to the housing stock depends on the smoothed value of the real mortgage rate (RRMET).

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$$\Delta((ECH)/KH(-1)) = 0.00289\ [6.41]$$
$$- 0.0242\ [-5.48] * ECH_{t-1}/KH_{t-2}$$
$$+ 0.501\ [6.73] * \Delta(ECH_{t-1}/KH_{t-2})$$
$$+ 0.00174\ [1.43] * RRMET/100$$

Regression statistics

Adjusted R^2:	0.330
S.E. of regression:	0.000274
Sum of squared residuals:	1.28e-05
Durbin-Watson statistic:	0.76
Sample period:	1970Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

a.5 QEC: Desired level of consumption (FRBUS definition)

QEC is the desired level of spending associated with consumption of nondurable goods and services plus the imputed service flow from the stock of durables (EC).

To interpret the QEC equation, note that permanent household income (ZYH) is the sum of permanent measures of transfer (ZYHT), property (ZYHP), and labor income (no explicit variable). Thus, the estimated coefficient on ZYH is the MPC out of permanent labor income, and the estimated coefficients on ZYHT and ZYHP measure the degree to which the propensities to spend out of these other components of permanent income differ from the propensity to spend out of labor income. The MPC out of non-transfer permanent income is estimated to have increased slightly since the mid-1980s, as indicated by the positive coefficient on DCON*(ZYH-ZYHT): 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. The measures of permanent income assume that households discount future incomes at a 25 percent annual rate.

The estimated coefficient values and equation statistics come from a cointegrating regression of EC on the set of explanatory variables. QEC is measured historically as the fitted values of this regression.

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$$\begin{aligned}\textbf{QEC} = {} & 0.759\ [24.91] * ZYH \\ & + 0.00258\ [0.66] * (DCON*(ZYH-ZYHT)) \\ & + 0.241 * ZYHT \\ & - 0.251\ [-2.28] * ZYHP \\ & + 0.0315\ [10.97] * (WPS+WPO)\end{aligned}$$

Regression statistics

Adjusted R^2:	1.000
S.E. of regression:	0.0161
Sum of squared residuals:	0.0472
Durbin-Watson statistic:	0.12
Sample period:	1967Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

a.6 QECO: Desired level of consumption of nondurable goods and nonhousing services

The elasticity of the desired level of consumption on nondurable goods and non-housing services is one with respect to the desired level of overall consumption and minus one with respect to the relative price (PCOR) of consumption on nondurable goods and non-housing services to overall consumption. A constant term ensures that historically the average log difference between ECO and QECO is zero.

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log(QECO) = log(QEC) - log(PCOR) - 0.337 [-273.95]

Regression statistics

Adjusted R^2:	1.000
S.E. of regression:	0.0171
Sum of squared residuals:	0.0567
Durbin-Watson statistic:	0.13
Sample period:	1965Q3 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

a.7 QECD: Target level of consumption of durable goods, trending component

The ratio of the target level of spending on consumer durable goods to the target level of overall consumption depends on two factors. The first factor is the relative rental rate, which is the product of the relative purchase price of consumer durables, PCDR, and the real financial cost of capital (plus depreciation) for such goods, RCCD. The relative rental rate is associated with the steady-state condition for the stock of consumer durables. The second factor converts the steady-state stock condition to one for gross investment 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).

The coefficients values and equation statistics come from a cointegrating regression in which actual investment (ECD) replaces target investment (QECD) as the dependent variable.

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QECD = QEC
* (JRCD/4 + HGGDPT/400 - 0.617 [-60.56]*HGPCDR/400)
* exp(2.56 [67.46] - 0.617 *log(PCDR*RCCD))

Regression statistics

Adjusted R^2:	0.960
S.E. of regression:	0.0513

Sum of squared residuals:	0.466
Durbin-Watson statistic:	0.27
Sample period:	1969Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

a.8 QEH: Target level of residential investment

The ratio of the target level of residential investment to the target level of overall consumption depends on two factors. The first factor is the relative rental rate, which is the product of the relative purchase price of residential investment, PHR*PXP/PCNIA, and the real financial cost of capital (plus depreciation) for such goods, RCCH. The relative rental rate is associated with the steady-state condition for the stock of housing. The second factor converts the steady-state stock condition to one for gross investment by multiplying the stock condition by the sum of two terms -- the depreciation rate for residential structures, and the steady-state growth rate of the target capital stock. The latter term 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 relative price does not show a pronounced trend.)

The coefficients values and equation statistics come from a cointegrating regression in which actual residential investment (EH) replaces target investment (QEH) as the dependent variable.

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$$\mathbf{QEH} = QEC * (JRH/4 + HGGDPT/400) * \exp(1.94\ [0.00] - \log(PHR*PXP/PCNIA) - 0.157\ [0.00]*\log(RCCH))$$

Regression statistics

Adjusted R^2:	1.000
S.E. of regression:	0
Sum of squared residuals:	0
Sample period:	1964Q1 2013Q4
Estimation date:	August 2014

Estimation method: Least Squares

a.9 ECNIA: Personal consumption expenditures, cw 2009$ (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).

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\begin{aligned}
\mathbf{log(ECNIA)} = {} & \log(ECNIA_{t-1}) + \\
& .5 * .01 * (PCOR*PCNIA*ECO/ECNIAN \\
& + PCOR_{t-1}*PCNIA_{t-1}*ECO_{t-1}/ECNIAN_{t-1}) \\
& * \Delta(\log(ECO)) \\
& + .5 * .01 * (PCDR*PCNIA*ECD/ECNIAN \\
& + PCDR_{t-1}*PCNIA_{t-1}*ECD_{t-1}/ECNIAN_{t-1}) \\
& * \Delta(\log(ECD)) \\
& + .5 * .01 * (PCHR*PCNIA*ECH/ECNIAN \\
& + PCHR_{t-1}*PCNIA_{t-1}*ECH_{t-1}/ECNIAN_{t-1}) \\
& * \Delta(\log(ECH))
\end{aligned}
$$

a.10 ECNIAN: Personal consumption expenditures, current $ (NIPA definition)

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

a.11 EHN: Residential investment expenditures

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$$EHN = .01 * PHR * PXP * EH$$

a.12 KCD: Stock of consumer durables, cw 2009$

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

a.13 KH: Stock of residential structures, cw 2009$

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

a.14 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 interest rate. The latter is approximated by the new auto loan rate minus expected inflation over the next five years. A MAX function is included to prevent RCCD from taking on implausible values, improving the stability of the model in stochastic simulations. Over history, RCCD has never approached this floor.

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$$RCCD = \max(100*JRCD + RCAR - ZPI5, .01)$$

a.15 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-TRFPM/100)*RME-ZPI10, plus the effective marginal property tax rate (1-TRFPM/100)*TRSPP. A MAX function is included to prevent RCCH from taking on implausible values, improving the stability of the model in stochastic simulations. Over history, RCCH has never approached this floor. 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.

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

a.16 JKCD: Consumption of fixed capital, consumer durables

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$$\mathbf{JKCD} = JRCD * KCD_{t-1}$$

a.17 EC: Consumption, cw 2009$ (FRB/US definition)

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

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$$\begin{aligned}\mathbf{log(EC)} = {} & \log(EC_{t-1}) + \\ & .5 * (PCOR*PCNIA*ECO/(EC*PCNIA) \\ & + PCOR_{t-1}*PCNIA_{t-1}*ECO_{t-1}/(EC_{t-1}*PCNIA_{t-1})) \\ & * \Delta(\log(ECO)) \\ & + .5 * (PCHR*PCNIA*ECH/(EC*PCNIA) \\ & + PCHR_{t-1}*PCNIA_{t-1}*ECH_{t-1}/(EC_{t-1}*PCNIA_{t-1})) \\ & * \Delta(\log(ECH))\end{aligned}$$

$+ .5 * ((PCDR*PCNIA*YHPCD+PCDR*PCNIA*JKCD)/(EC*PCNIA)$
$+ (PCDR_{t-1}*PCNIA_{t-1}*YHPCD_{t-1}+PCDR_{t-1}*PCNIA_{t-1}*JKCD_{t-1})/(EC_{t-1}*PCNIA_{t-1}))$
$* \Delta(\log(YHPCD+JKCD))$

a.18 YHPCD: Imputed income of the stock of consumer durables, 2009$

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log(YHPCD) = $\log(0.0537\ [0.00]) + \log(KCD_{t-1})$

Business Expenditures

Business investment is broken down into four categories: equipment, nonresidential structures, intellectual property, and inventories.

Equipment, nonresidential structures, and intellectual property

The equations for investment in equipment, nonresidential structures, and intellectual property are based partly on the framework of optimization subject to adjustment costs and partly on an ad hoc accelerator effect of output growth on investment growth. The latter may capture the effects of cash flow on the ability of liquidity-constrained firms to finance investment projects. The estimated fraction of investment associated with the accelerator term ranges from 15 percent for intellecutal property to a high of 54 percent for equipment.

In the optimization part of each equation, the level of investment that would be desired in the absence of adjustment costs is defined in two steps. In the first, the target capital-output ratio is a function of the user cost associated with that type of capital. In the second, the target investment-output ratio is formed as the product of the target capital-output ratio and the sum of the capital-specific rate of depreciation and the rate of growth of potential output. This is the rate of investment necessary to hold the capital-output ratio at its optimal level.

The targets for the individual capital-output ratios are derived jointly from a nested aggregate production function. At the highest level, the 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 type of capital stock. Within the capital-services bundle, the targets for the individual categories are assumed to have a unit elasticity with respect to the user cost of capital, as in a Cobb-Douglas production function. The framework deviates from the standard Cobb-Douglas specification, however, in allowing the long-run capital services shares to vary over time.

In the optimization framework, the polynomial adjustment cost (PAC) approach determines the actual path of investment. In this approach, investment responds to the lagged gap between actual and target investment, expected future growth in target investment, and lagged growth in actual investment.

Inventories

The stock of inventories is modeled with a simple error-correction equation in which the equilibrium ratio of inventories to final sales is a random walk with negative drift.

b.1 EPD: Investment in equipment, cw 2009$

Investment in producers' durable equipment is a weighted average of the investment spending of optimizing firms and an ad hoc term in lagged output growth adjusted for the trend rate of change in the optimal investment-output ratio. The weights on the two components are estimated to be nearly. The investment decisions of the optimizing firms are modeled using the polynomial adjustment cost (PAC) framework. The structure of the PAC component of the equation is based on equation (1) shown below in the PAC Overview section. To translate the general PAC specification into the form in which it appears in the EPD equation, associate log(EPD) with y, log(QEPD) with y*, and the sum of ZXBD and ZVPD with the expected weighted sum of future Δy^*. The order of adjustment costs (m) is 3. The

PAC component of the EPD equation differs from equation (1) by allowing for a response lag that is one quarter longer than usual to account for a delivery/gestation lag in investment.

PAC Overview: Let y denote the decision variable and y* its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

(1) $\Delta y_t^{pac} = a_0(y^*_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i \Delta y_{t-i} + E_{t-1} \sum_{i=0,\infty} d_i \Delta y^*_{t+i}$

The order of adjustment costs is given by parameter m. The forward weights, d_i {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see PAC Basics.

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Δ(log(EPD)) =

(0.164 [3.61]*(LOG(QEPD$_{t-2}$/EPD$_{t-2}$))
+ A2(L) {sum 0.815 } * Δ(log(EPD $_{t-1}$))
+ ZXBD$_{t-1}$
+ ZVPD$_{t-1}$)*(1-0.500)
+ 0.500 * (Δ(log(XBO$_{t-1}$)) + HGVPD$_{t-1}$)

Distributed lag coefficients

Name	Value
$A2_0$	0.445 [3.10]
$A2_1$	0.370 [2.67]
$A2_{SUM}$	0.815

Regression statistics

Adjusted R^2:	0.400
S.E. of regression:	0.0236
Sum of squared residuals:	0.0962
Durbin-Watson statistic:	2.00
Sample period:	1970Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

b.2 EPI: Investment in intellectual property, cw 2009$

Investment in intellectual property is a weighted average of the investment spending of optimizing firms and an ad hoc term in lagged output growth. The optimizing component is estimated to get 85 percent of the weight. The investment decisions of the optimizing firms are modeled using the polynomial adjustment cost (PAC) framework. The structure of the PAC component of the equation is based on equation (1) shown below in the PAC Overview section. To translate the general PAC specification into the form in which it appears in the EPI equation, associate log(EPI) with y, log(QEPI) with y*, and the sum of ZXBI and ZVPI with the expected weighted sum of future Δy*. The order of adjustment costs (m) is 3. The PAC component of the EPI equation differs from equation (1) by allowing for a response lag that is one quarter longer than usual to account for a delivery/gestation lag in investment.

PAC Overview: Let y denote the decision variable and y* its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

(1) $\Delta y_t^{pac} = a_0(y^*_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i \Delta y_{t-i} + E_{t-1}\sum_{i=0,\infty} d_i \Delta y^*_{t+i}$

The order of adjustment costs is given by parameter m. The forward weights, d_i {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see PAC Basics.

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Δ(log(EPI)) =

(0.0121 [0.73]*(LOG($QEPI_{t-2}$/EPI_{t-2}))
+ A2(L) {sum 0.859 } * Δ(log(EPI_{t-1}))
+ $ZXBI_{t-1}$
+ $ZVPI_{t-1}$)*(1-0.212 [2.68])
+ 0.212 [2.68] * Δ(log(XBO_{t-1}))

Distributed lag coefficients

Name	Value
$A2_0$	0.682 [6.82]
$A2_1$	0.177 [1.79]

$A2_{SUM}$ 0.859

Regression statistics

Adjusted R^2:	0.460
S.E. of regression:	0.00886
Sum of squared residuals:	0.0135
Durbin-Watson statistic:	1.94
Sample period:	1970Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Iterative Least Squares

b.3 EPS: Investment in nonresidential structures, cw 2009$

Investment in non-residential structures is a weighted average of the investment spending of optimizing firms and an ad hoc term in lagged output growth. The optimizing component is estimated to get 55 percent of the weight. The investment decisions of the optimizing firms are modeled using the polynomial adjustment cost (PAC) framework. The structure of the PAC component of the equation is based on equation (1) shown below in the PAC Overview section, except that the response lag is one quarter longer than usual, reflecting a delivery/gestation lag. To translate the general PAC specification into the form in which it appears in the EPS equation, associate log(EPS) with y, log(QEPS) with y*, and the sum of ZXBI and ZVPI with the expected weighted sum of future Δy*. The order of adjustment costs (m) is 3. The PAC component of the EPS equation differs from equation (1) by allowing for a response lag that is one quarter longer than usual to account for a delivery/gestation lag in investment. The EPS equation includes a dummy variable for the fourth quarter of 2001 to account for the unprecedented fluctuation that quarter.

PAC Overview: Let y denote the decision variable and y* its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

(1) $\Delta y_t^{pac} = a_0(y^*_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i\Delta y_{t-i} + E_{t-1}\sum_{i=0,\infty}d_i\Delta y^*_{t+i}$

The order of adjustment costs is given by parameter m. The forward weights, d_i {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see PAC Basics.

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Δ(log(EPS)) =

(0.0666 [3.00] * log($QEPS_{t-2}$/EPS_{t-2})
+ A2(L) {sum 0.869 } * Δ(log(EPS_{t-1}))
+ $ZXBS_{t-1}$
+ $ZVPS_{t-1}$) * (1-0.500)
+ 0.500 * (Δ(log(XBO_{t-1})))
- 0.0970 [-3.68] * D01Q4

Distributed lag coefficients

Name	**Value**
$A2_0$	0.543 [3.85]
$A2_1$	0.326 [2.41]
$A2_{SUM}$	0.869

Regression statistics

Adjusted R^2:	0.350
S.E. of regression:	0.0264
Sum of squared residuals:	0.12
Durbin-Watson statistic:	2.10
Sample period:	1970Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

b.4 KI: Stock of private inventories, cw 2009$

The KI equation has an error-correction form in which the desired inventory-sales ratio (QKIR) is a random walk with drift. The KI equation and the QKIR process are estimated using the Kalman Filter. The secular downtrend in the inventory-sales ratio is reflected in an estimated value of the drift in QKIR that is negative. In the KI equation, movements in the growth rate of final sales have temporary effects on inventories, but permanent effects on the inventory-sales ratio are precluded by restricting the coefficients on the lagged growth rates of sales and inventories to sum to unity.

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$$\Delta(\log(KI)) = -0.00131_{[-2.82]}$$
$$+ 0.0168_{[0.99]} * (\log(QKIR) - \log(KI_{t-1}/XFS_{t-1}))$$
$$+ 0.452_{[9.62]} * (\Delta(\log(KI_{t-1})) - -0.00131_{[-2.82]})$$
$$+ 0.262_{[5.86]} * \Delta(\log(XFS_{t-1}))$$
$$+ 0.287 * \Delta(\log(XFS_{t-2}))$$

Regression statistics

Sample period:	1960Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Maximum likelihood (Marquardt)

b.5 EI: Change in private inventories, cw 2009$

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

b.6 QEPD: Desired level of investment in equipment

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

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$$\log(QEPD) = 0.00$$
$$+ 1.00 * \log(XBO)$$
$$+ 1.00 * \log(VPD)$$
$$+ 1.00 * \log(HGX/100 + JRPD)$$

b.7 QEPS: Desired level of investment in structures

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

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$$\mathbf{log(QEPS)} = 0.00 + 1.00 * \log(XBO) + 1.00 * \log(VPS) + 1.00 * \log(HGX/100 + JRPS)$$

b.8 QEPI: Desired level of investment in intellectual property

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

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$$\mathbf{log(QEPI)} = 0.00 + 1.00 * \log(XBO) + 1.00 * \log(VPI) + 1.00 * \log(HGX/100 + JRPI)$$

b.9 QKIR: Desired Inventory Sales Ratio

The target inventory-sales ratio is estimated along with the equation for the stock of inventories (KI) using the Kalman filter. To ensure that long-run simulations are characterized by balanced growth, exogenous variable DGLPRD can be set to 1.0 to make the target inventory-sales ratio constant.

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$$\mathbf{log(QKIR)} = (1-DGLPRD)*-0.00189 + \log(QKIR_{t-1})$$

b.10 KPD: Capital stock - Equipment, 2009$

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$$\textbf{KPD} = 0.25 * \text{EPD} + (1-\text{JRPD}/4) * \text{KPD}_{t-1}$$

b.11 KPI: Capital Stock - Intellectual Property, 2009$

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$$\textbf{KPI} = 0.25 * \text{EPI} + (1-\text{JRPI}/4) * \text{KPI}_{t-1}$$

b.12 KPS: Capital stock - nonresidential structures, 2009$

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$$\textbf{KPS} = 0.25 * \text{EPS} + (1-\text{JRPS}/4) * \text{KPS}_{t-1}$$

b.13 HKS: Growth rate of KS, cw 2009$ (compound annual rate)

The growth rate of capital services is modeled as a weighted average of the growth rates of three 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.

The equation should also contain the stock of intellectual property, but data for that stock has yet to be officially published.

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$$\textbf{HKS} = 400 * (YKPDN * \Delta(\log(KPD)) + YKPSN * \Delta(\log(KPS)) + YKIN * \Delta(\log(KI))) / (YKPDN + YKPSN + YKIN) + HKSR$$

b.14 KS: Capital services, 2009 $

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

b.15 RPD: After-tax real financial cost of capital for business investment

The firm's financing cost is measured as a weighted average of borrowing costs in debt and equity markets. 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.

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$$\textbf{RPD} = 0.5*(7.2 + (1-TRFCIM)*(RG5E + RBBBE - RG10E) - ZPIB5) + 0.5*REQ$$

b.16 RTPD: User cost of capital for equipment

The annualized rental cost, relative to the price of output, of a unit of equipment has three components: the relative purchase price of new investment (PKPDR*PXP/PXB); the depreciation rate (JRPD) plus the real financing rate (RPD) less the trend growth rate of the relative price of equipment (HGPDR); and tax adjustments for depreciation and the marginal corporate tax rate.

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$$\textbf{RTPD} = (.01*RPD + JRPD - .01*HGPDR) * ((1-.01*TAPDT-TRFCIM*(1-TAPDDP*.01*TAPDT)*TAPDD)/(1-TRFCIM)) * (\Sigma_{i=0,1}(PXP_{t-i}*PKPDR_{t-i})/2))/PXB$$

b.17 RTPI: User cost of capital for intellectual property

The annualized rental cost, relative to the price of output, of a unit of intellectual property has two components: the relative purchase price of new investment (PPIR*PXP/PXB); the depreciation rate (JRPI) plus the real financing rate (RPD) less the trend growth rate of the relative price of intellectual property (HGPIR).

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$$\textbf{RTPI} = (.01*RPD + JRPI - .01*HGPIR) * (\Sigma_{i=0,1}(PXP_{t-i}*PPIR_{t-i})/2))/PXB$$

b.18 RTPS: User cost of capital for nonresidential structures

The annualized rental cost, relative to the price of output, of a unit of structures capital has three components: the relative purchase price of new investment (PPSR*PXP/PXB); the depreciation rate (JRPS) plus the real rate of interest (RPD) less the trend growth rate of the relative price of structures (HGPPSR); and the tax adjustment for depreciation and the marginal corporate tax rate.

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$$\textbf{RTPS} = \max((.01*RPD + JRPS - .01*HGPPSR) * ((1-TRFCIM*TAPSDA)/(1-TRFCIM))$$

$* (\Sigma_{i=0,1}(PXP_{t-i} * PPSR_{t-i})/2))/PXB, .02)$

b.19 RTINV: User cost of capital for inventories

The annualized rental cost, relative to the price of output, of a unit of inventory capital is equal to the relative purchase price of new investment (PKIR*PXP/PXB) multiplied by the after-tax financial rate (RPD) minus the trend growth rate of the relative price of inventories (HGPKIR).

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$$\textbf{RTINV} = (.01*RPD - .01*HGPKIR) * (\Sigma_{i=0,1}(PXP_{t-i} * PKIR_{t-i})/2))/PXB$$

b.20 VPD: Desired equipment-output ratio

The desired equipment-output ratio is inversely related to the user cost of capital, implying an elasiticity of substitution of one. The multiplicative factor UVPD has the interpretation of the equilibrium income share for nonresidential structures. UVPD is estimated with an HP filter over history and is assumed to be exogenous in simulation.

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$$\textbf{VPD} = UVPD*(PKPDR/PPDR)/RTPD$$

b.21 VPI: Desired intellectual property-output ratio

The desired intellectual property-output ratio is inversely related to the user cost of capital, implying an elasiticity of substitution of one. The multiplicative factor UVPI has the interpretation of the equilibrium income share for intellectual property. UVPI is estimated with an HP filter over history and is assumed to be exogenous in simulation.

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VPI = UVPI/RTPI

b.22 VPS: Desired structures-output ratio

The desired structures-output ratio is inversely related to the user cost of capital, implying an elasiticity of substitution of one. The multiplicative factor UVPS has the interpretation of the equilibrium income share for nonresidential structures. UVPS is estimated with an HP filter over history and is assumed to be exogenous in simulation.

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VPS = UVPS/RTPS

b.23 HGVPD: Trend Growth of VPD

Historical observations on the trend growth rate of the optimal capital-output ratio are constructed as an 18-quarter moving average of the actual growth rate. In simulation, the trend is a geometrically weighted moving average of past growth rates.

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$$\textbf{HGVPD} = 0.970 * HGVPD_{t-1} + 0.0300 * \log(VPD/VPD_{t-1})$$

b.24 HGVPS: Trend growth rate of VPS

Historical observations on the trend growth rate of the optimal capital-output ratio are constructed as an 18-quarter moving average of the actual growth rate. In simulation, the trend is a geometrically weighted moving average of past growth rates.

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HGVPS = $0.970 * HGVPS_{t-1}$
$+ 0.0300 * \log(VPS/VPS_{t-1})$

b.25 EPDN: Investment in equipment, current $

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EPDN = 0.01*PPDR*PXP*EPD

b.26 EPIN: Investment in intellectual property, current $

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EPIN = 0.01*PPIR*PXP*EPI

b.27 EPSN: Investment in nonresidential structures, current $

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EPSN = .01 * PPSR * PXP * EPS

b.28 EIN: Change in business inventories, current $

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EIN = .01*PXP*PKIR*EI

b.29 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.

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TAPSDA = (1-TAPSAD)*(1-EXP(-0.01*(RPD+ZPIB5)*TAPSSL))/
(0.01*(RPD+ZPIB5)*TAPSSL) +
TAPSAD*(1-D69) * 2 *
(1 - (1-EXP(-0.01*(RPD+ZPIB5)*TAPSSL))/
(0.01*(RPD+ZPIB5)*TAPSSL)) / (0.01*(RPD+ZPIB5)*TAPSSL)
+ TAPSAD*(D69-D81) *((1.5 /
(1.5 + .01 * TAPSSL * (RPD + ZPIB5))) *
(1 - exp(-0.5-0.33*(0.01*(RPD+ZPIB5)*TAPSSL))) +
(exp(-0.5)/(0.67*(0.01*(RPD+ZPIB5)*TAPSSL)))*
(exp(-0.33*(0.01*(RPD+ZPIB5)*TAPSSL)) -
exp(-(0.01*(RPD+ZPIB5)*TAPSSL))))
+ TAPSAD * (D81-D86) *((1.75 /
(1.75 + .01 * TAPSSL * (RPD + ZPIB5))) *
(1 - exp(-0.75-0.428*(0.01*(RPD+ZPIB5)*TAPSSL))) +
(exp(-0.75)/(0.572*(0.01*(RPD+ZPIB5)*TAPSSL)))*
(exp(-0.428*(0.01*(RPD+ZPIB5)*TAPSSL)) -
exp(-(0.01*(RPD+ZPIB5)*TAPSSL))))
+ TAPSAD * D86 * (1-EXP(-0.01*(RPD+ZPIB5)*TAPSSL))/
(0.01*(RPD+ZPIB5)*TAPSSL)

b.30 TAPDD: Present value of depreciation allowances for 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.

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TAPDD = .5 * D2003 + .5 * D2003 * (2.0 / (2.0 + .01 * TAPDS * (RPD + ZPIB5)))
+ .3 * D2002 + .7 * D2002 * (2.0 / (2.0 + .01 * TAPDS * (RPD + ZPIB5)))
+ (D87 - D2002 - D2003) * (2.0 / (2.0 + .01 * TAPDS * (RPD + ZPIB5)))
+ (D81-D87) * (1.5 / (1.5 + .01 * TAPDS * (RPD + ZPIB5)))
+ (1-D81)
* (((1-TAPDAD)*(1-exp(-(.01*TAPDS*(RPD+ZPIB5))))
/(.01*TAPDS*(RPD+ZPIB5)))
+ TAPDAD *2*(1-(1-exp(-(.01*TAPDS*(RPD+ZPIB5))))
/(.01*TAPDS*(RPD+ZPIB5)))
/(.01 * TAPDS * (RPD + ZPIB5)))

b.31 EGPDIN: Gross private domestic investment

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EGPDIN = EPDN + EPSN + EPIN + EHN + EIN

b.32 HGVPI: Trend growth rate of VPI

Historical observations on the trend growth rate of the optimal capital-output ratio are constructed as an 18-quarter moving average of the actual growth rate. In simulation, the trend is a geometrically weighted moving average of past growth rates.

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$$\mathbf{HGVPI} = 0.970 * HGVPI_{t-1} + 0.0300 * \log(VPI/VPI_{t-1})$$

Foreign Trade

The core of the foreign trade sector is a pair of error-correction equations for the volumes of exports and nonoil imports. An error-correction equation for domestic crude energy consumption, in conjunction with the exogenous domestic supply of crude energy, determines the volume of oil imports. In addition, the sector contains 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 2009 $

Exports is modeled in an error-correction format. In the long run, the volume of exports depends on foreign real GDP (FGDP) with an elasticity of one and the price of exports relative to foreign prices (PXR*PXP*FPX/FPC) with an elasticity of minus one. A high short-run income elasticity is captured by the positive estimated coefficients on the first difference of the foreign output gap (FXGAP). The effect of large dock strikes in the 1960s and 1970s is removed by dummying out affected quarters.

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$$\Delta(\log(EX)) = 0.812\ [5.12]$$
$$- 0.107\ [-5.03] * \log(EX_{t-1}*(PXR_{t-1}*PXP_{t-1}*FPX_{t-1})/(FGDP_{t-1}*FPC_{t-1}))$$
$$+ 1.39\ [4.99] * (FXGAP - FXGAP_{t-1})/100$$
$$+ 1.09\ [4.04] * (FXGAP_{t-1} - FXGAP_{t-2})/100$$
$$+ 1.01\ [5.12] * DDOCKX$$

Regression statistics

Adjusted R^2:	0.500
S.E. of regression:	0.0173
Sum of squared residuals:	0.0476
Durbin-Watson statistic:	2.14
Sample period:	1973Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

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

c.3 EMO: Imports of goods and services ex. petroleum, cw 2009$

The equation for non-petroleum imports has an error-correction format. In the long run, the volume of imports depends on the level of real domestic absorption with an elasticity of one, the relative price of non-oil imports with an elasticity of minus one, and an exogenous trend. Historical values of the trend (UEMOT) are measured by applying the HP filter to the ratio of nominal imports to nominal absorption. In the short-run, imports respond strongly to the first difference of the output gap. 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).

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$$
\begin{aligned}
\Delta(\log(EMO)) = {} & 0.0170\ [11.83] \\
& - 0.198\ [-6.06] * \log(EMO_{t-1} * (PMO_{t-1}/100)/(UEMOT_{t-1} * XGDEN_{t-1})) \\
& + 1.35\ [4.73] * (XGAP2 - XGAP2_{t-1})/100 \\
& + 1.67\ [6.11] * (XGAP2_{t-1} - XGAP2_{t-2})/100 \\
& + 0.357\ [2.82] * \log(DDOCKM) \\
& + 0.380\ [4.75] * \log(DDOCKM/DDOCKM_{t-1})
\end{aligned}
$$

Regression statistics

Adjusted R^2:	0.680
S.E. of regression:	0.0199
Sum of squared residuals:	0.0756
Durbin-Watson statistic:	1.74
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

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

c.5 CENG: Consumption of crude energy (oil, coal, natural gas), 2009 $

Domestic consumption of crude energy (oil, natural gas, and coal) is modeled in an error-correction format. The long-run level of consumption is proportional to aggregate gross output (XG) and the trend optimal energy-output ratio (VEOA). The short-run dynamics are also affected by the growth rates of lagged energy consumption, actual output, potential output, and the trend optimal energy-output ratio. The coefficients on these growth-rate terms, except for the trend optimal energy-output ratio, are constrained to sum to unity.

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Δ(log(CENG)) =

$$-0.148\ [-3.33] * (\log(CENG_{t-1})-\log(XG_{t-1}*VEOA_{t-1}))$$
$$+ 0.476\ [2.82] * \Delta(\log(XG))$$
$$+ 0.544\ [3.10] * \Delta(\log(XG_{t-1}))$$
$$- 0.230\ [-3.33] * \Delta(\log(CENG_{t-1}))$$
$$+ 0.466\ [3.70] * \Delta(\log(VEOA_{t-1}))$$
$$- 0.255 * HGX_{t-1}/400$$

Regression statistics

Adjusted R^2:	0.220
S.E. of regression:	0.0239
Sum of squared residuals:	0.109
Durbin-Watson statistic:	2.07
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

c.6 EMP: Petroleum imports, cw 2009$

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

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EMP = UEMP*(CENG-XENG)

c.7 EMPN: Petroleum imports, current $

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EMPN = .01*PMP*EMP

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

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

c.9 EM: Imports of goods and services, cw 2009$

The volume of total imports is approximated by the Divisia aggregate of oil and non-oil imports.

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$$\begin{aligned}\mathbf{log(EM)} = {} & \log(EM_{t-1}) \\ & + .5 * (EMON/EMN + EMON_{t-1}/EMN_{t-1}) * \Delta(\log(EMO)) \\ & + .5 * (EMPN/EMN + EMPN_{t-1}/EMN_{t-1}) * \Delta(\log(EMP))\end{aligned}$$

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) and a discrepancy term (FCBRN).

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

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.

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

c.12 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 the sum of the current account balance expressed at a quarterly rate, estimates of capital gains and losses on the gross investment positions due to price and exchange rate changes, and a residual term.

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$$\begin{aligned} \boldsymbol{\Delta}(\textbf{ FNIN}) = {} & .25*FCBN \\ & + .54 * (\Delta(\log(FPC)) * FNICN_{t-1}) \\ & - .32 * (\Delta(\log(PGDP)) * FNILN_{t-1}) \\ & - .67 * (\Delta(\log(FPX)) * FNICN_{t-1}) \\ & + .06 * (\Delta(\log(FPX)) * FNILN_{t-1}) \\ & + FNIRN \end{aligned}$$

c.13 FTCIN: Corporate taxes paid to rest of world, current $

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

c.14 FYNIN: Net investment income received from the rest of the world, current $

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$$FYNIN = FYNICN - FYNILN$$

c.15 HGEMP: Petroleum imports, cw 2009$, trend growth rate

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$$HGEMP = 0.900 * HGEMP_{t-1} + 0.100 * 400*\log(EMP/EMP_{t-1})$$

c.16 FNICN: Gross stock of claims of US residents on the rest of the world, current $

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$$\Delta(FNICN)/XGDPTN = .54 * \Delta(\log(FPC))*FNICN_{t-1}/XGDPTN - .67 * \Delta(\log(FPX))*FNICN_{t-1}/XGDPTN + RFNICT$$

c.17 FNILN: Gross stock of liabilities of US residents to the rest of the world, current $

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$$FNILN = FNICN - FNIN$$

c.18 FYNICN: Gross investment income received from the rest of the world, current $

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$$\textbf{FYNICN} = .01*RFYNIC*FNICN_{t-1}$$

c.19 FYNILN: Gross investment income paid to the rest of the world, current $

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$$\textbf{FYNILN} = .01*RFYNIL*FNILN_{t-1}$$

c.20 RFYNIC: Average yield earned on gross claims of US residents on the rest of the world

The average rate of return on the gross claims of U.S. residents on the rest of the world (RFYNIC) is estimated to converge to a value 180 basis points (100*.255/.144) above the rate of return on the gross claims of the rest of the world on U.S. residents (RFYNIL).

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$$\begin{aligned}\Delta(\textbf{ RFYNIC}) = {} & 0.260\ [3.88] \\ & - 0.147\ [-4.02] * (RFYNIC_{t-1} - RFYNIL_{t-1}) \\ & + 0.148\ [2.36] * \Delta(RFYNIC_{t-1}) \\ & + 0.642\ [9.08] * \Delta(RFYNIL)\end{aligned}$$

Regression statistics

Adjusted R^2:	0.390
S.E. of regression:	0.299
Sum of squared residuals:	15.4
Durbin-Watson statistic:	2.27
Sample period:	1970Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

c.21 RFYNIL: Average yield earned on liabilities of US residents on the rest of the world

The average yield on U.S. liabilities to the rest of the world is modeled in an error correction format. In the long run, this yield is a function of the rates of return on a range of domestic assets. Short-run movements in these rates of return have additional effects on the average yield on U.S. liabilities.

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$$
\begin{aligned}
\Delta(\mathbf{RFYNIL}) = {} & 0.188\ [2.39] \\
& - 0.244\ [-6.09] * RFYNIL_{t-1} \\
& + 0.0790\ [3.61] * RG10_{t-1} \\
& + 0.0888\ [4.64] * RTB_{t-1} \\
& + 0.0406\ [3.77] * REQP_{t-1} \\
& + 0.144\ [2.76] * \Delta(RFYNIL_{t-1}) \\
& + 0.0838\ [1.66] * \Delta(RG10) \\
& + 0.256\ [9.17] * \Delta(RTB) \\
& + 0.00782\ [0.33] * \Delta(REQP)
\end{aligned}
$$

Regression statistics

Adjusted R^2:	0.590
S.E. of regression:	0.217
Sum of squared residuals:	7.89
Durbin-Watson statistic:	2.31
Sample period:	1970Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

c.22 FNIRN: Net stock of claims of US residents on the rest of the world, residual

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

Aggregate Output Identities

Product-side identities

On the product side of the national accounts, Divisia aggregation of the components of real final sales forms aggregate final sales (XFS), and chain aggregation of final sales and inventory investment forms real GDP (XGDP). The Divisia formula is also used to compute real domestic absorption (XGDE) from GDP, exports, and imports. Divisia aggregation of the components of final sales excluding government compensation and imports forms an aggregate (XP) that, in conjunction with its price index, enters the identities that relate labor costs in the nonfarm business sector to prices of the components of final sales.

Some of the channels through which movements in real GDP are transmitted elsewhere in the model go through XGDO, XBO, and XGO, which are estimates respectively of real GDP, real business output, and real business output plus oil imports, each adjusted for measurement error.

Potential GDP, the output gap, and sectoral measures of actual and potential value added

The key production sector in FRB/US is business output plus oil imports. Potential output (XGPOT) of this sector is modeled with a three-factor Cobb-Douglas production function, whose inputs are potential quality-adjusted labor hours, capital services, and trend energy use. Trend multifactor productivity captures a standard Solow residual. XGPOT is linked to potential GDP (XGDPT) through a sequence of identities that can be described most easily in terms of the relationships between various measures of the percentage gap between actual and potential output -- the output gap. First, the level of potential output in the standard definition of the business sector (XBT) must satisfy the condition that this sector's output gap is a weighted average of the output gap in the adjusted business sector (XGAP) and the gap between actual and trend oil imports. Then, the level of potential GDP (XGDPT) must satisfy the condition that the GDP gap (XGAP2) is a constant fraction of the business sector output gap. This specification is based on the observation that the output outside of the business sector has little or no cyclical variation. The non-business sector does not appear explicitly in FRB/US.

The lack of cyclical variation in non-business output also underlies the relationship between the actual levels, adjusted for measurement error, of real GDP (XGDO), business output (XBO), and business output plus oil imports (XGO). Specifically, the elasticities of XBO and XGO with respect to XGDP are the inverse of their average nominal historical ratios to GDP, when potential GDP is held fixed, and 1.0 when actual and potential GDP move together. The level of actual business output plus oil imports (XG) is the Divisia aggregate of XB and oil imports.

Many of the variables that are used to calculate the three measures of potential output (XGPOT, XBT, XGDPT) are modeled as stochastic processes that permit both (log) level and growth rate shocks. As a result, the trend rate of growth of such a variable differs from and is generally smoother than the growth rate of its trend level. Because the same holds true by construction for the three measures of aggregate potential output, FRB/US contains separate variables for each trend level and each trend growth rate: XGPOT and HGX; XBT and HXBT; and XGDPT and HGGDPT.

Historical data for potential output and its determinants

The historical values of some of the key variables that enter the construction of potential output are estimated as latent variables in a reduced-form state-space model that is documented here and whose code and data are available in the FRB/US supply-side package. Among these latent variables are the potential levels of GDP and business sector output, as well as potential business sector employment (LEPPOT), the natural rate of unemployment (LURNAT) and the trend components of the labor-force participation rate (QLFPR) and the workweek (QLWW). The historical values of the measures of real GDP, real business output, and real business output plus oil imports that are adjusted for measurement error (XGDO, XBO, and XGO) also come from the state-space model.

d.1 XFS: Final sales of gross domestic product, cw 2009$

Real final sales of gross domestic product is approximated by the Divisia aggregate of its components.

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$$
\begin{aligned}
\mathbf{\log(XFS)} = {} & \log(XFS_{t-1}) \\
& + .5*((ECNIAN/XFSN + ECNIAN_{t-1}/XFSN_{t-1}) * \Delta(\log(ECNIA)) \\
& + (EHN/XFSN + EHN_{t-1}/XFSN_{t-1}) * \Delta(\log(EH)) \\
& + (EPDN/XFSN + EPDN_{t-1}/XFSN_{t-1}) * \Delta(\log(EPD)) \\
& + (EPSN/XFSN + EPSN_{t-1}/XFSN_{t-1}) * \Delta(\log(EPS)) \\
& + (EPIN/XFSN + EPIN_{t-1}/XFSN_{t-1}) * \Delta(\log(EPI)) \\
& + (EGFON/XFSN + EGFON_{t-1}/XFSN_{t-1}) * \Delta(\log(EGFO)) \\
& + (EGFIN/XFSN + EGFIN_{t-1}/XFSN_{t-1}) * \Delta(\log(EGFI)) \\
& + (EGFLN/XFSN + EGFLN_{t-1}/XFSN_{t-1}) * \Delta(\log(EGFL)) \\
& + (EGSON/XFSN + EGSON_{t-1}/XFSN_{t-1}) * \Delta(\log(EGSO)) \\
& + (EGSIN/XFSN + EGSIN_{t-1}/XFSN_{t-1}) * \Delta(\log(EGSI)) \\
& + (EGSLN/XFSN + EGSLN_{t-1}/XFSN_{t-1}) * \Delta(\log(EGSL)) \\
& + (EXN/XFSN + EXN_{t-1}/XFSN_{t-1}) * \Delta(\log(EX)) \\
& - (EMON/XFSN + EMON_{t-1}/XFSN_{t-1}) * \Delta(\log(EMO)) \\
& - (EMPN/XFSN + EMPN_{t-1}/XFSN_{t-1}) * \Delta(\log(EMP)))
\end{aligned}
$$

d.2 XGDP: GDP, cw 2009$

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

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$$
\begin{aligned}
\mathbf{XGDP} = {} & XGDP_{t-1} * SQRT(\\
& ((XFSN_{t-1}/XGDPN_{t-1}) * (XFS/XFS_{t-1}) \\
& + (.01 * EI_{t-1}*PKIR_{t-1}*PXP_{t-1} / XGDPN_{t-1}) * (EI/EI_{t-1})) \\
& * 1/ \\
& ((XFSN/XGDPN) * (XFS_{t-1}/XFS) \\
& + (.01 * EI*PKIR*PXP / XGDPN) * (EI_{t-1}/EI)))
\end{aligned}
$$

d.3 HGGDP: Growth rate of GDP, cw 2009$ (annual rate)

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$$\textbf{HGGDP} = 400*\Delta(\log(XGDP))$$

d.4 XGDE: Domestic absorption, cw 2009$

Domestic Absorption (or Gross Domestic Expenditure) is approximated by the Divisia aggregate of GDP plus imports less exports.

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$$\begin{aligned}\textbf{log(XGDE)} = {} & \log(XGDE_{t-1}) \\ & + .5*(\,(XGDPN/XGDEN + XGDPN_{t-1}/XGDEN_{t-1}) * \Delta(\log(XGDP)) \\ & - (EXN/XGDEN + EXN_{t-1}/XGDEN_{t-1}) * \Delta(\log(EX)) \\ & + (EMON/XGDEN + EMON_{t-1}/XGDEN_{t-1}) * \Delta(\log(EMO)) \\ & + (EMPN/XGDEN + EMPN_{t-1}/XGDEN_{t-1}) * \Delta(\log(EMP)))\end{aligned}$$

d.5 XGO: Output of business sector plus oil imports, adjusted for measurement error, cw 2009$

The coefficient on XGAP2 is consistent with the observation that value added outside of the business sector has little or no cyclical variation and thus that movements in the gap between actual and potential business output plus oil imports fully account for movements in the GDP gap.

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$$\textbf{log(XGO)} = \log(XGPOT) + 1.31 * XGAP2/100$$

d.6 XBO: Business output, adjusted for measurement error, cw 2009$

The estimated coefficient on XGAP2 is consistent with the observation that value added outside of the business sector has little or no cyclical variation and thus that movements in the business sector output gap fully account for movements in the GDP gap.

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$$\mathbf{log(XBO)} = \log(XBT) + 1.34\ [993.54] * XGAP2/100$$

Regression statistics

Adjusted R^2:	1.000
S.E. of regression:	0.00055
Sum of squared residuals:	5.9e-05
Durbin-Watson statistic:	0.04
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

d.7 XP: Final sales plus imports less government labor, cw 2009$

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

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$$
\begin{aligned}
\mathbf{log(XP)} = {} & \log(XP_{t-1}) \\
& + .5 * (ECNIAN/XPN + ECNIAN_{t-1}/XPN_{t-1}) * \Delta(\log(ECNIA)) \\
& + .5 * (EHN/XPN + EHN_{t-1}/XPN_{t-1}) * \Delta(\log(EH)) \\
& + .5 * (EPDN/XPN + EPDN_{t-1}/XPN_{t-1}) * \Delta(\log(EPD)) \\
& + .5 * (EPIN/XPN + EPIN_{t-1}/XPN_{t-1}) * \Delta(\log(EPI)) \\
& + .5 * (EPSN/XPN + EPSN_{t-1}/XPN_{t-1}) * \Delta(\log(EPS)) \\
& + .5 * (EGFON/XPN + EGFON_{t-1}/XPN_{t-1}) * \Delta(\log(EGFO)) \\
& + .5 * (EGFIN/XPN + EGFIN_{t-1}/XPN_{t-1}) * \Delta(\log(EGFI)) \\
& + .5 * (EGSON/XPN + EGSON_{t-1}/XPN_{t-1}) * \Delta(\log(EGSO)) \\
& + .5 * (EGSIN/XPN + EGSIN_{t-1}/XPN_{t-1}) * \Delta(\log(EGSI)) \\
& + .5 * (EXN/XPN + EXN_{t-1}/XPN_{t-1}) * \Delta(\log(EX))
\end{aligned}
$$

d.8 XB: Business output (BEA definition), cw 2009$

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$$\mathbf{XB} = XBN / (PXB/100)$$

d.9 XG: Output of business sector plus oil imports, cw 2009$

Output of the business sector plus oil imports is an aggregate of business output (XB) and oil imports (EMP). Aggregation is done in growth rates using weights that are the product of a fixed component (the .035 equilibrium energy share in the XGPOT production function) and a time-varying component (the nominal ratio of oil imports to total domestic energy use).

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$$\mathbf{log(XG)} = \log(XG_{t-1})$$
$$+ (1 - .5*(.035*EMPN/(.01*PCENG*CENG) + .035*EMPN_{t-1}/(.01*PCENG_{t-1}*CENG_{t-1}))) * \Delta(\log(XB))$$
$$+ .5*(.035*EMPN/(.01*PCENG*CENG) + .035*EMPN_{t-1}/(.01*PCENG_{t-1}*CENG_{t-1})) * \Delta(\log(EMP))$$

d.10 XGPOT: Potential output of business sector plus oil imports, cw 2009$

Potential output (XGPOT) is this sector 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). 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 an estimate of the average 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.

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$$\textbf{log(XGPOT)} = (0.700 * (\log(LEPPOT) + \log(QLWW) + \log(LQUALT)) + 0.265 * \log(KS) + 0.0350 * \log(VEOA) + \log(MFPT)) / (1-0.0350)$$

d.11 HMFPT: Trend growth rate of multifactor productivity

Trend multi-factor productivity follows a random walk with drift. The drift term, HMFPT, is an AR(1) process. As with all drift terms in FRB/US supply-side stochastic trends, HMFPT is assumed to be mean-reverting at a five percent quarterly rate.

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$$\textbf{HMFPT} = 0.0550 + 0.950 * HMFPT_{t-1}$$

d.12 MFPT: Multifactor productivity, trend level

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

d.13 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.

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

d.14 VEOA: Average energy-output ratio of existing capital stock

The average energy-output ratio has two components. One component moves gradually with the optimal energy-output ratio (VEO) in a pattern consistent with a putty-clay characteristic of capital that makes it difficult or costly to modify the energy intensity of the existing captial stock. The second component (UVEOA) captures movements in trend energy use that are unrelated to relative price changes. Its historical values are calculated by apply the HP filter to the difference between the log of the actual average energy-output ratio -- log(ceng/xg) -- and the first component.

In the first component, the imposed adjustment speed of 1.2 percent per quarter yielded a series for VEOA that provided the best fit for the model's energy (CENG) equation, before it was found necessary to add the UVEOA term. Over the past decade, the average energy-output ratio has been somewhat higher than would be predicted by the first component of the equation alone.

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$$\begin{aligned}\textbf{log(VEOA)} = {} & 0.988 * \log(VEOA_{t-1}) \\ & + 0.0120 * \log(VEO_{t-1}) \\ & + UVEOA\end{aligned}$$

d.15 EMPT: Petroleum imports trend, cw 2009$

The trend component of oil imports is updated in simulations using an imposed error-correction equation that ensures gradual adjustment of the trend to actual imports (EMP). In the historical data, EMPT is obtained by running the HP filter on EMP.

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$$\boldsymbol{\Delta}\textbf{(log(EMPT))} = 0.100 \; [0.00] * \log(EMP_{t-1}/EMPT_{t-1})$$

+ 1.00 [0.00] * HGX/400

d.16 XBT: Potential business output, cw 2009$

The log of the ratio of potential to actual business output is a function of the log of the ratio of potential to actual adjusted business output and the log of the ratio of potential to actual oil imports. The weight on the latter is the product of a fixed component (the .035 equilibrium energy share in the XGPOT production function) and a time-varying component (the nominal ratio of oil imports to total domestic energy use).

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log(XBT) = log(XB) + (log(XGPOT/XG)

- .5 *(.035*EMPN/(.01*PCENG*CENG) + .035*$EMPN_{t-1}$/(.01*$PCENG_{t-1}$*$CENG_{t-1}$)) * log(EMPT/EMP)) /

(1 - .5 *(.035*EMPN/(.01*PCENG*CENG) + .035*$EMPN_{t-1}$/(.01*$PCENG_{t-1}$*$CENG_{t-1}$)))

d.17 XGDPT: Potential GDP, cw 2009$

The difference between the logs of potential GDP and business sector output -- log(UXBT) -- is a stochastic trend that is modeled as a random walk with drift. The drift component follows as AR(1) process.

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log(XGDPT) = log(XBT) + log(UXBT)

d.18 UXBT: Stochastic component of trend ratio of XGDPT to XBT

The trend component of potential GDP is a random walk with drift. The drift component (HUXB) follows an AR(1) process.

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log(UXBT) = $0.00 + \log(UXBT_{t-1}) + .0025*HUXB$

d.19 HUXB: Drift term in UXBT

The stochastic trend component of potential GDP, UXBT, follows a random walk with drift. The drift term, HUXB, is an AR(1) process. As with all drift terms in FRB/US supply-side stochastic trends, HUXB is assumed to be mean-reverting at a five percent quarterly rate. In long-run simulations, the dummy variable DGLPRD can be set to 1.0 to ensure that potential GDP and potential business sector output grow at the same rate.

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HUXB = $(1-DGLPRD) *(-0.0182$ [-886.28] $+ 0.950 *HUXB_{t-1})$

Regression statistics

Adjusted R^2:	1.000
S.E. of regression:	0.000284
Sum of squared residuals:	1.54e-05
Durbin-Watson statistic:	0.07
Sample period:	1966Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

d.20 XGAP: Output gap for business plus oil imports (100*log(actual/potential)

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XGAP = $100*\log(XGO/XGPOT)$

d.21 XGAP2: Output gap for GDP (100*log(actual/potential)

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XGAP2 = 100 * log(XGDO/XGDPT)

d.22 HGX: Trend growth rate of XG, cw 2009$ (annual rate)

Some of the components of potential output are modeled as stochastic trends with stochastic drift terms. Because both log level shocks and growth rate shocks occur in this framework, the trend rate of growth of such a component differs from the growth rate of its trend level. The trend rate of growth of nonfarm business output plus oil imports is calculated using the distinct trend rates of growth, rather than on the growth rate of trends, of multifactor productivity (HMFPT) and those factor inputs that have trend growth rates (HLEPT, HQLWW). The imposed coefficients are the same as those in the production function for the level of XGPOT. The trend growth rate of adjusted business sector output (HGX) is smoother than the growth rate of the level of potential adjusted business sector output (400*del(log(XGX))).

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HGX = (.7*(HLEPT + HQLWW + 400*Δ(log(LQUALT))) + .265*HKS
+ .035*400*Δ(log(VEOA)) + HMFPT)/.965

d.23 HXBT: Trend rate of growth of XB , cw 2009$ (annual rate)

The trend rate of growth of business output is a function of the trend rate of growth of adjusted business output (HGX) and the rate of growth of trend oil imports. The weight on the latter is the product of a fixed component (the .035 equilibrium energy share in the XGPOT production function) and a time-varying component (the nominal ratio of oil imports to total domestic energy use). Because FRB/US permits some of the components of potential output to have separate log level and growth rate shocks, the trend growth rate of HXBT is different (and smoother) than the growth rate of the level of potential business output (400*del(log(XBT))).

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$$\textbf{HXBT} = (HGX - .5 *(.035*EMPN/(.01*PCENG*CENG) + .035*EMPN_{t-1}/(.01*PCENG_{t-1}*CENG_{t-1})) * 400*\Delta(\log(EMPT))) / (1 - .5 *(.035*EMPN/(.01*PCENG*CENG) + .035*EMPN_{t-1}/(.01*PCENG_{t-1}*CENG_{t-1})))$$

d.24 HGGDPT: Trend growth rate of XGDP, cw 2009$ (annual rate)

The trend growth rate of GDP is the sum of the trend growth rates of business output and the stochastic trend component of potential GDP. Because FRB/US permits separate log level and growth rate shocks, the trend growth rate of GDP (HGGDPT) is different (and smoother) than the growth rate of potential GDP (400*del(log(XGDPT)).

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$$\textbf{HGGDPT} = HXBT + HUXB$$

d.25 XGDPTN: Potential GDP, current $

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$$\textbf{XGDPTN} = .01*PGDP*XGDPT$$

d.26 XENG: Crude energy production, cw 2009$

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

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XENG = UXENG * XGPOT

d.27 XGDI: Gross domestic income, cw 2009$

Gross domestic income is modeled with an identity as the product of gross domestic product adjusted for measurement error (XGDO) and a discrepancy factor (MEI) whose logarithm follows an AR(1) process.

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XGDI = XGDO*MEI

d.28 XGDO: Gross domestic product, adjusted for measurement error, cw 2009$

XGDO is real GDP adjusted for measurement error. In simulation XGDO equals the ratio of real gross domestic product (XGDP) to a discrepancy factor (MEP) whose logarithm follows an AR(1) process. The historical values of XGDO are estimated as latent variables in the reduced-form state-space model documented here.

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XGDO = XGDP/MEP

Labor Market

This sector contains equations for a variety of labor market variables, including hours worked, private employment in the nonfarm business sector, household employment, labor force participation, and the unemployment rate.

A central equation in the sector is the one for total hours, which is modeled using the polynomial adjustment cost (PAC) framework. Over time, hours error-corrects to an 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).

Another key equation is the one for the employment discrepancy (LEO), whose variation around a trend is estimated to be procyclical. An identity determines the unemployment rate.

The historical values of some of the variables in this sector are estimated as latent variables in a reduced-form state-space model that is documented here and whose code and data are available in the FRB/US supply-side package. Among these latent variables are the natural rate of unemployment (LURNAT) and the trend levels and drift terms for the labor-force participation rate (QLFPR, HQLFPR) and the workweek (QLWW, HQLWW).

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

Firms attempt to keep aggregate hours in line with the expected level of production adjusted for the trend level of labor productivity. This definition of the target level of hours is embedded in a version of the polynomial adjustment cost framework that is modified to allow some portion of labor hours to adjust 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. The structure of the PAC component of the equation is outlined below in Note 1. To translate the general PAC specification into the form in which it appears in the LHP equation, associate log(LHP) with y, log(QLHP) - Δ log(MFPT) with y*, and ZLHP with the expected weighted sum of future Δy*. The order of adjustment costs (m) is 2.

The portion of hours that adjusts costlessly is captured by the current growth in target hours (the growth rate of XG less the trend growth rate of output per hour, HLPRDT). The coefficient on the latter indicates that more than 40 percent of hours adjust costlessly and a bit less than 60 percent of hours adjust according to the PAC specification. The aggregation of slow-adjusting and fast-adjusting hours is outlined below in Note 2.

Note 1: PAC Overview: Let y denote the decision variable and y* its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

$$\Delta y_t^{pac} = a_0(y^*_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i \Delta y_{t-i} + E_{t-1}\sum_{i=0,\infty} d_i \Delta y^*_{t+i}$$

The order of adjustment costs is given by parameter m. The forward weights, d_i {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see PAC Basics.

Note 2: To describe the aggregation of slow-adjusting PAC hours and fast-adjusting hours, let h and q be the logs of total hours and target hours, and z be the weighted sum of expected growth of target hours. Subscripts denote slow-adjusting ("1") and fast-adjusting ("2") components. Assume the shares of the two types of hours are approximately constant. Write

$$\Delta h_t = c^*\Delta h_{1t} + (1-c)^*\Delta h_{2t}$$
$$\Delta h_{1t} = a_0(q_1-h_1)_{t-1} + a_1^*\Delta h_{1,t-1} + zh_{1t}$$
$$\Delta h_{2t} = \Delta q_{2t} = \Delta q_t$$

By assumption, the total hours gap (q-h) is concentrated in the slow adjusting hours, which leads to the final equation in the following steps

$$(q_{1t}-h_{1t}) = (q_t-h_t)/c$$
$$\Delta h_{1t} = (\Delta h_t - (1-c)^*\Delta q_t)/c$$
$$\Delta h_{1t} = a_0^*(q-h)_{t-1}/c + a_1^*(\Delta h_{t-1} - (1-c)\Delta q_{t-1})/c + zh_{1t}$$
$$\Delta h_t = a_0^*(q-h)_{t-1} + a_1^*\Delta h_{t-1} + c^*zh_t + (1-c)^*\Delta q_t + a_1^*(1-c)^*\Delta q_{t-1}$$

The final form of the equation assumes $zh = zh_1$.

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Δ(log(LHP)) =

0.255 [8.42] $* (\log(QLHP_{t-1}/LHP_{t-1}) - \Delta(\log(MFPT))/.965)$
$+ 0.149$ [2.52] $* \Delta(\log(LHP_{t-1}))$
$+ 0.390$ [11.09] $* ZLHP$
$+ 0.610 * (\Delta(\log(XGO)) - HLPRDT_{t-1}/400 - \Delta(HMFPT)/(.965*400))$
$- 0.0909 * (\Delta(\log(XGO_{t-1})) - HLPRDT_{t-2}/400 - \Delta(HMFPT_{t-1})/(.965*400))$

Regression statistics

Adjusted R^2:	0.830
S.E. of regression:	0.00342
Sum of squared residuals:	0.00226
Durbin-Watson statistic:	1.91
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Iterative Least Squares

e.2 QLHP: Desired level of business labor hours

The desired level of aggregate hours equals adjusted business sector output (XG) divided by trend labor productivity (LPRDT).

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$$QLHP = XGO/LPRDT$$

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

In the long run, the workweek grows as its trend rate (HQLWW). In the short run, the workweek error corrects at nearly a 20 percent rate to the lagged deviation of its level from its trend level (QLWW). QLWW is modeled as a random walk with drift. About 30 percent of the contemporaneous deviation of the rate of growth of total hours from its trend shows up as a change in the workweek (and thus about 70 percent shows up as a change in employment).

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$$\Delta(\log(LWW)) = HQLWW/400 + 0.198\ [9.32] * \log(QLWW_{t-1}/LWW_{t-1}) + 0.313\ [18.17] * (\Delta(\log(LHP)) - (HLEPT + HQLWW)/400)$$

Regression statistics

Adjusted R^2:	0.650
S.E. of regression:	0.00194
Sum of squared residuals:	0.000752
Durbin-Watson statistic:	1.88
Sample period:	1963Q3 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

The trend workweek is a random walk with drift.

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$$\log(QLWW) = \log(QLWW_{t-1}) + HQLWW_{t-1}/400$$

e.5 HQLWW: Trend growth rate of workweek

The trend growth rate of the workweek follows an AR(1) process. As with all drift terms in FRB/US supply-side stochastic trends, HQLWW is assumed to be mean-reverting at a five percent quarterly rate.

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$$HQLWW = 0.950 * HQLWW_{t-1} + (1-0.950) * -0.313\ [2.43]$$

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

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

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LEP = LHP / LWW

e.7 LEO: Difference between household and business sector payroll employment, less gov't emp.

LEO error corrects to the discrepancy between its lagged and desired values and also varies counter-cyclically. The desired value of LEO is the product of a desired ratio (QLEOR) and the equilibrium labor force. QLEOR is measured historically as the value of LEO that is consistent with equilibrium values of the labor force, employment in various sectors, and the unemployment rate. In simulation, QLEOR is exogenous.

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$$\mathbf{log(LEO) =} \log(QLEOR * QLF) + 0.700\ [12.66] * \log(LEO_{t-1}/(QLEOR_{t-1} * QLF_{t-1})) - 0.0162\ [-5.01] * XGAP2_{t-1}$$

Regression statistics

Adjusted R^2:	0.970
S.E. of regression:	0.0636
Sum of squared residuals:	0.444
Durbin-Watson statistic:	2.00
Sample period:	1986Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

The ratio of federal employment to constant-dollar federal government expenditures on employee compensation (EGFL) depends on the exogeous proportionality factor ULEF and an adjustment 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. The equation is written in first differences so that the productivity adjustment enters as a growth rate rather than as a level. The appropriate value of the latter would be difficult to estimate.

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

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

The ratio of state and local employment to constant-dollar S&L government expenditures on employee compensation (EGSL) depends on the exogeous proportionality factor ULES and an adjustment 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. The equation is written in first differences so that the productivity adjustment enters as a growth rate rather than as a level. The appropriate value of the latter would be difficult to estimate.

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

e.10 LEH: Civilian employment (break adjusted)

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

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$$\mathbf{LEH} = LEP + LEO + LES + LEF$$

e.11 LFPR: Labor force participation rate

In the long run, the participation rate moves at its trend first difference (HQLFPR). In the short run, the participation rate error corrects at a 45 percent rate to the lagged deviation of its level from its trend level (QLFPR). QLFPR is modeled as a random walk with time-varying drift. Cyclical variation in the participation rate is captured by including the gap between the unemployment rate and its natural rate (LURNAT), which is lagged to avoid coefficient bias that might arise from measurement error that is common to LUR and LFPR.

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$$\Delta(\mathbf{LFPR}) = HQLFPR$$
$$+ 0.558\ [9.62] * (QLFPR_{t-1} - LFPR_{t-1})$$
$$- 0.000876 [-8.86] * (LUR_{t-1} - LURNAT_{t-1})$$

Regression statistics

Adjusted R^2:	0.320
S.E. of regression:	0.00125
Sum of squared residuals:	0.000313
Durbin-Watson statistic:	1.91
Sample period:	1963Q3 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

e.12 QLFPR: Trend labor force participation rate

The trend participation rate follows a random walk with time-varying drift.

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QLFPR = $QLFPR_{t-1}$ + HQLFPR

e.13 HQLFPR: Drift component of change in QLFPR

The trend first difference of the workweek follows an AR(1) process. HQLFPR is assumed to revert to a mean of zero at a five percent quarterly rate.

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HQLFPR = $0.00 + 0.950 * HQLFPR_{t-1}$

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

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LF = LFPR * N16

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

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LUR = 100*(1 - LEH/LF)

e.16 LURBLS: Civilian unemployment rate (published)

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LURBLS = LUR

e.17 QLEP: Desired level of business employment

The desired level of business employment equals aggregate business hours divided by the trend workweek.

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QLEP = LHP / QLWW

e.18 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.

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QLF = QLFPR * N16

e.19 LEFT: Federal civilian employment ex. gov. enterprise, trend

Trend employment in the federal government sector gradually adjusts toward actual federal employment. The adjustment dynamics make trend employment each quarter a weighted average of trend federal employment in the prior quarter, adjusted for the trend change in the labor force, and contemporaneous actual federal employment.

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$$\textbf{LEFT} = 0.900\ [0.00] * LEFT_{t-1} * (HQLFPR + N16/N16_{t-1}) + 0.100\ [0.00] * LEF$$

e.20 LEST: S&L government employment ex. gov. enterprise, trend

Trend employment of state and local governments gradually adjusts toward actual S&L employment. The adjustment dynamics make trend employment each quarter a weighted average of trend employment in the prior quarter, adjusted for the trend change in the labor force, and contemporaneous actual employment.

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$$\textbf{LEST} = 0.900 \, [0.00] * LEST_{t-1} * (HQLFPR + N16/N16_{t-1}) + 0.100 \, [0.00] * LES$$

e.21 LEPPOT: Potential employment in business sector

The trend level of employment in the 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 business consists of trend government employment (LEST + LEFT) and trend "other" employment (QLEOR * QLF).

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$$\textbf{LEPPOT} = QLF*(1-.01*LURNAT - QLEOR) - LEFT - LEST$$

e.22 HLEPT: Trend growth rate of LEP (annual rate)

The trend rate of growth of employment in the business sector (HLEPT) equals the weighted sum of trend growth rates of the components of LEPPOT. The weighted sum is constructed by calculating ΔLEPPOT/LEPPOT and replacing ΔQLF in the resulting expression with its trend: HQLFPR*N16 + QLFPR*&\Delta;N16. In the calculation, LURNAT and QLEOR are assumed to be random walks.

The dummmy variable DMPSTB is sometimes set equal to one when the model is used to run stochastic simulations. This makes HLEPT equal to the growth rate of population, a simplification that improves the long-run stability of the model.

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$$\begin{aligned}\textbf{HLEPT} = {} & (1-\text{DMPSTB}) * 400 * \\ & (\text{HQLFPR} * \text{N16} * (1-.01*\text{LURNAT}-\text{QLEOR}) \\ & + \Delta(\text{N16}) * \text{QLFPR} * (1-.01*\text{LURNAT}-\text{QLEOR}) \\ & - \Delta(\text{LEFT}) \\ & - \Delta(\text{LEST})\ ) \\ & / \Sigma_{i=0,1}(\text{LEPPOT}_{t-i})/2 \\ & + \text{DMPSTB} * 400 * \Delta(\log(\text{N16}))\end{aligned}$$

e.23 LPRDT: Trend labor productivity

Trend labor productivity in the adjusted 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).

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

e.24 HLPRDT: Trend growth rate of output per hour

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

e.25 LURNAT: Natural rate of unemployment

The natural rate of unemployment follows a random walk with zero drift.

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$$\mathbf{LURNAT} = LURNAT_{t-1}$$

Nominal Income

Many of the equations in this sector are accounting identities for measures of nominal income, output, and product. Some of the identities make use 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.

The sector also contains equations for the measures of after-tax household income and its primary components -- labor, transfer, and property -- that are 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. (An inflation adjustment to interest earned on corporate debt is not necessary, since an offsetting adjustment would need to be made to the definition of corporate profits.)

The sector contains estimated equations for dividends, consumer interest payments to business, the net interest and rental income component of national income, and the net financial debt of nonfinancial corporations.

f.1 XPN: Final sales plus imports less government labor, current $

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XPN = .01 * PXP * XP

f.2 XGDPN: GDP, current $

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XGDPN = XPN + EIN - EMN + EGFLN + EGSLN

f.3 XFSN: Final sales of gross domestic product, current $

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XFSN = XGDPN - EIN

f.4 XGDEN: Nominal Absorption, current $

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XGDEN = XGDPN + EMN - EXN

f.5 XBN: Business output (BEA definition), current $

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XBN = PXB/100*XBO + XGDPN -XGDO*PGDP/100

f.6 XGN: Output of business sector plus oil imports, current $

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XGN = XBN + EMPN

f.7 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.

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

f.8 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, JRPD), real business capital stocks (KH, KPS, KPD), and the prices of new investment or capital goods (the relative prices PHR, PPSR, PKPDR, multiplied by PXP). Because investment prices are used in place of capital prices in two of the three instances, an exogenous conversion factor (UJCCA) is used to make the equation an identity.

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$$\mathbf{JCCAN} = JYGFGN + JYGFEN + JYGSGN + JYGSEN + .01*UJCCA*PXP_{t-1} * (PHR_{t-1}*KH_{t-1}*JRH + PPSR_{t-1}*KPS_{t-1}*JRPS + PKPDR_{t-1}*KPD_{t-1}*JRPD)$$

f.9 JYGFEN: CFC, federal government enterprises, current $

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JYGFEN = UJYGFE * (.01 * PGDP * XGDPT)

f.10 JYGFGN: CFC, federal government, general, current $

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JYGFGN = UJYGFG * (.01 * PGDP * XGDPT)

f.11 JYGSEN: CFC, state and local government enterprises, current $

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JYGSEN = UJYGSE * (.01 * PGDP * XGDPT)

f.12 JYGSGN: CFC, state and local government, general, current $

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JYGSGN = UJYGSG * (.01 * PGDP * XGDPT)

f.13 JYNCN: Noncorporate business CFC, current $

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JYNCN = JCCAN - JCCACN - JYGFGN - JYGFEN - JYGSGN - JYGSEN

f.14 YNIN: National income

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.

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YNIN = UYNI*(XGDIN+FYNIN-JCCAN)

f.15 YNILN: Labor income (national income 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.

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YNILN = 0.01 * UYL * (PL*LHP + PGFL*EGFL + PGSL*EGSL)

f.16 YNISEN: Proppprietors' income (national income component)

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

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YNISEN = UYSEN*XBN

f.17 YNIIN: Net interest and rental income (national income component)

The share of net interest and rental income in non-labor national income varies with the level of nominal interest rates and with the ratios of various assets and liabilities to non-labor national income.

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YNIIN/(YNIN(-1)-YNILN(-1)) = 0.0134 [3.60]

$+ 0.872$ [22.64] $* (YNIIN_{t-1}/(YNIN_{t-2}-YNILN_{t-2}))$

$+ 0.0311$ [1.99] $* (.01*RRMET*.01*PHR_{t-1}*PXP_{t-1}*KH_{t-1}/(YNIN_{t-1}-YNILN_{t-1}))$

$+ 0.128 * ((.01*RBBBE)*(WDNFCN_{t-1}/(YNIN_{t-1}-YNILN_{t-1})))$

$+ 0.477$ [6.17] $* (.01*\Delta(RBBBE*(WDNFCN_{t-1}/(YNIN_{t-1}-YNILN_{t-1}))))$

$+ 0.328$ [1.71] $* (.01*FNIN_{t-1}/(YNIN_{t-1}-YNILN_{t-1}))$

Regression statistics

Adjusted R^2:	0.980
S.E. of regression:	0.00627
Sum of squared residuals:	0.00594
Durbin-Watson statistic:	1.71
Sample period:	1975Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

f.18 QYNIDN: Desired level of dividends

The desired level of dividends is a constant fraction of after-tax corporate profits, with a shift in the desired fraction 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. A max function is used to prevent simulation problems arising from attempts to take the log of a negative number.

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log(QYNIDN) = -0.989 [-45.53]
+ 0.361 [13.90]*D79A
+ 1.00 *log(max(YNICPN-TFCIN-TSCIN,.01))

Regression statistics

Adjusted R^2:	0.500
S.E. of regression:	0.167
Sum of squared residuals:	5.37
Durbin-Watson statistic:	0.19
Sample period:	1965Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

f.19 YNIDN: Dividends (national income component)

Dividends are modeled using the polynomial adjustment cost (PAC) 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 growth of desired dividents. To translate the general PAC specification, whose structure is shown below in the PAC Overview section, associate log((YNIDN-YMSDN)/PXB) with y, log(QYNIDN/PXB) with y*, and ZYNID with the expected weighted sum of future Δy*. The order of adjustment costs (m) is 2. The equation adjusts dividends for the one-time Microsoft cash payout of late 2004 (YMSDN).

PAC Overview: Let y denote the decision variable and y* its desired level in the absence of adjustment frictions. The decision rule derived from the PAC Euler equation has the following form.

(1) $\Delta y_t = a_0(y^*_{t-1} - y_{t-1}) + \sum_{i=1,m-1} a_i \Delta y_{t-i} + E_{t-1}\sum_{i=0,\infty} d_i \Delta y^*_{t+i}$

The order of adjustment costs is given by parameter m. The forward weights, d_i {i=0,∞}, are functions of the estimated values of a_i {i=0,m-1} and a fixed discount factor (0.98). Estimation imposes the growth neutrality restriction $\sum_{i=1,m-1} a_i + \sum_{i=0,\infty} d_i = 1$. For more information, see PAC Basics.

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Δ(log((YNIDN-YMSDN)/PXB)) =

0.0904 [4.77] $* \log(QYNIDN_{t-1}/(YNIDN_{t-1}-YMSDN_{t-1}))$
$- 0.136$ [-1.92] $* \Delta(\log((YNIDN_{t-1}-YMSDN_{t-1})/PXB_{t-1}))$
$+ 1.00 * ZYNID$

Regression statistics

Adjusted R^2:	0.030
S.E. of regression:	0.0438
Sum of squared residuals:	0.37
Durbin-Watson statistic:	1.77
Sample period:	1965Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

f.20 YNICPN: Corporate profits (national income component)

Corporate profits (YNICPN) are the residual component of national income (YNIN - YNILN - YNIIN - YNISEN). To mitigate numerical problems in simulations, the max function places a positive lower bound on profits.

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YNICPN = UYNICP * max(YNIN-YNILN-YNIIN-YNISEN-TFIBN-TSIBN+GFSUBN+GSSUBN,TFCIN+TSCIN+.01*XGDPN)

f.21 YPN: Personal income

The exogenous conversion factor (UYP) used in the personal income identity reflects the ommission 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.

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YPN = UYP * (YHLN + YHTN + YHPTN)

f.22 YDN: Disposable income

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YDN = UYD * (YPN - TFPN - TSPN)

f.23 RSPNIA: Personal saving rate

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RSPNIA = 100 * YHSN / YDN

f.24 YCSN: Net corporate cash flow with IVA and CCA

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YCSN = YNICPN - TFCIN - TSCIN - FTCIN - YNIDN + JCCACN

f.25 YKIN: Income from stock of inventories

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YKIN = $.01 * RTINV * PXB * \Sigma_{i=0,1}(KI_{t-i})/2)$

f.26 YKPDN: Income from stock of equipment

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YKPDN = $.01 * RTPD * PXB * \Sigma_{i=0,1}(KPD_{t-i})/2)$

f.27 YKPSN: Income from stock of nonresidential structures

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YKPSN = $.01 * RTPS * PXB * \Sigma_{i=0,1}(KPS_{t-i})/2)$

f.28 YH: Income, household, total (real after-tax)

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YH = YHL + YHT + YHP

f.29 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).

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$$\textbf{YHGAP} = 100*(YHSHR/ZYHST-1)$$

f.30 YHIBN: Consumer interest payments to business

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$$
\begin{aligned}
\Delta(\log(\textbf{YHIBN})) = {} & 1.00 * \Sigma_{i=0,3}(PICXFE_{\ t-i}/1600)/4 \\
& - 0.134\ [-2.30] \\
& + 0.0655\ [3.68] * \log(ECNIAN_{t-1}/YHIBN_{t-1}) \\
& + 0.294\ [4.54] * (\Delta(\log(YHIBN_{t-1})) - \Sigma_{i=0,3}(PICXFE_{\ t-i-1}/1600)/4) \\
& + 0.0236\ [3.18] * D79A \\
& + 0.00250\ [4.04] * RCAR_{t-1} \\
& + 0.0664\ [2.74] * \log(.01*PCDR_{t-1}*PCNIA_{t-1}*ECD_{t-1}/ECNIAN_{t-1}) \\
& + 0.00538\ [4.01] * \Delta(RFFE)
\end{aligned}
$$

Regression statistics

Adjusted R^2:	0.390
S.E. of regression:	0.0189
Sum of squared residuals:	0.0675
Durbin-Watson statistic:	2.02
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

f.31 YHIN: Income, household, net interest and rent

The exogenous conversion factor (UYHI) used in the household interest and rental income identity corrects for the deduction, in the FRB/US measure of GSINTN, of dividends received by state and local governments.

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

f.32 YHL: Income, household, labor compensation (real after-tax)

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YHL = (1-TRYH)*YHLN/(.01*PCNIA)

f.33 YHLN: Income, household, labor compensation

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YHLN = UYHLN * (YNILN - TFSIN - TSSIN)

f.34 YHP: Income, household, property (real after-tax)

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YHP = ((1-TRYH)*YHPTN+YHPNTN)/(.01*PCNIA)

f.35 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).

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YHPGAP = 100*(YHPSHR/ZYHPST-1)

f.36 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.

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YHPNTN = .01*PCNIA*PCDR*YHPCD
- YHIBN + YNICPN - TFCIN - TSCIN - YNIDN
- .01 * ZPI10 *(GFDBTN+GSDBTN)

f.37 YHPSHR: Income, household, property, ratio to YH (real after-tax)

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YHPSHR = YHP/YH

f.38 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.

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YHPTN = UYHPTN*(YNISEN+YHIN+YNIDN)

f.39 YHSHR: Income, household, total, ratio to XGDP (real after-tax)

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YHSHR = YH/XGDP

f.40 YHSN: Personal saving

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YHSN = YHLN + YHTN + YHPTN - TFPN - TSPN - ECNIAN - YHIBN
+ UYHSN * XGDPTN

f.41 YHT: Income, household, transfer (real after-tax), net basis

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YHT = YHTN/(.01*PCNIA)

f.42 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).

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YHTGAP = 100*(YHTSHR/ZYHTST-1)

f.43 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.

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$$\textbf{YHTN} = UYHTN*(GFTN+GSTN)$$

f.44 YHTSHR: Income, household, transfer, ratio to YH (real after-tax)

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$$\textbf{YHTSHR} = YHT/YH$$

f.45 WDNFCN: Net financial liabilities, nonfinancial nonfarm corporations

Net financial liabilities are modeled using an error-correction format in which the equilibrium ratio of liabilities to non-labor national income is procyclical.

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$$\begin{aligned}\boldsymbol{\Delta(\log(WDNFCN))} = & -0.0221 \text{ [-2.46]} * \log(WDNFCN_{t-1}/(YNIN_{t-1}-YNILN_{t-1})) \\ & + 0.0144 \text{ [6.04]} \\ & + 0.238 \text{ [3.01]} * \Delta(\log(WDNFCN_{t-1})) \\ & + 0.0969 \text{ [1.26]} * \Delta(\log(WDNFCN_{t-2})) \\ & + 0.00167 \text{ [2.74]} * XGAP2\end{aligned}$$

Regression statistics

Adjusted R^2:	0.260
S.E. of regression:	0.0167
Sum of squared residuals:	0.0421
Durbin-Watson statistic:	2.01
Sample period:	1975Q1 2013Q4

Estimation date:	August 2014
Estimation method:	Least Squares

f.46 XGDIN: Gross domestic income, current $

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XGDIN = XGDI *(PGDP/100)

Wages and Prices

Main Equations

At the center of price-wage sector is a pair of equations for core PCE price inflation (PICXFE) and the rate of change of the ECI measure of hourly compensation (PIECI). The equations are estimated simultaneously. The form of each equation is based on a variant of the New Keynesian Phillips Curve (NKPC) derived by Cogley and Sbordonne (2008) for the case in which the subset of prices or wages that is not optimally reset each period is indexed to either past or trend inflation.

(1) $\Pi_t = E_{t-1}[\Pi_{t+1} + \kappa\mu_t] + \varepsilon_t$

(2) $\Pi_t \equiv \pi_t - \gamma\pi\hat{}_t - (1-\gamma)\pi^*_t$

(3) $\pi\hat{}_t \equiv \sum(i=1,n)\pi_{t-i} /n$

Equation 1 is the basic NKPC expressed in terms of the composite variable Π, which is defined in equation 2 as the difference between actual price or wage inflation (π) and a weighted average of past (π^) and trend (π*) price or wage inflation.

Expectations are formed on the basis of "t-1" information, β(=.98) is the discount factor, and μ is the markup gap.

Past inflation (equation 3) is measured using a single lag (n=1) in the price NKPC and a four-quarter average (n=4) in the wage NKPC. For prices, trend inflation is measured using survey data on expectations of ten-year consumer price inflation (PTR). Trend wage inflation equals the sum of trend price inflation and the trend rate of increase of labor productivity, less an estimate of the trend rate of change of the relative price of consumption.

The detrended level of the log labor share in the nonfarm business sector is a key part of both the price and wage markup gaps. The consumption price markup gap is approximately equal to a weighted average of the detrended labor share, the relative price of nonoil imports, and a few additional but minor terms, all measured in logs. The wage markup gap -- in theory, the difference between the marginal rate of substitution and the real wage -- is expressed as a function of the detrended labor share and the unemployment gap (LUR-LURNAT). This structural dependence of wage inflation on the unemployment gap leads to a dependence of price inflation on the unemployment gap through expected price inflation.

The structure of the PICXFE and PIECI equations, along with various related equations and identities, ensures that the sector has a long-run equilibrium in which the labor share of income is constant (given by the inverse of PWSTAR). Historically, PWSTAR has a trend that is estimated using a one-sided variant of the HP filter. The long-run equilibrium conditions associated with a given value of PWSTAR are embedded in the definitions of a set of desired or target price and wage levels: QPXG, QPL, QPXP, and QPCNIA. UQPCT, which is the trend in the ratio of the price of consumption (PCNIA) to the price of final sales (PXP), also enters this structure. In a long-run equilibrium, actual inflation will equal trend inflation, where the latter is usually specified to converge to the rate of inflation desired by policymakers.

More information on the estimation of the price-wage NKPC equations is available here.

Price Disaggregation

The prices of most non-consumption components of GDP are determined in two stages. The first stage consists of the equation for PIPXNC, which is the rate of price inflation for an aggregate of business fixed investment, residential investment, non-labor government purchases, and exports. The main determinant of PIPXNC is the rate of growth of consumption prices including food and energy (PICNIA), adjusted for an estimate of the trend in PIPXNC-PICNIA. In the second stage, PIPXNC is disaggregated into nine component prices using a set of equations of the form,

(4) $\Delta\log(P_i/PXP) = C_i + \Delta\log(PXNC/PXP) + DPADJ$

where P_i is a component price, PXNC is the price level associated with PIPXNC, and DPADJ is a correction factor that accounts for the fact that the set of equations given by (4) yields an inexact decomposition of PNXC each quarter. The equation also includes the aggregate consumption and non-consumption price, PXP, as a scaling variable and a constant. The coded equation for each P_i sets the constant to zero, but in most simulation applications the equivalent of a non-zero intercept is included via an add factor whose value is based on that equation's average historical error. The prices determined in this system are PHR, PPDR, PPIR, PPSR, PGFOR, PGFIR, PGSOR, PGSIR, and PXR.

Other Prices

The fundamental energy price is the average per barrel price of imported oil, POIL. It is closely linked to the price index for imported oil, PMP, and is the key determinant of the price of domestic energy production, PCENG, which in turn drives the price of personal consumption expenditures on energy, PCER.

The price index for nonoil imports, PMO, depends on a weighted average of the exchange-rate adjusted foreign CPI and the price index for nonfarm business output.

The rest of the sector consists of a large number of identities for such variables as the GDP price index (PGDP).

g.1 PICXFE: Inflation rate, personal consumption expenditures, ex. food and energy, cw

This is the main price equation in FRB/US. Its specification is based on a variant of the New Keynesian Phillips Curve (NKPC) derived by Cogley and Sbordonne (2008) for the case in which the subset of prices that is not optimally reset each period is indexed to either past or trend price inflation.

(1) $\Pi_t = E_{t-1}[\beta\Pi_{t+1} + \kappa\mu_t] + \varepsilon_t$

(2) $\Pi_t \equiv \pi_t - \gamma\pi\hat{}_t - (1-\gamma)\pi^*_t$

(3) $\pi\hat{}_t \equiv \pi_{t-1}$

Equation 1 is the basic NKPC expressed in terms of the composite variable Π, which is defined in equation 2 as the difference between actual inflation (π) and a weighted average of past (π^) and trend (π*) inflation. Expectations are formed on the basis of "t-1" information, β(=.98) is the discount factor, and μ is the price markup gap.

Past inflation is measured as the first lag (equation 3). Trend price inflation is measured using survey data on ten-year inflation expectations (PTR). The price markup gap (log(QPCNIA/PCNIA)) is measured using a set of relationships that, if linearized, would set it equal to a weighted average of the detrended labor share in the nonfarm business sector, the relative price of nonoil imports, and a few additional but minor terms. For purposes of simplicity, the markup gap enters as a t-1 observation rather than the t-1 expectation of the observation in period t.

The unemployment rate does not directly appear in the structural price equation. The sensitivity of price inflation to the unemployment rate is indirect and operates through the effect that the structural dependence of wage inflation (PIECI) on labor market conditions has on the expectation of PICXFE in period t+1 (ZPICXFE).

The PICXFE equation, which is estimated simultaneously with the equation for the rate of growth of the ECI measure of hourly compensation (PIECI), contains two estimated parameters. γ (=.615) is the fraction of non-optimized prices that is indexed to past inflation, and κ (=.00231) is the response of inflation to the price markup gap.

More information on the estimation of the price-wage NKPC equations is available here.

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PICXFE = $(0.645 * PICXFE_{t-1}$
$+ 0.980 * ZPICXFE$
$+ (1-0.980)*(1-0.645)*PTR_{t-1}$
$+ 0.00374 * 400*\log(QPCNIA_{t-1}/PCNIA_{t-1})) / (1+0.645 * 0.980)$

Regression statistics

Sample period: 1988q1 - 2013q4

Estimation date: August 2014

g.2 PIECI: Annualized rate of growth of EI hourly compensation

This is the main wage equation in FRB/US. Its specification is based on a variant of the New Keynesian Phillips Curve (NKPC) derived by Cogley and Sbordonne (2008) for the case in which the subset of wages that is not optimally reset each period is indexed to either past or trend wage inflation.

(1) $\Pi(w)_t = E_{t-1}[\beta\Pi(w)_{t+1} + \kappa\mu_t] + \varepsilon_t$

(2) $\Pi(w)_t \equiv \pi(w)_t - \gamma\pi\hat{}(w)_t - (1-\gamma)\pi^*(w)_t$

(3) $\pi(w)\hat{}_t \equiv .25 \sum(i=1,4)\pi(w)_{t-i}$

Equation 1 is the basic NKPC expressed in terms of the composite variable Π(w), which is defined in equation 2 as the difference between actual wage inflation (π(w)) and a weighted average of past (π^(w)) and trend (π*(w)) wage inflation. Expectations are formed on the basis of "t-1" information, β(=.98) is the discount factor, and μ is the wage markup gap.

Past wage inflation is measured as a four-quarter average (equation 3). Trend wage inflation is measured as the sum of survey data on ten-year consumer price inflation expectations (PTR) and the FRB/US estimate of the trend rate of growth of labor productivity (HLPRDT), less the FRB/US estimate of trend rate of growth of the price of consumption relative to the price of final sales (HUQPCT). The wage markup gap -- in theory, the difference between the marginal rate of substitution and the real wage -- is expressed as a function of the unemployment gap (LUR-LURNAT) and the detrended labor share (log(PL/QPL)). For purposes of simplicity, each component of the markup gap enters as a t-1 observation rather than the t-1 expectation of the observation in period t. ZPIECI is the expectation of PIECI in period t+1.

The PIECI equation, which is estimated simultaneously with the equation for core PCE price inflation (PICXFE), contains three estimated parameters: the fraction of non-optimized wages that is indexed to past inflation (γ) is at its upper limit of 1.0; the coefficient on the detrended labor share is 0.00162; and the coefficient on the unemployment gap is -0.0205.

More information on the estimation of the price-wage NKPC equations is available here.

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$$\textbf{PIECI} = (.25*0.812*((1-0.980)*(PIECI_{t-1}+PIECI_{t-2}+PIECI_{t-3}) + PIECI_{t-4})$$
$$+ 0.980*ZPIECI$$
$$+ (1-0.980)*(1-0.812)*(PTR_{t-1} + HLPRDT_{t-1} - 400*HUQPCT_{t-1})$$
$$- 0.0149*(LUR_{t-1}-LURNAT_{t-1})$$
$$+ 0.00187*400*\log(QPL_{t-1}/PL_{t-1})) / (1+.25*0.812*0.980)$$

Regression statistics

Sample period: 1985q1 - 2013q4

Estimation date: August 2014

g.3 PIPXNC: Inflation rate, price of adjusted final sales excluding consumption (annual rate)

The difference between nonconsumption price inflation (PIPXNC) and consumption price inflation (PICNIA), adjusted for the trend difference between the two (1.99*400*HUQPCT), depends on two lags of itself and the rate of change of the real exchange rate.

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$$\textbf{PIPXNC} = PICNIA - 1.99 * 400 * HUQPCT$$
$$+ 0.463 * (PIPXNC_{t-1} - PICNIA_{t-1} + 1.99 * 400 * HUQPCT_{t-1})$$
$$+ 0.230 * (PIPXNC_{t-2} - PICNIA_{t-2} + 1.99 * 400 * HUQPCT_{t-2})$$
$$- 0.284 * .5 * (\Sigma_{i=0,1}((EMON_{t-i}/XPN_{t-i}))/2) * 400 * \Delta(\log(FPXR))$$

g.4 PICNIA: Inflation rate, personal consumption expenditures, cw

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$$\textbf{PICNIA} = PICXFE$$
$$+ (\Sigma_{i=0,1}(UCFS_{t-i})/2)) * 400 * \Delta(\log(PCFR))$$
$$+ (\Sigma_{i=0,1}(UCES_{t-i})/2)) * 400 * \Delta(\log(PCER))$$

g.5 PCNIA: Price index for personal consumption expenditures, cw (NIPA definition)

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Δ(log(PCNIA)) = PICNIA / 400

g.6 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.

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PCPI = UPCPI * EXP(.025*LOG(PCER)) * PCNIA

g.7 PCPIX: Consumer price index,excluding food and energy

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PCPIX = UPCPIX * PCXFE

g.8 PIPL: Rate of growth of PL

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PIPL = PIECI

g.9 PL: Compensation per hour, business

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$$\textbf{log(PL)} = \log(PL_{t-1}) + PIPL/400$$

g.10 PXNC: Price of adjusted final sales excluding consumption

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$$\boldsymbol{\Delta}\textbf{(log(PXNC))} = PIPXNC/400$$

g.11 PWSTAR: Equilibrium business sector price markup

PWSTAR, which is the nonstationary component of the inverse of the log labor share in the adjusted nonfarm business sector, is estimated historically as a one-sided HP filter (lambda = 80000) of log(PXG*LPRDT/PL). In simulation, PWSTAR follows a random walk.

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$$\textbf{PWSTAR} = 0.00 + 1.00 * PWSTAR_{t-1}$$

g.12 QPXG: Desired price level of private output ex. energy, housing, and farm

Given the levels of hourly compensation (PL) and trend labor productivity (LRPDT) in the adjusted nonfarm business sector, QPXG is the level of that sector's price that would set the price markup (inverse labor share) equal to its equilibrium (PWSTAR).

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log(QPXG) = log(PWSTAR) + 0.00 + 1.00 *log(PL/LPRDT)

g.13 QPL: Desired level of compensation per hour, trending component

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). As a result, the percentage wage gap, log(PL/QPL), is the negative of the percentage price gap, log(PXG/QPXG), and both measure the deviation of the labor share (inverse price markup) in the adjusted nonfarm business sector from its long-run equilibrium.

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log(QPL) = log(PL) + 1.00 * log(PXG/QPXG)

g.14 QPXP: Desired price level of adjusted final sales

In order to understand how the identity for the target price of adjusted final sales works, rewrite it as follows

(1) QPXP = QPXG*XG/XP + 100*(XPN-XGN)/XP

and then expand the second term of (1).

(2) 100*(XPN-XGN)/XP = 100*[(XGDPN-XBN-EGFLN-EGSLN) + EMON - EIN]/XP

Substitute (2) into (1) and then log-linearize the result around QPXP=PXP and QPXG=PXG to get the following approximation

(3) log(QPXP) = w1*log(QPXG) + w2*log(PMO) + ...

where w1 = XGN/XPN and w2 = EMON/XPN are nominal share weights. The complete form of (3) also includes a constant and terms associated with the price of inventories and the price of output in sectors other than nonfarm business (except output in the form of government labor compensation).

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

g.15 QPCNIA: Desired level of consumption price

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$$\textbf{log(QPCNIA)} = \log(QPXP) + \log(UQPCT)$$

g.16 PXP: Price index for final sales plus imports less gov. labor

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$$\Delta(\log(PXP)) =$$

$$.5*(ECNIAN/XPN + ECNIAN_{t-1}/XPN_{t-1}) * \Delta(\log(PCNIA))$$

$$+ .5*((XPN-ECNIAN)/XPN + (XPN_{t-1}-ECNIAN_{t-1})/XPN_{t-1}) * \Delta(\log(PXNC))$$

g.17 PGFIR: Price index for federal gov. investment, cw (relative to PXP)

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$$\textbf{log(PGFIR) - log(PGFIR(-1))} = 0.00 + PIPXNC/400 + DPADJ - \Delta(\log(PXP))$$

g.18 PGFOR: Price index for federal governemnt consumption ex. emp. comp., cw (relative to PXP)

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log(PGFOR) - log(PGFOR(-1)) = 0.00 + PIPXNC/400 + DPADJ - Δ(log(PXP))

g.19 PGSIR: Price index for S&L government investment (relative to PXP)

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log(PGSIR) - log(PGSIR(-1)) = 0.00 + PIPXNC/400 + DPADJ - Δ(log(PXP))

g.20 PGSOR: Price index for S&L government consumption ex. emp. comp., cw (relative to PXP)

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log(PGSOR) - log(PGSOR(-1)) = 0.00 + PIPXNC/400 + DPADJ - Δ(log(PXP))

g.21 PHR: Price index for residential investment, cw (relative to PXP)

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log(PHR) - log(PHR(-1)) = 0.00 + PIPXNC/400 + DPADJ - Δ(log(PXP))

g.22 PPDR: Price level of EPD compared to PXP

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log(PPDR) - log(PPDR(-1)) = 0.00 + PIPXNC/400 + DPADJ - Δ(log(PXP))

g.23 PPIR: Price level of EPI compared to PXP

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$$\mathbf{log(PPIR) - log(PPIR(-1)) =} \text{PIPXNC}/400 + \text{DPADJ} - \Delta(\log(\text{PXP}))$$

g.24 PPSR: Price index for nonresidential structures, cw (relative to PXP)

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$$\mathbf{log(PPSR) - log(PPSR(-1)) =} 0.00 + \text{PIPXNC}/400 + \text{DPADJ} - \Delta(\log(\text{PXP}))$$

g.25 PXR: Price index for exports, cw (relative to PXP)

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$$\mathbf{log(PXR) - log(PXR(-1)) =} 0.00 + \text{PIPXNC}/400 + \text{DPADJ} - \Delta(\log(\text{PXP}))$$

g.26 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.

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$$\begin{aligned}\mathbf{DPGAP =} & \ \text{PIPXNC}/400 - (\\ & .5 * (\text{EHN}/(\text{XPN} - \text{ECNIAN}) + \text{EHN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIAN}_{t-1})) \\ & * \Delta(\log(\text{PHR}*\text{PXP})) \\ & + .5 * (\text{EPDN}/(\text{XPN} - \text{ECNIAN}) + \text{EPDN}_{t-1}/(\text{XPN}_{t-1} - \text{ECNIAN}_{t-1})) \\ & * \Delta(\log(\text{PPDR}*\text{PXP}))\end{aligned}$$

$+ .5 * (EPIN/(XPN - ECNIAN) + EPIN_{t-1}/(XPN_{t-1} - ECNIAN_{t-1}))$
$* \Delta(\log(PPIR*PXP))$
$+ .5 * (EPSN/(XPN - ECNIAN) + EPSN_{t-1}/(XPN_{t-1} - ECNIAN_{t-1}))$
$* \Delta(\log(PPSR*PXP))$
$+ .5 * (EGFON/(XPN - ECNIAN) + EGFON_{t-1}/(XPN_{t-1} - ECNIAN_{t-1}))$
$* \Delta(\log(PGFOR*PXP))$
$+ .5 * (EGFIN/(XPN - ECNIAN) + EGFIN_{t-1}/(XPN_{t-1} - ECNIAN_{t-1}))$
$* \Delta(\log(PGFIR*PXP))$
$+ .5 * (EGSON/(XPN - ECNIAN) + EGSON_{t-1}/(XPN_{t-1} - ECNIAN_{t-1}))$
$* \Delta(\log(PGSOR*PXP))$
$+ .5 * (EGSIN/(XPN - ECNIAN) + EGSIN_{t-1}/(XPN_{t-1} - ECNIAN_{t-1}))$
$* \Delta(\log(PGSIR*PXP))$
$+ .5 * (EXN/(XPN - ECNIAN) + EXN_{t-1}/(XPN_{t-1} - ECNIAN_{t-1}))$
$* \Delta(\log(PXR*PXP)))$

g.27 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.

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$$\mathbf{DPADJ - DPADJ(-1) =} 1.00 * DPGAP_{t-1}$$

g.28 PLMIN: Minimum wage

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

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

g.29 QPXNC: Desired level of nonconsumption price

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log(QPXNC) = log(PXNC)
+ 2.99 * log(QPXP/PXP)
- 1.99 * log(QPCNIA/PCNIA)

g.30 UQPCT: Stochastic component of trend ratio of PCNIA to PXP

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log(UQPCT) = 0.00 + log($UQPCT_{t-1}$) + HUQPCT

Regression statistics

Sample period: 1962:Q1 - 2009:Q4

Estimation date: August 2010

g.31 HUQPCT: Drift term in stochastic component of trend ratio of PCNIA to PXP

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HUQPCT = 0.00 + 0.950 *$HUQPCT_{t-1}$

Regression statistics

Sample period: 1962:Q1 - 2009:Q4

Estimation date: August 2010

g.32 POILR: Price of imported oil, relative to price index for bus. sector output

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

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$$\mathbf{\Delta(log(POILR)) =} -0.239\ [-6.13] * \log(POILR_{t-1}/POILRT_{t-1})$$
$$- 0.00382 [-0.42]$$
$$+ 0.399\ [6.01] * \Delta(\log(POILR_{t-1}))$$
$$+ 0.225\ [0.62] * \Delta(\log(POILRT))$$

Regression statistics

Adjusted R^2:	0.250
S.E. of regression:	0.113
Sum of squared residuals:	2.45
Durbin-Watson statistic:	1.89
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

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$$\mathbf{\Delta(log(PCXFE)) =} PICXFE/400$$

g.34 POIL: Price of imported oil ($ per barrel)

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

g.35 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).

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PMP = UPMP*POIL

g.36 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.

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$$\Delta(\log(PCENGR)) = 0.0462\ [3.09] - 0.0105\ [-0.39] * \Delta(\log(PCENGR_{t-1})) - 0.0962\ [-3.23] * \log(PCENGR_{t-1}) + 0.0821\ [3.16] * \log(POILR_{t-1}) + 0.798\ [35.43] * \Delta(\log(POILR))$$

Regression statistics

Adjusted R^2:	0.900
S.E. of regression:	0.0347
Sum of squared residuals:	0.182
Durbin-Watson statistic:	1.86
Sample period:	1975Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

g.37 PCENG: Price index for aggregate energy consumption

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PCENG = PCENGR*PXB

g.38 PCER: Price index for personal consumption expenditures on energy (relative to PCXFE)

Consumer energy prices are a weighted average of the price of crude energy (PCENG) and core consumer prices (PCXFE). Core consumer prices are a proxy for the influence of taxes, refining and distribution costs, the capital cost of generating electricity, and other non-crude-energy factors which are assumed to have a fixed Leontief weight in total costs.

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$$\Delta(\log(PCER)) = 0.105\ [3.92] * \log((0.563\ [35.57] * PCENG_{t-1} + (1-0.563\ [35.57])*PCXFE_{t-1})/(PCER_{t-1}*PCXFE_{t-1}))$$
$$+ 0.686\ [21.82] * \Delta(\log((0.563\ [35.57] * PCENG + (1-0.563\ [35.57])*PCXFE)/PCXFE))$$
$$+ 0.0403\ [1.46] * \Delta(\log((0.563\ [35.57] * PCENG_{t-1} + (1-0.563\ [35.57])*PCXFE_{t-1})/PCXFE_{t-1}))$$

Regression statistics

Adjusted R^2:	0.810
S.E. of regression:	0.0175
Sum of squared residuals:	0.0587
Durbin-Watson statistic:	2.14
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

g.39 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.

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Δ(log(PCFR)) = -0.176 [-6.18] * log($PCFR_{t-1}$/$PCFRT_{t-1}$)
- 7.90E-05[-0.16]
+ B1(L) {sum 0.743 } * Δ(log($PCFR_{t-1}$))
+ 0.324 [1.29] * Δ(log(PCFRT))

Distributed lag coefficients

Name	Value
$B1_0$	0.378 [5.78]
$B1_1$	0.0235 [0.34]
$B1_2$	0.341 [4.97]
$B1_{SUM}$	0.743

Regression statistics

Adjusted R^2:	0.360
S.E. of regression:	0.00705
Sum of squared residuals:	0.00943
Durbin-Watson statistic:	1.97
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

g.40 UCES: Energy share of nominal consumption expenditures

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.

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$$\mathbf{\Delta(\ log(UCES)) =} -0.183\ [-4.58] * \log(UCES_{t-1}) + 0.155\ [4.49] * \log(PCER_{t-1}) + 0.0800\ [3.35] * \log(CENG_{t-1}/XG_{t-1}) - 0.000441[-3.12] * T47 - 0.202\ [-3.63] - 0.0645\ [-1.84] * \Delta(\ \log(UCES_{t-1})) + 0.807\ [25.14] * \Delta(\ \log(PCER)) + 0.176\ [3.72] * \Delta(\ \log(CENG/XG))$$

Regression statistics

Adjusted R^2:	0.780
S.E. of regression:	0.0171
Sum of squared residuals:	0.0547
Durbin-Watson statistic:	2.33
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

g.41 UCFS: Food share of nominal consumption expenditures

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.

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$$\mathbf{\Delta(\ log(UCFS)) =} -0.0352\ [-1.95] * \log(UCFS_{t-1}) + 0.0453\ [2.36] * \log(PCFR_{t-1}) - 0.000150[-1.75] * T47 - 0.0565\ [-2.22] + 0.00246\ [0.04] * \Delta(\ \log(UCFS_{t-1})) + 0.997\ [3.90] * \Delta(\ \log(PCFRT)) + 0.335\ [4.89] * \Delta(\ \log(PCFR/PCFRT))$$

Regression statistics

Adjusted R^2:	0.190
S.E. of regression:	0.00762
Sum of squared residuals:	0.011
Durbin-Watson statistic:	2.00
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

g.42 PMO: Price index for imports ex. petroleum, cw

The price index for non-petroleum imports (PMO) is modeled using a Kalman filter specification in which the price level 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, only 64 percent of any movement in FPCM or FPXM is allowed to pass through to PMO in the long run. This pass-through 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.

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$$\begin{aligned}\mathbf{\Delta(\log(PMO))} = & -0.00317 \\ & + 0.449\ [4.95] * (\log(QPMO) + .64*\log(FPCM_{t-1}/FPXM_{t-1}) + .36*\log(PXB_{t-1}) \\ & - \log(PMO_{t-1})) \\ & + 0.294 * \Delta(\log(FPCM/FPXM)) \\ & + 0.706 * \Delta(\log(PXB))\end{aligned}$$

Regression statistics

Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Maximum likelihood (Marquardt)

g.43 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 a random walk with drift and is derived from Kalman filter estimation of the non-oil import price (PMO) equation.

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$$\mathbf{log(QPMO) =} \log(QPMO_{t-1}) - 0.00335$$

g.44 PGDP: Price index for GDP, cw

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$$\mathbf{PGDP =} 100*XGDPN/XGDP$$

g.45 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. 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.

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$$\begin{aligned}\mathbf{\Delta(\,log(PGFL)) =} \; & \Delta(\,\log(UPGFL)) \\ & + \Delta(\,\log(PL)) \\ & - DGLPRD*(\Delta(\,\log(LPRDT)))\end{aligned}$$

g.46 PGSL: Price index for S&L government employee compensation, cw

The price index for federal employee compensation (PGSL) is proportional to the economy-wide compensation rate (PL). They are linked by the exogenous conversion factor UPGSL. 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.

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$$\Delta(\log(PGSL)) = \Delta(\log(UPGSL)) + \Delta(\log(PL)) - DGLPRD*(\Delta(\log(LPRDT)))$$

g.47 PKPDR: Ratio of price of equipment stock (KPD) to PXP

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$$PKPDR = UPKPD * PPDR$$

g.48 PXG: Price index for business output plus oil imports

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$$PXG = 100*XGN/XG$$

g.49 PXB: Price index for business sector output

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PXB = UPXB*PGDP

g.50 HGPDR: Trend Price Growth of PPDR

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$$\mathbf{HGPDR} = 0.900 * HGPDR_{t-1} + 0.100 * 400*\log(PPDR/PPDR_{t-1})$$

g.51 HGPIR: Trend Price Growth of PPIR

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$$\mathbf{HGPIR} = 0.900 * HGPIR_{t-1} + 0.100 * 400*\log(PPIR/PPIR_{t-1})$$

g.52 HGPKIR: Trend growth rate of PKIR

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$$\mathbf{HGPKIR} = 0.900 * HGPKIR_{t-1} + 0.100 * 400*\log(PKIR/PKIR_{t-1})$$

g.53 HGPPSR: Trend growth rate of PPSR

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$$\textbf{HGPPSR} = 0.900 * HGPPSR_{t-1} + 0.100 * 400*\log(PPSR/PPSR_{t-1})$$

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

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$$\textbf{PICNGR} = (\Delta(\log(PCENG/PXP_{t-1})) * \Sigma_{i=0,1}(PCENG_{t-i}*CENG_{t-i}/(PXP_{t-i}*XP_{t-i}))/2))$$

g.55 PIGDP: Inflation rate, GDP, cw

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$$\textbf{PIGDP} = 400*\Delta(\log(PGDP))$$

g.56 PCOR: Price index for non-durable goods and non-housing services, cw (relative to 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).

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$$\textbf{log(PCOR) - log(PCOR(-1))} = (-.5 * .01 * (PCDR*PCNIA*ECD/ECNIAN + PCDR_{t-1}*PCNIA_{t-1}*ECD_{t-1}/ECNIAN_{t-1})) / (.5 * .01 * (PCOR*PCNIA*ECO/ECNIAN + PCOR_{t-1}*PCNIA_{t-1}*ECO_{t-1}/ECNIAN_{t-1})) * \Delta(\log(PCDR))$$

$$- .5 * .01 * (PCHR*PCNIA*ECH/ECNIAN + PCHR_{t-1}*PCNIA_{t-1}*ECH_{t-1}/ECNIAN_{t-1}) * \Delta(\log(PCHR)) / (.5 * .01 * (PCOR*PCNIA*ECO/ECNIAN + PCOR_{t-1}*PCNIA_{t-1}*ECO_{t-1}/ECNIAN_{t-1}))$$

g.57 PCHR: Price index for housing services, cw (relative to to PCNIA)

The growth rate of the relative (to PCNIA) price of housing services (PCHR) is assumed to follow a first order autoregressive process.

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$$\mathbf{\Delta(\log(PCHR))} = 0.000532_{[1.58]} + 0.595_{[9.72]}*\Delta(\log(PCHR_{t-1}))$$

Regression statistics

Adjusted R^2:	0.350
S.E. of regression:	0.00433
Sum of squared residuals:	0.00324
Durbin-Watson statistic:	1.99
Sample period:	1970Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

g.58 PICX4: Four-quarter percent change core in PCE prices

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

g.59 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 first order autoregressive process.

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$$\mathbf{\Delta(log(PCDR))} = -0.00321_{[-5.83]} + 0.507_{[7.73]} * \Delta(\log(PCDR_{t-1}))$$

Regression statistics

Adjusted R^2:	0.250
S.E. of regression:	0.00459
Sum of squared residuals:	0.00365
Durbin-Watson statistic:	1.99
Sample period:	1970Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

g.60 PIC4: Four-quarter percent change in PCE prices

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

Government

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

Identities. Much of sector consists of identities that: (1) relate nominal purchases (consumption and investment expenditures), transfers, and grants to associated constant-dollar variables and price indexes; (2) link tax receipts to tax rates and tax bases; and (3) compute the budget surplus and stock of debt.

Estimated equations. Error-correction equations link spending on various types of purchases to trend spending in these categories. Other estimated equations account for cyclical fluctuations in transfer payments and tax rates.

Personal income tax-rate reaction functions. The sector includes three options for setting the personal income tax rate of each level of government. The choice of an option is determined by which switch variable -- DFPSRP, DFPDBT, DFPEX -- is set to one. Activation of DFPSRP causes the tax rates to adjust so that the ratio of each government's surplus to GDP gradually stabilizes at a specified value. Activitation of DFPDBT causes the adjustments to stabilize the ratios of government debt to GDP at specified values. No adjustments take place when DFPEX is activated, making this a suitable choice only in the short run. The switches are exogenous variables whose values can change over the course of a simulation.

h.1 EGF: Federal government consumption and gross investment, cw 2009$

Total federal government consumption and gross investment expenditures are approximated by the Divisia aggregate of its components.

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$$
\begin{aligned}
\textbf{log(EGF)} = {} & \log(EGF_{t-1}) \\
& + .5 * (EGFON/EGFN + EGFON_{t-1}/EGFN_{t-1}) * \Delta(\log(EGFO)) \\
& + .5 * (EGFIN/EGFN + EGFIN_{t-1}/EGFN_{t-1}) * \Delta(\log(EGFI)) \\
& + .5 * (EGFLN/EGFN + EGFLN_{t-1}/EGFN_{t-1}) * \Delta(\log(EGFL))
\end{aligned}
$$

h.2 EGFN: Federal government consumption and gross investment, current $

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EGFN = EGFLN + EGFIN + EGFON

h.3 EGFI: Federal government gross investment, cw 2009$

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$$\Delta(\log(EGFI)) = -0.00162\ [-0.73]$$
$$-\ 0.124\ [-2.61] * \log(EGFI_{t-1}/EGFIT_{t-1})$$
$$+\ A2(L)\ \{sum\ -0.297\} * \Delta(\log(EGFI_{t-1}))$$
$$+\ 1.56\ [5.74] * \Delta(\log(EGFIT))$$
$$+\ A4(L)\ \{sum\ 0.000247\} * XGAP2_t$$

Distributed lag coefficients

Name	Value
$A2_0$	-0.195 [-2.53]
$A2_1$	-0.103 [-1.39]
$A2_{SUM}$	-0.297
$A4_0$	0.00254 [0.83]
$A4_1$	-0.00230[-0.75]
$A4_{SUM}$	0.000247

Regression statistics

Adjusted R^2:	0.220
S.E. of regression:	0.0276
Sum of squared residuals:	0.144
Durbin-Watson statistic:	2.00
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.4 EGFIN: Federal government gross investment, current $

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EGFIN = .01 * PXP * PGFIR * EGFI

h.5 EGFIT: Federal government gross investment, cw 2009$, trend

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$$\Delta(\log(EGFIT)) = -0.403 - 0.100 * \log(.01*PGFIR_{t-1}*PXP_{t-1}*EGFIT_{t-1}/XGDPTN_{t-1}) + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600$$

h.6 EGFL: Federal government employee compensation, cw 2009$

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$$\Delta(\log(EGFL)) = -6.06E\text{-}05\,[-0.10] - 0.0693\,[-2.81] * \log(EGFL_{t-1}/EGFLT_{t-1}) + A2(L)\,\{sum\ 0.255\} * \Delta(\log(EGFL_{t-1})) + 1.06\,[5.39] * \Delta(\log(EGFLT)) + A4(L)\,\{sum\ 2.77E\text{-}05\} * XGAP2_t$$

Distributed lag coefficients

Name	Value
$A2_0$	0.305 [4.30]
$A2_1$	-0.0497 [-0.68]
$A2_{SUM}$	0.255
$A4_0$	-0.00264[-2.77]
$A4_1$	0.00267 [2.79]
$A4_{SUM}$	2.77E-05

Regression statistics

Adjusted R^2:	0.370
S.E. of regression:	0.00853

Sum of squared residuals:	0.0137
Durbin-Watson statistic:	1.97
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.7 EGFLN: Federal government employee compensation, current $

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

h.8 EGFLT: Federal government employee compensation, cw 2009$, trend

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$$\begin{aligned} \mathbf{\Delta(\log(EGFLT))} = & -0.376 \\ & - 0.100 * \log(.01*PGFL_{t-1}*EGFLT_{t-1}/XGDPTN_{t-1}) \\ & + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600 \end{aligned}$$

h.9 EGFO: Federal government consumption ex. employee comp., cw 2009$

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$$\begin{aligned} \mathbf{\Delta(\log(EGFO))} = & -0.00272 [-1.01] \\ & - 0.165 [-3.11] * \log(EGFO_{t-1}/EGFOT_{t-1}) \\ & + A2(L) \{sum\ -0.404\} * \Delta(\log(EGFO_{t-1})) \\ & + 1.89 [5.22] * \Delta(\log(EGFOT)) \\ & + A4(L) \{sum\ -0.000408\} * XGAP2_{t} \end{aligned}$$

Distributed lag coefficients

Name	Value
$A2_0$	-0.266 [-3.44]
$A2_1$	-0.138 [-1.91]
$A2_{SUM}$	-0.404
$A4_0$	-0.00466[-1.52]
$A4_1$	0.00425 [1.38]
$A4_{SUM}$	-0.000408

Regression statistics

Adjusted R^2:	0.240
S.E. of regression:	0.0274
Sum of squared residuals:	0.142
Durbin-Watson statistic:	2.04
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

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EGFON = .01 * PXP * PGFOR * EGFO

h.11 EGFOT: Federal government consumption ex. employee comp., cw 2009$, trend

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$$\Delta(\log(EGFOT)) = -0.343 - 0.100 * \log(.01*PGFOR_{t-1}*PXP_{t-1}*EGFOT_{t-1}/XGDPTN_{t-1}) + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600$$

h.12 EGS: S&L government consumption and gross investment, cw 2009$

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

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$$\mathbf{log(EGS)} = \log(EGS_{t-1}) + .5 * (EGSON/EGSN + EGSON_{t-1}/EGSN_{t-1}) * \Delta(\log(EGSO)) + .5 * (EGSIN/EGSN + EGSIN_{t-1}/EGSN_{t-1}) * \Delta(\log(EGSI)) + .5 * (EGSLN/EGSN + EGSLN_{t-1}/EGSN_{t-1}) * \Delta(\log(EGSL))$$

h.13 EGSN: S&L government consumption and gross investment, current $

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

h.14 EGSI: S&L government gross investment, cw 2009$

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$$\mathbf{\Delta(log(EGSI))} = -1.41E\text{-}05 [-0.01] - 0.202 [-3.86] * \log(EGSI_{t-1}/EGSIT_{t-1}) + A2(L) \{sum -0.0289\} * \Delta(\log(EGSI_{t-1})) + 1.12 [3.36] * \Delta(\log(EGSIT)) + A4(L) \{sum 0.00137\} * XGAP2_{t}$$

Distributed lag coefficients

Name	Value
$A2_0$	0.0513 [0.70]
$A2_1$	-0.0803 [-1.11]

$A2_{SUM}$ -0.0289
$A4_0$ 0.00446 [1.34]
$A4_1$ -0.00309[-0.93]
$A4_{SUM}$ 0.00137

Regression statistics

Adjusted R^2:	0.170
S.E. of regression:	0.0285
Sum of squared residuals:	0.153
Durbin-Watson statistic:	2.02
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.15 EGSIN: S&L government gross investment, current $

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EGSIN = .01 * PXP * PGSIR * EGSI

h.16 EGSIT: S&L government gross investment, cw 2009$, trend

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$$\Delta(\log(EGSIT)) = -0.380 - 0.100 * \log(.01*PGSIR_{t-1}*PXP_{t-1}*EGSIT_{t-1}/XGDPTN_{t-1}) + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600$$

h.17 EGSL: S&L government employee compensation, cw 2009$

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$$\Delta(\log(EGSL)) = 0.000433\,[1.00]$$
$$- 0.141\ [-4.76] * \log(EGSL_{t-1}/EGSLT_{t-1})$$
$$+ A2(L)\ \{sum\ 0.212\} * \Delta(\log(EGSL_{t-1}))$$
$$+ 0.692\ [5.90] * \Delta(\log(EGSLT))$$
$$+ A4(L)\ \{sum\ 0.000273\} * XGAP2_t$$

Distributed lag coefficients

Name	Value
$A2_0$	0.174 [2.57]
$A2_1$	0.0376 [0.55]
$A2_{SUM}$	0.212
$A4_0$	-0.00156[-4.21]
$A4_1$	0.00183 [4.99]
$A4_{SUM}$	0.000273

Regression statistics

Adjusted R^2:	0.640
S.E. of regression:	0.00307
Sum of squared residuals:	0.00178
Durbin-Watson statistic:	2.00
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.18 EGSLN: S&L government employee compensation, current $

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$$EGSLN = .01 * PGSL * EGSL$$

h.19 EGSLT: S&L government employee compensation, cw 2009$, trend

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$$\Delta(\log(EGSLT)) = -0.260 - 0.100 * \log(.01*PGSL_{t-1}*EGSLT_{t-1}/XGDPTN_{t-1}) + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600$$

h.20 EGSO: S&L government consumption ex. employee comp., cw 2009$

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$$\Delta(\log(EGSO)) = -0.000201[-0.16] - 0.0937\ [-5.19] * \log(EGSO_{t-1}/EGSOT_{t-1}) + A2(L)\ \{sum\ 0.712\} * \Delta(\log(EGSO_{t-1})) + 0.274\ [2.17] * \Delta(\log(EGSOT)) + A4(L)\ \{sum\ 6.68E-06\} * XGAP2_t$$

Distributed lag coefficients

Name	Value
$A2_0$	0.548 [8.10]
$A2_1$	0.164 [2.30]
$A2_{SUM}$	0.712
$A4_0$	-0.00239[-2.48]
$A4_1$	0.00240 [2.52]
$A4_{SUM}$	6.68E-06

Regression statistics

Adjusted R^2:	0.650
S.E. of regression:	0.00854
Sum of squared residuals:	0.0138
Durbin-Watson statistic:	2.02
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

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EGSON = .01 * PXP * PGSOR * EGSO

h.22 EGSOT: S&L government consumption ex. employee comp., cw 2009$, trend

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$$\Delta(\log(EGSOT)) = -0.383 - 0.100 * \log(.01*PGSOR_{t-1}*PXP_{t-1}*EGSOT_{t-1}/XGDPTN_{t-1}) + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600$$

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

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$$GFDBTN = UGFDBT*(GFDBTN_{t-1} - .25*GFSRPN + .25*EGFIN - .25*JYGFGN - .25*JYGFEN)$$

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

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$$GFINTN = RGFINT*GFDBTN_{t-1}$$

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

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$$\Delta(\log(GFS)) = -0.361 - 0.100 * \log(GFSN_{t-1}/XGDPTN_{t-1}) + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600$$

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

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$$GFSN = .01*PGDP*GFS$$

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

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$$GFSRPN = TFPN + TFCIN + TFIBN + TFSIN + TFDIV - EGFLN - EGFON - GFTN - GFINTN - GFSUBN - GFSN$$

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

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$$\Delta(\log(GFSUB)) = -0.550 - 0.100 * \log(GFSUBN_{t-1}/XGDPTN_{t-1}) + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600$$

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

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GFSUBN = .01*PGDP*GFSUB

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

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

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GFT = (GFTRD+GFTRT)*XGDPT

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

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GFTN = .01*PGDP*GFT

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

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GFTRD = -3.60E-05[-0.25]
+ 0.659 [13.02] * $GFTRD_{t-1}$
- 0.000241[-4.33] * XGAP2

Regression statistics

Adjusted R^2:	0.600

S.E. of regression:	0.00203
Sum of squared residuals:	0.000799
Durbin-Watson statistic:	2.03
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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

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

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. 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 nonfarm business sector output (XBN).

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

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

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GSSRPN = TSPN + TSCIN + TSIBN + TSSIN + GFSN
- EGSLN - EGSON - GSTN - GSINTN - GSSUBN

h.36 GSSUBN: S&L government subsidies less surplus, current $

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GSSUBN = .01*PGDP*GSSUB

h.37 GSTN: S&L government net transfer payments, current $

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GSTN = .01*PGDP*GST

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

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GST = (GSTRD+GSTRT)*XGDPT

h.39 GSTRD: Deviation of ratio of S&L transfers to GDP from trend ratio

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GSTRD = -1.24E-05 [-0.31]
+ 0.737 [15.94] * $GSTRD_{t-1}$

- 4.48E-05[-3.10] * XGAP2

Regression statistics

Adjusted R^2:	0.620
S.E. of regression:	0.000564
Sum of squared residuals:	6.14e-05
Durbin-Watson statistic:	2.31
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.40 GSSUB: S&L government subsidies less surplus, deflated by PGDP

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GSSUB = UGSSUB*XGDPT

h.41 TFCIN: Federal corporate income tax accruals, current $

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TFCIN = TRFCI * YNICPN

h.42 TFIBN: Federal indirect business tax receipts, current $

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TFIBN = TRFIB * ECNIAN

h.43 TFPN: Federal personal income tax and nontax receipts, current $

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TFPN = TRFP * (YPN - GFTN - GSTN)

h.44 TFSIN: Federal social insurance tax receipts

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TFSIN = TRFSI * YNILN

h.45 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 (TAPDT), 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.

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TRFCI = 0.00134 [0.15]
+ 0.813 [25.35] * $TRFCI_{t-1}$
+ 0.109 [3.48] * TRFCIM
- 0.219 [-3.99] * .01*PXP*EPD*PPDR*.01*TAPDT/YNICPN
+ 0.00137 [3.04] * XGAP2
+ 0.00232 [4.30] * PICNIA

Regression statistics

Adjusted R^2:	0.950
S.E. of regression:	0.0133
Sum of squared residuals:	0.0334

Durbin-Watson statistic:	1.76
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.46 TRFP: Average federal tax rate for personal income tax and nontax receipts

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TRFP = 1.00 * TRFPT
+ A2(L) {sum 0.915 } * (TRFP $_{t-1}$-TRFPT $_{t-1}$)
+ 0.000372[2.82] * XGAP2$_{t-1}$

Distributed lag coefficients

Name	Value
$A2_0$	0.625 [9.05]
$A2_1$	0.290 [4.30]
$A2_{SUM}$	0.915

Regression statistics

Adjusted R^2:	0.770
S.E. of regression:	0.00509
Sum of squared residuals:	0.005
Durbin-Watson statistic:	1.98
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.47 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 if DFDBT is set to 1, and it adjusts to deviations of the surplus ratio from its target if DFSRP is set to 1.

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$$
\begin{aligned}
\textbf{TRFPT} = {} & \text{DFPEX} * \text{TRFPTX} \\
& + \text{DFPDBT} * (\ \text{TRFPT}_{t-1} \\
& + 0.0500\ [0.00] * (\text{GFDBTN}_{t-1}/\text{XGDPN}_{t-1} - \text{GFDRT}_{t-1}) \\
& + 0.500\ [0.00] * \Delta(\ \text{GFDBTN}_{t-1}/\text{XGDPN}_{t-1} - \text{GFDRT}_{t-1})\ ) \\
& + \text{DFPSRP} * (\ \text{TRFPT}_{t-1} \\
& - 0.100\ [0.00] * ((\text{GFSRPN}_{t-1} - \text{EGFIN}_{t-1} + \text{JYGFGN}_{t-1} \\
& + \text{JYGFEN}_{t-1})/\text{XGDPN}_{t-1} - \text{GFSRT}_{t-1}))
\end{aligned}
$$

h.48 TRSCI: Average S&L corporate income tax rate

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$$
\begin{aligned}
\textbf{TRSCI} = {} & 0.791\ [17.70] * \text{TRSCI}_{t-1} \\
& + A2(L)\ \{\text{sum } 0.209\ \} * \text{TRSCIT}_{t} \\
& + A3(L)\ \{\text{sum } 4.50\text{E-}05\} * \text{XGAP2}_{t} \\
& + 0.114\ [9.72] * \Delta(\ \text{TRFCI})
\end{aligned}
$$

Distributed lag coefficients

Name	Value
$A2_0$	0.906 [2.00]
$A2_1$	-0.697
$A2_{SUM}$	0.209
$A3_0$	-0.000768[-2.99]
$A3_1$	0.000813[3.16]
$A3_{SUM}$	4.50E-05

Regression statistics

Adjusted R^2:	0.970
S.E. of regression:	0.00217
Sum of squared residuals:	0.0009
Durbin-Watson statistic:	2.17
Sample period:	1965Q1 2013Q4

Estimation date:	August 2014
Estimation method:	Least Squares

h.49 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).

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$$\textbf{TRSIB} = 0.913\ [31.87] * TRSIB_{t-1}$$
$$+ A2(L)\ \{sum\ 0.0866\ \} * TRSIBT_{t}$$
$$- 3.35E\text{-}05[-2.10] * XGAP2$$

Distributed lag coefficients

Name	Value
$A2_0$	1.34 [7.92]
$A2_1$	-1.25
$A2_{SUM}$	0.0866

Regression statistics

Adjusted R^2:	0.990
S.E. of regression:	0.000625
Sum of squared residuals:	7.53e-05
Durbin-Watson statistic:	1.89
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.50 TRSP: Average S&L tax rate for personal income tax and nontax receipts

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TRSP = 0.633 [11.23] * $TRSP_{t-1}$

+ A2(L) {sum 0.367 } * $TRSPT_{t}$

+ 2.41E-05[1.21] * $XGAP2_{t-1}$

+ 0.0131 [1.35] * Δ(TRFP)

Distributed lag coefficients

Name	Value
$A2_0$	0.882 [2.00]
$A2_1$	-0.515
$A2_{SUM}$	0.367

Regression statistics

Adjusted R^2:	0.980
S.E. of regression:	0.000743
Sum of squared residuals:	0.000106
Durbin-Watson statistic:	1.97
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.51 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 it 1.

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TRSPT = DFPEX * TRSPTX

+ DFPDBT * ($TRSPT_{t-1}$

+ 0.0500 [0.00] * ($GSDBTN_{t-1}$/$XGDPN_{t-1}$ - $GSDRT_{t-1}$)

+ 0.500 [0.00] * Δ($GSDBTN_{t-1}$/$XGDPN_{t-1}$ - $GSDRT_{t-1}$))

+ DFPSRP * ($TRSPT_{t-1}$

- 0.250 [0.00] * (($GSSRPN_{t-1}$ - $EGSIN_{t-1}$ + $JYGSGN_{t-1}$

+ $JYGSEN_{t-1}$)/$XGDPN_{t-1}$ - $GSSRT_{t-1}$))

h.52 TRSSI: Average S&L social insurance tax rate

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TRSSI = A1(L) {sum 0.950 } * $TRSSI_{t-1}$
+ A2(L) {sum 0.0501 } * $TRSSIT_{t}$
- 5.03E-06[-2.86] * XGAP2

Distributed lag coefficients

Name	Value
$A1_0$	1.18 [17.11]
$A1_1$	-0.232 [-3.32]
$A1_{SUM}$	0.950
$A2_0$	1.58 [6.35]
$A2_1$	-1.53
$A2_{SUM}$	0.0501

Regression statistics

Adjusted R^2:	0.990
S.E. of regression:	6.83e-05
Sum of squared residuals:	8.97e-07
Durbin-Watson statistic:	2.03
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

h.53 TSCIN: S&L corporate income tax accruals, current $

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TSCIN = TRSCI * YNICPN

h.54 TSIBN: S&L indirect business tax receipts, current $

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TSIBN = TRSIB * ECNIAN

h.55 TSPN: S&L personal income tax and nontax receipts, current $

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TSPN = TRSP * (YPN - GFTN - GSTN)

h.56 TSSIN: S&L social insurance tax receipts, current $

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TSSIN = TRSSI * YNILN

h.57 YGFSN: Federal government saving

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YGFSN = GFSRPN + JYGFGN + JYGFEN

h.58 YGSSN: State and Local government saving

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YGSSN = GSSRPN + JYGSGN + JYGSEN

h.59 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.

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TRYH = (TFPN+TSPN)/(YHLN+YHPTN)

Financial Sector

The financial sector of FRB/US is divided into three blocks of equations: equations determining the stance of monetary policy, defined as the value of the federal funds rate; equations for other interest rates based on arbitrage relationships; and equations for household wealth, including one that relates the value of the stock market to real bond yields and expected growth in dividends.

Interest rates whose names end with an "E" are labeled "effective" to indicate that they are expressed as compound annual rates. In most cases, there is a corresponding variable whose name excludes the "E" and whose measurement corresponds to the units in which data on that interest rate are conventionally reported. For example, RFFE is the effective federal funds rate and RFF is the corresponding reported rate.

Monetary Policy

In the monetary policy block, there are seven basic options for setting the federal funds rate, including variants of the Taylor rule, an estimated policy rule, a pre-determined path for the funds rate that can be defined in either nominal or real terms, and a generalized policy rule that can be used, for example, to target either inflation or the price level. These options are mutually exclusive, although it is possible to switch from one option to another in multi-period simulations by varying a group of exogenous "switches."

The chosen basic policy option can be modified so that the outcome for the federal funds rate is subject to the zero lower bound (ZLB). In addition, the timing of the liftoff of the funds rate from the ZLB can be determined by a version of the threshold criteria that appeared in FOMC statements from December 2012 to January 2014. In this case, liftoff is delayed until either the unemployment rate falls below a threshold or the expected inflation rate rises above a threshold.

The choice of a basic option is determined by which of seven switch variables -- DMPEX, DMPRR, DMPTAY, DMPTLR, DMPINTAY, DMPALT, and DMPGEN -- is set to one. Activation of one of the first two switches sets the funds rate to an pre-determined nominal (RFFIX) or real path (RRFIX). Activation of any of the remaining switches sets the funds rate to the outcome of an equation whose structure corresponds to a given policy rule (eg, RFFTAY, RFFTLR, etc). The RFFRULE equation combines the seven options in a form that yields the outcome for the funds rate under the chosen option.

Setting the exogenous variable RFFMIN to zero (or a small positive value) imposes the ZLB; setting RFFMIN to a large negative number eliminates the constraint.

When the exogenous switch variable DMPTRSH = 1, liftoff from the ZLB is delayed until either the unemployment rate falls below a critical rate (LURTRSH) or expected inflation rises above a critical rate (PITRSH). Once either threshold is crossed, the policy rate is determined, with a one-quarter delay and subject to the ZLB, by the chosen basic policy option, and it continues to be set according to that policy option irrespective of the subsequent outcomes for unemployment and expected inflation. The implementation of the threshold-based policy relies on four endogenous trigger variables, DMPTLUR, DMPTPI, DMPTMAX, and DMPTR. When either of the thresholds has been crossed, the value of DMPTR becomes 1.0 and remains at that value in subsequent quarters.

The final equation in the monetary policy block determines the value of the effective federal funds rate (RFFE) by modifying the value of RFFRULE for the effects of the thresholds, when they are turned on and are binding.

Other Interest Rates

In the block of equations that determines other interest rates, the most important are those for yields on BBB corporate bonds (RBBBE) and 5-, 10-, and 30-year government bonds (RG5E, RG10E, RG30E). 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/risk premium. The equations employ an approximation in which the weighted average is calculated over an infinite horizon and the weights decline at a geometric rate that is based on the bond's duration. The latter is calculated as a function of the bond's maturity and the average historical level of nominal interest rates.

(1) $R_t^{(m)} = (1-w^{(m)})E_t[\sum(i=0,\infty)w^{(m)i}\ r_{t+i}] + \varphi_t^{(m)}$

where $R^{(m)}$ is the rate of interest on a bond whose maturity is m quarters, r is the federal funds rate, and $\varphi^{(m)}$ is the term/risk premium. The following formulas define the value of $w^{(m)}$.

(2) $w^{(m)} = (D^{(m)}-1)/D^{(m)}$

(3) $D^{(m)} = (1-g^m)/(1-g)$

(4) $g = 1/(1+(R\hat{})^{.25})$

$D^{(m)}$ is the duration of a bond whose maturity is m quarters. R^ is the average nominal rate of interest.

The term/risk premiums $\varphi^{(m)}$ associated with the four bond rates consist of a constant, a serially correlated residual, and an element that varies with the output gap (x) expressed as a present value with the same form as the funds rate present value.

(5) $(1-w^{(m)})E_t[\sum(i=0,\infty)w^{(m)i}\ x_{t+i}]$

The funds rate present value in equation (1) is assigned to a variable whose name starts with the characters ZRFF (eg, ZRFF10) and the output gap present value in equation (5) is assigned to a variable whose name starts ZGAP (eg, ZGAP10).

In addition to the four main bond rates, the second block of equations contains estimated equations for yields on Treasury bills (RTBE), home mortgages (RME), and new car loans (RCAR).

Wealth

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 (WPSN) and other (WPON). The former is determined using a linearization of the standard Gordon formula, in which stock prices depend on the level of dividends (proxied by one-half the level of after-tax corporate profits), expected future growth in dividends, the real interest rate (on 30-year government bonds), and an equity premium. The equity premium is a function of the BBB premium and a serially correlated error. The change from one quarter to the next in household net worth excluding corporate equity equals the sum of personal savings, net investment in consumer durables, and capital gains on houses and other assets.

i.1 RFFTAY: Value of eff. federal funds rate given by the Taylor rule with output gap

RFFTAY is a version of the Taylor Rule. According to the equation, the nominal funds rate equals 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).

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$$\begin{aligned} \textbf{RFFTAY} = {} & \text{RSTAR} \\ & + \Sigma_{i=0,3}(\text{PICXFE}_{t-i})/4) \\ & + 0.500 * (\Sigma_{i=0,3}(\text{PICXFE}_{t-i})/4) - \text{PITARG}) \\ & + 1.00 * \text{XGAP2} \end{aligned}$$

i.2 RFFTLR: Value of eff. federal funds rate given by the Taylor rule with unemployment gap

RFFTLR is a version of the Taylor Rule. According to the equation, the nominal funds rate equals 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 unemployment rate from the natural rate of unemployment.

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RFFTLR = RSTAR

$$- 0.500 * PITARG$$
$$+ 0.375 * (\Sigma_{i=0,3}(PICXFE_{t-i}))$$
$$+ 1.10 * (LURNAT + DEUC * LEUC - LUR)$$

i.3 RFFINTAY: Value of eff. federal funds rate given by the inertial Taylor rule

RFFINTAY is an inertial version of the Taylor Rule. According to the equation, the nominal funds rate gradually adjusts to a value consistent with a Taylor rule in which the funds equals the sum of the equilibrium real funds rate as perceived by policymakers (RSTAR), a four-quarter moving average of actual inflation, and adjustements in response to deviations of actual inflation from the target rate of inflation (PITARG) and deviations of the level of output from potential (XGAP2).

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RFFINTAY = $0.850 * RFFE_{t-1}$

$$+ (1-0.850) * (RSTAR$$
$$+ \Sigma_{i=0,3}(PICXFE_{t-i})/4)$$
$$+ 0.500 * (\Sigma_{i=0,3}(PICXFE_{t-i})/4) - PITARG)$$
$$+ 1.00 * XGAP2)$$

i.4 RFFALT: Value of eff. federal funds rate given by estimated policy rule

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RFFALT = 0.0551

+ 1.20 * RFF$_{t-1}$
- 0.390 * RFF$_{t-2}$
+ 0.695 * XGAP2
- 0.517 * XGAP2$_{t-1}$
+ 0.329 * ($\Sigma_{i=0,3}$(PICXFE $_{t-i}$)/4))

i.5 RFFGEN: Value of eff. federal funds rate given by the generalized 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.

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RFFGEN = 0.00
+ A1(L) {sum 0.00 } * RFFE $_{t-1}$
+ A2(L) {sum 1.50 } * PICNIA $_t$
+ A3(L) {sum 0.500 } * XGAP2 $_t$
+ A4(L) {sum 0.00 } * LUR $_t$
+ A5(L) {sum 0.00 } * PCNIA $_t$
+ B1(L) {sum 1.00 } * RSTAR $_t$
+ B2(L) {sum -0.500 } * PITARG $_t$
+ B4(L) {sum 0.00 } * LURNAT $_t$
+ B5(L) {sum 0.00 } * PCSTAR $_t$
+ B6(L) {sum 0.00 } * PICXFE $_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	0.00	$A3_4$	0.00	$B1_2$	0.00	$B4_{SUM}$	0.00
$A1_1$	0.00	$A3_{SUM}$	0.500	$B1_3$	0.00	$B5_0$	0.00
$A1_2$	0.00	$A4_0$	0.00	$B1_4$	0.00	$B5_1$	0.00

$A1_{3}$	0.00	$A4_{1}$	0.00	$B1_{SUM}$	1.00	$B5_{2}$	0.00
$A1_{SUM}$	0.00	$A4_{2}$	0.00	$B2_{0}$	-0.500	$B5_{3}$	0.00
$A2_{0}$	0.375	$A4_{3}$	0.00	$B2_{1}$	0.00	$B5_{4}$	0.00
$A2_{1}$	0.375	$A4_{4}$	0.00	$B2_{2}$	0.00	$B5_{SUM}$	0.00
$A2_{2}$	0.375	$A4_{SUM}$	0.00	$B2_{3}$	0.00	$B6_{0}$	0.00
$A2_{3}$	0.375	$A5_{0}$	0.00	$B2_{4}$	0.00	$B6_{1}$	0.00
$A2_{4}$	0.00	$A5_{1}$	0.00	$B2_{SUM}$	-0.500	$B6_{2}$	0.00
$A2_{SUM}$	1.50	$A5_{2}$	0.00	$B4_{0}$	0.00	$B6_{3}$	0.00
$A3_{0}$	0.500	$A5_{3}$	0.00	$B4_{1}$	0.00	$B6_{4}$	0.00
$A3_{1}$	0.00	$A5_{4}$	0.00	$B4_{2}$	0.00		
$A3_{2}$	0.00	$A5_{SUM}$	0.00	$B4_{3}$	0.00		
$A3_{3}$	0.00	$B1_{0}$	1.00	$B4_{4}$	0.00		
		$B1_{1}$	0.00				

i.6 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.

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$$\textbf{RSTAR} = RSTAR_{t-1} + 0.0500 * ((RRFFE - RSTAR_{t-1}) * DRSTAR)$$

i.7 RFFRULE: Federal funds rate (effective ann. yield)

The RFFRULE equation combines the seven basic options for setting the federal funds rate in a form that yields the outcome for the funds rate under the chosen option. The funds rate is exogenous in nominal terms when DMPEX is one and the other policy switches are zero. The funds rate is exogenous in real terms when DMPRR is one. Other settings select one of the policy reaction functions. The equation sets a lower limit on the nominal funds rate, based on the value of RFFMIN. Setting it to zero (or a small positive value) imposes the zero lower bound; setting it to a large negative number effectively eliminates the constraint.

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$$
\begin{aligned}
\textbf{RFFRULE} = \text{MAX}(&\text{DMPEX} * 100 * ((1+\text{RFFFIX}/36000)**365-1) \\
&+ \text{DMPRR} * (\text{RRFIX} + \Sigma_{i=0,3}(\text{PICXFE}_{t-i})/4)) \\
&+ \text{DMPTAY} * \text{RFFTAY} \\
&+ \text{DMPTLR} * \text{RFFTLR} \\
&+ \text{DMPINTAY} * \text{RFFINTAY} \\
&+ \text{DMPALT} * 100*((1+\text{RFFALT}/36000)**365-1) \\
&+ \text{DMPGEN} * \text{RFFGEN}, \text{RFFMIN})
\end{aligned}
$$

i.8 DMPTLUR: Monetary policy indicator for unemployment threshold

DMPTLUR equals zero when the unemployment rate is above its threshold (LURTRSH) one when it is below. A logistic function smoothes the transition, improving solution convergence properties.

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$$\textbf{DMPTLUR} = 1/(1+\exp(25.0 *(\text{LUR}-\text{LURTRSH})))$$

i.9 DMPTPI: Monetary policy indicator for inflation threshold

DMPTPI equals zero when expected inflation is below its threshold and one when it is above. A logistic function smoothes the transition, improving solution convergence properties.

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$$\textbf{DMPTPI} = 1/(1+\exp(-25.0 *(\text{ZPIC58}-\text{PITRSH})))$$

i.10 DMPTMAX: Monetary policy indicator for both thresholds

DMPTMAX equals one when either the unemployment threshold or the inflation threshold is breached.

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$$\textbf{DMPTMAX} = \max(DMPTLUR, DMPTPI)$$

i.11 DMPTR: Monetary policy indicator for policy rule thresholds

DMPTR is initially zero. It remains at that value until either the unemployment threshold or the inflation threshold is breached, after which it equals one.

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$$\textbf{DMPTR} = \max(DMPTMAX, DMPTR_{t-1})$$

i.12 RFFE: Federal funds rate (effective ann. yield)

The equation for the effective federal funds rate imposes the lower bound (RFFMIN) and, when DMPTRSH = 1, imposes a version of the unemployment and inflation threshold policy that appeared in FOMC statements from December 2012 to January 2014. In a ZLB episode, DMPTR = 0 before the thresholds are reached, and the funds rate is equal to the value of RFFMIN. After one of the thresholds is breached, DMPTR = 1, and, with a one-quarter lag, the funds rate is set according to the policy rule chosen by RFFRULE.

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$$\begin{aligned}\textbf{RFFE} = {} & (1-DMPTRSH) * MAX(RFFRULE, RFFMIN) \\ & + DMPTRSH * MAX((DMPTR_{t-1}*RFFRULE + (1-DMPTR_{t-1})*RFFMIN), RFFMIN)\end{aligned}$$

i.13 RFF: Federal funds rate

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$$\textbf{RFF} = 36000*((1+.01*\text{RFFE})**(1/365) - 1)$$

i.14 DELRFF: Federal funds rate, first diff

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$$\textbf{DELRFF} = \text{RFF} - \text{RFF}_{t-1}$$

i.15 RRFFE: Real federal funds rate (effective ann. yield)

The real federal funds rate (RRFFE) is defined as the nominal effective funds rate (RFFE) minus a 4-quarter moving average of core consumer price inflation (PICXFE).

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$$\textbf{RRFFE} = \text{RFFE} - \Sigma_{i=0,3}(\text{PICXFE}_{\ t-i})/4)$$

i.16 RTBE: 3-month Treasury bill rate (effective ann. yield)

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$$\textbf{RTBE} = -0.0668\ [-2.14]$$
$$+ B1(L)\ \{sum\ 0.894\ \} * \text{RTBE}_{\ t-1}$$
$$+ B2(L)\ \{sum\ 0.106\ \} * \text{RFFE}_{\ t}$$

Distributed lag coefficients

Name	Value
$B1_0$	0.772 [16.40]
$B1_1$	0.122 [4.13]
$B1_{SUM}$	0.894
$B2_0$	0.785 [31.74]
$B2_1$	-0.680
$B2_{SUM}$	0.106

Regression statistics

Adjusted R^2:	0.990
S.E. of regression:	0.342
Sum of squared residuals:	22.4
Durbin-Watson statistic:	2.18
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.17 RTB: 3-month Treasury bill rate

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RTB = 36000/90 * (1-(.01*RTBE+1)**(-90/365))

i.18 RG5P: 5-year Treasury note rate. term premium

The term premium on 5-year Treasury bonds consists of a constant, a serially correlated residual, and a counter-cyclical term that depends on a weighted average of expected future output gaps.

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RG5P = 0.748 [1.52]
- 0.398 [-5.65] * ZGAP05
+ 0.912 [24.79] * ($RG5P_{t-1}$ - 0.748 [1.52] - -0.398 [-5.65]*$ZGAP05_{t-1}$)

Regression statistics

Adjusted R^2:	0.850
S.E. of regression:	0.504
Sum of squared residuals:	33.8
Durbin-Watson statistic:	1.90
Sample period:	1980Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.19 RG5E: 5-year Treasury note rate (effective ann. yield)

The yield on five-year Treasury bonds equals a duration-specific weighted average of the future values of the federal funds (ZRFF5) plus a endogenous term premium (RG5P).

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RG5E = ZRFF5 + RG5P

i.20 RG5: 5-year Treasury note rate

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RG5 = (((.01*RG5E + 1)**.5 - 1) * 200)

i.21 RG10P: 10-year Treasury bond rate, term premium

The term premium on 10-year Treasury bonds consists of a constant (which shifts upward over 1980-1995), a serially correlated residual, and a counter-cyclical term that depends on a weighted average of expected future output gaps.

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RG10P = 0.999 [2.48]

- 0.472 [-3.89] * ZGAP10

+ 0.731 [2.26] * D8095

+ 0.896 [21.93] * ($RG10P_{t-1}$ - 0.999 [2.48] - -0.472 [-3.89]*$ZGAP10_{t-1}$ - 0.731 [2.26]*$D8095_{t-1}$)

Regression statistics

Adjusted R^2:	0.880
S.E. of regression:	0.455
Sum of squared residuals:	27.3
Durbin-Watson statistic:	1.67
Sample period:	1980Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.22 RG10E: 10-year Treasury bond rate (effective ann. yield)

The yield on ten-year Treasury bonds equals a duration-specific weighted average of the future values of the federal funds (ZRFF10) plus a endogenous term premium (RG10P).

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RG10E = ZRFF10 + RG10P

i.23 RG10: 10-year Treasury bond rate

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RG10 = (((.01*RG10E + 1)**.5 - 1) * 200)

i.24 RG30P: 30-year Treasury bond rate, term premium

The term premium on 30-year Treasury bonds consists of a constant (which shifts upward over 1980-1995), a serially correlated residual, and a counter-cyclical term that depends on a weighted average of expected future output gaps.

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RG30P = 1.34 [3.20]

- 0.589 [-2.69] * ZGAP30

+ 0.837 [2.67] * D8095

+ 0.905 [23.41] * ($RG30P_{t-1}$ - 1.34 [3.20] - -0.589 [-2.69]*$ZGAP30_{t-1}$ - 0.837 [2.67]*$D8095_{t-1}$)

Regression statistics

Adjusted R^2:	0.890
S.E. of regression:	0.437
Sum of squared residuals:	25.2
Durbin-Watson statistic:	1.64
Sample period:	1980Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.25 RG30E: 30-year Treasury bond rate (effective ann. yield)

The yield on thirty-year Treasury bonds equals a duration-specific weighted average of the future values of the federal funds (ZRFF30) plus a endogenous term premium (RG30P).

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RG30E = ZRFF30 + RG30P

i.26 RG30: 30-year Treasury bond rate

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RG30 = (((.01*RG30E + 1)**.5 - 1) * 200)

i.27 RBBBP: S&P BBB corporate bond rate, risk/term premium

The term premium on BBB corporate bonds consists of a constant, a serially correlated residual, and a counter-cyclical term that depends on a weighted average of expected future output gaps.

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RBBBP = 1.66 [7.75]
- 0.149 [-2.28] * ZGAP10
+ 0.887 [22.15] * ($RBBBP_{t-1}$ - 1.66 - -0.149 *$ZGAP10_{t-1}$)

Regression statistics

Adjusted R^2:	0.810
S.E. of regression:	0.287
Sum of squared residuals:	11.3
Durbin-Watson statistic:	1.78
Sample period:	1973Q1 2007Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.28 RBBBE: S&P BBB corporate bond rate (effective ann. yield)

The yield on long-term BBB corporate bonds is equal to the ten-year Treasury bond yield (RG10E) plus an endogenous risk premium (RBBBP).

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RBBBE = RBBBP + RG10E

i.29 RBBB: S&P BBB corporate bond rate

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RBBB = (((0.01*RBBBE + 1)**.5 - 1) * 200)

i.30 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.

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RCAR = 2.10 [6.86]
- 1.17 [-4.50] * D79A
- 0.00839[-3.46] * ((1-D79A)*T47)
+ 0.694 [25.59] * $RCAR_{t-1}$
+ A4(L) {sum 0.306 } * $RG5_t$

Distributed lag coefficients

Name	Value
$A4_0$	0.103 [2.65]
$A4_1$	0.203
$A4_{SUM}$	0.306

Regression statistics

Adjusted R^2:	0.990
S.E. of regression:	0.301
Sum of squared residuals:	17.3
Durbin-Watson statistic:	1.55

Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.31 RME: Interest rate on conventional mortgages (effective ann. yield)

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Δ(RME) = 0.493 [5.59]
+ 0.678 [11.94] * Δ(RG10E)
+ 0.242 [2.50] * D87 * Δ(RG10E)
+ 0.231 [5.73] * ($RG10E_{t-1}$-RME_{t-1})
+ 0.0681 [2.45] * D87 * ($RG10E_{t-1}$-RME_{t-1})

Regression statistics

Adjusted R^2:	0.630
S.E. of regression:	0.321
Sum of squared residuals:	19.6
Durbin-Watson statistic:	1.84
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.32 REQP: Real expected rate of return on equity, premium component

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REQP = 2.88 [5.26] + 0.640 [3.16] * RBBBP
+ 0.819 [15.19] * ($REQP_{t-1}$ - 2.88 - 0.640 *$RBBBP_{t-1}$)

Regression statistics

Adjusted R^2:	0.750
S.E. of regression:	0.818
Sum of squared residuals:	75.6

Durbin-Watson statistic:	2.48
Sample period:	1985Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.33 REQ: Real expected rate of return on equity

The rate of return on equity equals the rate on thirty-year Treasury bonds (RG30E), minus the average rate of inflation expected to prevail over the coming 30 years (ZPIC30), plus an equity premium (REQP). The latter varies with the corporate bond premium (RBBBP) and also includes an AR(1) error term.

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REQ = RG30E - ZPIC30 + REQP

i.34 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 half corporate profits (YNICPN) less corporate taxes (TFCIN+TSCIN). The equation is expressed as a semi-log approximation to improve model simulation properties. The linearization assumes a long-run average dividend-price ratio of 4 percent, which is consistent with a long-run real required return on equity of 7 percent and a real dividend growth rate of 3 percent.

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log(WPSN) = log((YNICPN-TFCIN-TSCIN)*.5)
- .25 * (REQ-ZDIVGR)
+ log(25) + 1

i.35 WPS: Household stock market wealth, real

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$$\textbf{WPS} = \text{WPSN}/(.01*\text{PCNIA})$$

i.36 RCGAIN: Rate of capital gain on the non-equity portion of household wealth

RCGAIN measures the rate of capital gain on non-equity, non-housing household net worth. In addtion to an adjustment for inflation, its equation has a cyclical component and an autocorrelated residual.

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$$\begin{aligned}\textbf{RCGAIN} = {} & \text{PICX4} + 0.152\ [0.46] \\ & + 0.299\ [2.66] * \text{XGAP2} \\ & + 0.251\ [3.65] * (\text{RCGAIN}_{t-1} - \text{PICX4}_{t-1} - 0.152 \\ & - 0.299 * \text{XGAP2}_{t-1}\ )\end{aligned}$$

Regression statistics

Adjusted R^2:	0.100
S.E. of regression:	3.5
Sum of squared residuals:	2.44e+03
Durbin-Watson statistic:	2.07
Sample period:	1963Q3 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.37 PHOUSE: Loan Performance House Price Index

The price of owner-occupied real estate is modeled in an error-correction format. The housing price is proportional to housing rents (PCHR*PCNIA) in the long run.

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$$\mathbf{\Delta(\log(PHOUSE))} = 0.00482\ [3.51] + 0.890\ [25.84] * \Delta(\log(PHOUSE_{t-1})) - 0.0112\ [-3.09] * \log(PHOUSE_{t-1}/(PCHR_{t-1}*PCNIA_{t-1}))$$

Regression statistics

Adjusted R^2:	0.830
S.E. of regression:	0.00784
Sum of squared residuals:	0.00915
Durbin-Watson statistic:	1.73
Sample period:	1976Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.38 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 housing and other assets. The capital gains on housing and other assets are weighted by their ratios to WPON. PHOUSE is scaled by a factor of 116 so that PHOUSE*KH matches housing wealth (both owner occupied and noncorporate rental real estate) from the Flow of Funds over the past decade.

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$$\begin{aligned}\mathbf{WPON} = {} & WPON_{t-1}*\exp(\ (1-((PHOUSE_{t-1}*KH_{t-1}/116)/WPON_{t-1}))*RCGAIN/400 \\ & + ((PHOUSE_{t-1}*KH_{t-1}/116)/WPON_{t-1})*\Delta(\log(PHOUSE))\ ) \\ & + .25 * (YDN-ECNIAN-YHIBN) \\ & + .25 * (.01*PCDR*PCNIA*(ECD-JKCD))\end{aligned}$$

i.39 MEI: Multiplicative discrepancy for the difference between XGDI and XGDO

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$$\log(MEI) = 0.860 * \log(MEI_{t-1})$$

i.40 WPO: Household property wealth ex. stock market, real

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WPO = WPON/(.01*PCNIA)

i.41 MEP: Multiplicative discrepancy for the difference between XGDP and XGDO

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$$\log(MEP) = 0.860 * \log(MEP_{t-1})$$

i.42 RGW: Approximate average rate of interest on new federal debt

The weighted average of the four current treasury yields, with the weights based on the Treasury's average issue patterns over some appropriate period.

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RGW = 0.00495 * RTB
+ 0.00271 * RG5
+ 0.00129 * RG10
+ 0.00105 * RG30

i.43 RGFINT: Average rate of interest on existing federal debt

The average rate of interest on federal government debt (RGFINT) is measured historically as the ratio of net interest paid to the lagged stock of debt outstanding. In this equation, RGFINT adjusts toward the weighted average rate of interest on new government debt (RGW), with the speed of adjustment depending positively on the rate of growth of debt.

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$$\textbf{RGFINT} = (0.860 * RGFINT_{t-1} + (1-0.860\ )*RGW_{t-1})*(GFDBTN_{t-2}/GFDBTN_{t-1})$$
$$+ RGW_{t-1}*(1-GFDBTN_{t-2}/GFDBTN_{t-1}) + 0.00542\ [26.62]$$

Regression statistics

Adjusted R^2:	0.990
S.E. of regression:	0.00285
Sum of squared residuals:	0.00158
Durbin-Watson statistic:	1.64
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

i.44 RRMET: Real mortgage rate, trend

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$$\textbf{RRMET} = 0.905 * RRMET_{t-1}$$
$$+ 0.0952 * (RME-ZPI10)$$

Foreign Activity

Key measures of foreign activity are determined in a small-scale reduced-form forecasting model. The system contains four primary equations: an estimated "IS" curve, in which the level of foreign output gap is a function of the real short-term interest rate abroad; an estimated foreign inflation equation in which inflation expectations are expressed as a weighted average of past and target inflation; an imposed monetary policy reaction function that determines the foreign short-term rate of interest; and an estimated yield curve equation in which the foreign bond rate depends on the foriegn short-term rate and the foreign output gap. Coefficient restrictions are imposed to ensure long-run stability.

The real exchange rate is determined via an open interest parity condition based on real bond rates, augmented with a term to capture country risk.

Additional identities use exogenous conversion factors to translate many of the foreign variables between different country coverages (G10 vs G39) and different aggregation weights.

j.1 FXGAP: Foreign output gap (world, bilateral export weights)

The equation for the foreign output gap is a reduced-form IS curve. The gap depends on lags of the foreign output gap, the real short-term foreign interest rate (FRS10 less a moving average of FPI10), and the U.S. output gap (XGAP2). The coefficient on the real short-term interest rate is set equal to the estimate from a similar equation estimated on U.S. data.

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FXGAP =

$$+ 1.28\ [19.51] * FXGAP_{t-1}$$
$$- 0.454\ [-7.16] * FXGAP_{t-2}$$
$$- 0.0500 * (\Sigma_{i=0,2}(FRS10_{t-i-1}$$
$$-(FPI10_{t-i-1}+FPI10_{t-i-2}+FPI10_{t-i-3}+FPI10_{t-i-4})/4)/3)-FRSTAR)$$
$$+ 0.0274\ [2.09] * XGAP2_{t-1}$$

Regression statistics

Adjusted R^2:	0.850

S.E. of regression:	0.491
Sum of squared residuals:	46.5
Durbin-Watson statistic:	1.94
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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).

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$$\mathbf{FGDP} = FGDPT * \exp(FXGAP/100)$$

j.3 FGDPT: Foreign aggregate GDP (world, bilateral export weights), trend

In simulations, the level of trend foreign GDP moves in proportion with level of U.S potential GDP in the long run. In the short run, the rate of growth of the foreign trend varies one-for-one with the rate of growth of U.S. potential output.

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$$\begin{aligned}\mathbf{\Delta(\log(FGDPT))} = & -0.458 \\ & - 0.100 * \log(FGDPT_{t-1}/XGDPT_{t-1}) \\ & + 1.00 * (HGGDPT+HGGDPT_{t-1}+HGGDPT_{t-2}+HGGDPT_{t-3}) / 1600\end{aligned}$$

j.4 FPI10: Foreign consumer price inflation (G10)

Foreign CPI inflation is a function of a weighted average of past and trend foreign inflation, the foreign output gap, and current and lagged changes in the relative price of oil. Historical values of trend inflation (FPITRG) are measured as a step function whose value since 1991 is 2.1 percent.

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$$\textbf{FPI10=}\ 0.705\ [13.78] * (\Sigma_{i=0,3}(\ FPI10_{\ t-i-1})/4)\ )$$
$$+\ 0.295 * FPITRG$$
$$+\ 0.253\ [4.08] * FXGAP_{t-1}$$
$$+\ B4(L)\ \{sum\ 6.24\ \} * \Delta(\ \log(POILR_{\ t}))$$

Distributed lag coefficients

Name	**Value**
$B4_0$	5.32 [8.67]
$B4_1$	0.916 [1.49]
$B4_{SUM}$	6.24

Regression statistics

Adjusted R^2:	0.900
S.E. of regression:	1.05
Sum of squared residuals:	203
Durbin-Watson statistic:	1.42
Sample period:	1967Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

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.

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$$\textbf{FPI10T=}\ 0.950\ [0.00] * FPI10T_{t-1}$$
$$+\ 0.0500\ [0.00] * FPI10$$

j.6 FPIC: Foreign consumer price inflation (G39, bilateral export trade weights)

In the long run, foreign consumer price inflation as measured on a G39 basis moves one for one with foreign inflation as measured on a G10 basis.

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FPIC= 2.17 [5.79]
+ 0.699 [10.48] * FPI10
+ 0.301 * $FPIC_{t-1}$

Regression statistics

Adjusted R^2:	0.420
S.E. of regression:	4.38
Sum of squared residuals:	3.73e+03
Durbin-Watson statistic:	2.10
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

j.7 FPC: Foreign aggregate consumer price (G39, import/export trade weights)

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FPC = FPC_{t-1}*exp(FPIC/400)

j.8 FPCM: Foreign aggregate consumer price (G39, bilateral non-oil import trade weights)

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FPCM = UFPCM*FPC

j.9 FRS10: Foreign short-term interest rate (G10)

The foreign short-term interest rate (FRS10) is set either according to a version of the Taylor rule (DFMPRR = 0), or as the sum of an exogenous real interest rate (RFRS10) and a four-quarter moving average of foreign CPI inflation (DFMPRR = 1).

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$$
\begin{aligned}
\textbf{FRS10} = {} & \text{DFMPRR} * (0.00 \\
& + 1.00 * \text{FRSTAR}_{t-1} \\
& + 1.00 * (\Sigma_{i=0,3}(\text{FPI10}_{t-i})/4)) \\
& + 0.500 * (\Sigma_{i=0,3}(\text{FPI10}_{t-i})/4) - \text{FPITRG}) \\
& + 1.00 * \text{FXGAP}) \\
& + (1-\text{DFMPRR}) * (\text{RFRS10} + \Sigma_{i=0,3}(\text{FPI10}_{t-i})/4))
\end{aligned}
$$

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.

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$$
\begin{aligned}
\textbf{FRSTAR} = {} & 0.950 * \text{FRSTAR}_{t-1} \\
& + 0.0500 * (\text{FRS10} - \Sigma_{i=0,3}(\text{FPI10}_{t-i})/4))
\end{aligned}
$$

j.11 FRL10: Foreign long-term interest rate (G10)

The foreign long-term interest rate (FRL10) is modeled using a reduced-form error-correction specification in which the long rate converges to the foreign short-term interest rate plus a constant premium.

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FRL10 - FRL10(-1) = 0.0399 [1.23]
- 0.0729 [-3.08] * $(FRL10_{t-1} - FRS10_{t-1})$
+ 0.0840 [1.17] * $(FRL10_{t-1} - FRL10_{t-2})$
+ 0.364 [6.92] * $(FRS10 - FRS10_{t-1})$
+ 0.132 [2.43] * $(FXGAP - FXGAP_{t-1})$

Regression statistics

Adjusted R^2:	0.390
S.E. of regression:	0.296
Sum of squared residuals:	11.5
Durbin-Watson statistic:	1.67
Sample period:	1980Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

j.12 FPXR: Real exchange rate (G39, import/export trade weights)

The real exchange rate is determined via an open interest parity condition based on real bond rates, augmented with a term in the ratio of the net stock of U.S. claims on the rest of the world to U.S. GDP that captures country risk. The equation is written as an identity through the inclusion of a multiplicative residual, FPXRR.

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log(FPXR) - log(FPXRR) =
0.0480 *(RG10E-ZPI10F-FRL10+FPI10T)
+ 0.500 *(FNIN/XGDPN)

j.13 FPXRR: Real exchange rate residual

The unexplained component of the exchange rate error-corrects to its long-run exogenous trend (FPXRRT).

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$$\mathbf{\Delta(log(FPXRR))} = 0.0301\ [2.25] * \log(FPXRRT_{t-1}/FPXRR_{t-1})$$
$$+\ 0.203\ [2.91] * \Delta(\log(FPXRR_{t-1}))$$
$$+\ (1-0.203\ [2.91]) * \Delta(\log(FPXRRT))$$

Regression statistics

Adjusted R^2:	0.060
S.E. of regression:	0.0286
Sum of squared residuals:	0.158
Durbin-Watson statistic:	2.00
Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

j.14 FPX: Nominal exchange rate (G39, import/export trade weights)

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FPX = FPXR*FPC/PCPI

j.15 FPXM: Nominal exchange rate (G39, bilateral import trade weights)

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FPXM = UFPXM*FPX*FPCM/FPC

Expectations

This sector contains the identities that are used for expectational variables when the assumption of "VAR" expectations is employed. The form of each identity is determined by the structure and parameters of the sub-model that is used to estimate the structural equation in which the expectation appears. In most cases, the expectation is for a weighted sum of a variable over future quarters. The exceptions are in the wage-price block (ZPICXFE, ZPIECI), where expectations are for one period ahead. In all cases, the VAR expectation is expressed as a linear function of an observable information set. Two types of parameters determine the coefficient values in the typical expectations equation: discounting weights that specify the horizon of each expectation and coefficients of the VAR system used to generate forecasts that proxy for expectations in the estimation sub-model.

In the VAR-expectations formulas, the information set 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 financial equations assume that current-period data are in the information set, while those in 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 PAC equation's 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. The sum of the discounting weights in PAC expectations is not unity. For the expectational components of long-term interest rates and the required rate of return on equity, the discounting weights sum to unity and depend on the duration of the financial instrument. For the expectations of permanent income appearing in the target level of consumption, the discouting weights sum to unity and are based on a general discount factor of 25 percent per year.

For further information, see Var Expectations Basics.

z1.1 PTR: 10-year expected PCE price inflation (Survey of Professional Forecasters)

PTR gradually adjusts toward a weighted average of actual and target inflation.

Historical values of PTR come from several sources. Since 1991q4, the source is the Survey of Professional Forecasters (SPF), first for expected CPI inflation and then, when it becomes available in 2007, for expected PCE price inflation. PTR data from 1981q1 to 1991q3 is primarily from a survey conducted by Richard Hoey. The Hoey and SPF CPI observations are reduced by 40 basis to account for the average difference between CPI and PCE inflation. Values of PTR before 1981 are constructed in a manner similar to the one described in Kozicki and Tinsley (2001, section 3.3), "Term Structure Views of Monetary Policy under Alternative Models of Agent Expectations," Journal of Economic Dynamics and Control, 25: 149-184.

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$$\mathbf{PTR} = 0.900 * PTR_{t-1} + 0.0500 * PICXFE_{t-1} + 0.0500 * PITARG_{t-1}$$

z1.2 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.

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$$\mathbf{RRTR} = 0.970 * RRTR_{t-1} + 0.0300 * RRFFE$$

z1.3 RTR: Expected federal funds rate in the long run (Blue Chip)

Historical values of RTR since 1984q3 are based on data from the Blue Chip Survey. Prior to that, RTR = PTR + 2.0.

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RTR = RRTR + PTR

z1.4 ZRFF5: Expected federal funds rate, for RG5E eq. (5-yr mat.) (VAR exp.)

ZRFF5 is a weighted average of future federal funds rates. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

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ZRFF5= -2.89E-13
+ A1(L) {sum -0.105 } * $PICNIA_t$
+ A2(L) {sum 0.369 } * $RFFE_t$
+ 0.631 * RTR
+ 0.105 * PTR
+ A5(L) {sum 0.166 } * $XGAP_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	-0.0333	$A1_{SUM}$	-0.105	$A2_{SUM}$	0.369
$A1_1$	-0.0165	$A2_0$	0.264	$A5_0$	0.705
$A1_2$	-0.0523	$A2_1$	-0.0190	$A5_1$	-0.488
$A1_3$	-0.00254	$A2_2$	0.216	$A5_2$	-0.0222
		$A2_3$	-0.0928	$A5_3$	-0.0289
				$A5_{SUM}$	0.166

Regression statistics

Sample period:	1964Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.5 ZRFF10: Expected federal funds rate, for RG10E eq. (10-yr mat.) (VAR exp.)

ZRFF10 is a weighted average of future federal funds rates. The weights sum to one and decline geometrically at a rate based on the average duration of a ten-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

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ZRFF10= -1.23E-13
+ A1(L) {sum -0.0733 } * PICNIA $_t$
+ A2(L) {sum 0.231 } * RFFE $_t$
+ 0.769 * RTR
+ 0.0733 * PTR
+ A5(L) {sum 0.0881 } * XGAP $_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	-0.0277	$A1_{SUM}$	-0.0733	$A2_{SUM}$	0.231
$A1_1$	-0.0119	$A2_0$	0.159	$A5_0$	0.424
$A1_2$	-0.0329	$A2_1$	-0.00651	$A5_1$	-0.297
$A1_3$	-0.000799	$A2_2$	0.133	$A5_2$	-0.0184
		$A2_3$	-0.0540	$A5_3$	-0.0206
				$A5_{SUM}$	0.0881

Regression statistics

Sample period:	1964Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.6 ZRFF30: Expected federal funds rate, for RG30E eq. (30-yr mat.) (VAR exp.)

ZRFF30 is a weighted average of future federal funds rates. The weights sum to one and decline geometrically at a rate based on the average duration of a thirty-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

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ZRFF30= -6.43E-14
+ A1(L) {sum -0.0392 } * PICNIA $_t$
+ A2(L) {sum 0.124 } * RFFE $_t$
+ 0.876 * RTR
+ 0.0392 * PTR
+ A5(L) {sum 0.0468 } * XGAP $_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	-0.0147	$A1_{SUM}$	-0.0392	$A2_{SUM}$	0.124
$A1_1$	-0.00637	$A2_0$	0.0854	$A5_0$	0.227
$A1_2$	-0.0176	$A2_1$	-0.00361	$A5_1$	-0.159
$A1_3$	-0.000475	$A2_2$	0.0710	$A5_2$	-0.00976
		$A2_3$	-0.0290	$A5_3$	-0.0109
				$A5_{SUM}$	0.0468

Regression statistics

Sample period:	1964Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.7 ZGAP05: Expected output gap, for RG5E eq. (VAR exp.)

ZGAP05 is a weighted average of expected future output gaps. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

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ZGAP05= 2.26E-15
+ A1(L) {sum -0.205 } * PICNIA $_t$
+ A2(L) {sum -0.148 } * RFFE $_t$
+ 0.148 * RTR
+ 0.205 * PTR
+ A5(L) {sum 0.476 } * XGAP $_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	-0.160	$A1_{SUM}$	-0.205	$A2_{SUM}$	-0.148
$A1_1$	-0.0271	$A2_0$	-0.392	$A5_0$	1.04
$A1_2$	-0.0564	$A2_1$	0.105	$A5_1$	-0.412
$A1_3$	0.0379	$A2_2$	0.116	$A5_2$	-0.0622
		$A2_3$	0.0236	$A5_3$	-0.0951
				$A5_{SUM}$	0.476

Regression statistics

Sample period:	1964Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.8 ZGAP10: Expected output gap, for RG10E eq. (VAR exp.)

ZGAP10 is a weighted average of expected future output gaps. The weights sum to one and decline geometrically at a rate based on the average duration of a ten-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

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ZGAP10= 1.91E-15

+ A1(L) {sum -0.114 } * PICNIA$_t$
+ A2(L) {sum -0.0694 } * RFFE$_t$
+ 0.0694 * RTR
+ 0.114 * PTR
+ A5(L) {sum 0.249 } * XGAP$_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	-0.0886	$A1_{SUM}$	-0.114	$A2_{SUM}$	-0.0694
$A1_1$	-0.0151	$A2_0$	-0.205	$A5_0$	0.557
$A1_2$	-0.0306	$A2_1$	0.0579	$A5_1$	-0.221
$A1_3$	0.0204	$A2_2$	0.0641	$A5_2$	-0.0360
		$A2_3$	0.0134	$A5_3$	-0.0521
				$A5_{SUM}$	0.249

Regression statistics

Sample period: 1964Q1 2013Q4
Estimation date: August 2014
Estimation method: Least Squares

z1.9 ZGAP30: Expected output gap, for RG30E eq. (VAR exp.)

ZGAP30 is a weighted average of expected future output gaps. The weights sum to one and decline geometrically at a rate based on the average duration of a thirty-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

<td< td=""></td<>

ZGAP30= 9.19E-15
+ A1(L) {sum -0.0606 } * PICNIA$_t$
+ A2(L) {sum -0.0367 } * RFFE$_t$
+ 0.0367 * RTR
+ 0.0606 * PTR
+ A5(L) {sum 0.132 } * XGAP$_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	-0.0470	$A1_{SUM}$	-0.0606	$A2_{SUM}$	-0.0367
$A1_1$	-0.00806	$A2_0$	-0.109	$A5_0$	0.297
$A1_2$	-0.0164	$A2_1$	0.0307	$A5_1$	-0.118
$A1_3$	0.0108	$A2_2$	0.0343	$A5_2$	-0.0191
		$A2_3$	0.00691	$A5_3$	-0.0277
				$A5_{SUM}$	0.132

Regression statistics

Sample period:	1964Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.10 ZPI5: Expected cons. price infl., for RCCD eq. (5-yr mat.) (VAR exp.)

ZPI5 is a weighted average of future PCE price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

<td< td=""></td<>

ZPI5= B1(L) {sum 0.110 } * PICNIA $_{t-1}$
+ B2(L) {sum -0.234 } * RFFE $_{t-1}$
+ 0.234 * RTR$_{t-1}$
+ 0.890 * PTR$_{t-1}$
+ B5(L) {sum 0.195 } * XGAP $_{t-1}$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$B1_0$	0.0676	$B1_{SUM}$	0.110	$B2_{SUM}$	-0.234
$B1_1$	0.0216	$B2_0$	-0.178	$B5_0$	0.183
$B1_2$	0.0178	$B2_1$	-0.0122	$B5_1$	-0.0650
$B1_3$	0.00296	$B2_2$	-0.0334	$B5_2$	0.0529

$B2_3$	-0.0102	$B5_3$	0.0240
		$B5_{SUM}$	0.195

Regression statistics

Sample period: 1964Q2 2013Q4
Estimation date: August 2014
Estimation method: Least Squares

z1.11 ZPIB5: Expected output price infl., for RPD eq. (5-yr mat.) (VAR exp.)

ZPI5 is a weighted average of future business sector price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond. The equation shown below is the reduced-form representation of this expectational computation based on a small-scale VAR model.

<td< td=""></td<>

ZPIB5= 2.01E-14
+ A1(L) {sum 0.150 } * $PICNIA_{t-1}$
+ A2(L) {sum -0.332 } * $RFFE_{t-1}$
+ 0.332 * RTR_{t-1}
+ 0.755 * PTR_{t-1}
+ A5(L) {sum 0.213 } * $XGAP_{t-1}$
+ A6(L) {sum 0.0955 } * (400*Δ(log(PXB_{t-1})))

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	0.0838	$A1_{SUM}$	0.150	$A2_{SUM}$	-0.332	$A5_{SUM}$	0.213
$A1_1$	0.0397	$A2_0$	-0.238	$A5_0$	0.158	$A6_0$	0.0513
$A1_2$	0.0297	$A2_1$	-0.0286	$A5_1$	-0.0333	$A6_1$	0.0211
$A1_3$	-0.00329	$A2_2$	-0.0593	$A5_2$	0.0696	$A6_2$	0.00513
		$A2_3$	-0.00682	$A5_3$	0.0183	$A6_3$	0.0179
						$A6_{SUM}$	0.0955

Regression statistics

Sample period: 1964Q2 2013Q4

Estimation date: August 2014
Estimation method: Least Squares

z1.12 ZPI10: Expected cons. price infl., for RCCH, RRMET, and YHPNTN eqs. (10-yr mat.) (VAR exp.)

ZPI10 is a weighted average of future PCE price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a ten-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

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ZPI10= B1(L) {sum 0.0664 } * PICNIA $_{t-1}$
+ B2(L) {sum -0.145 } * RFFE $_{t-1}$
+ 0.145 * RTR$_{t-1}$
+ 0.934 * PTR$_{t-1}$
+ B5(L) {sum 0.103 } * XGAP $_{t-1}$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$B1_0$	0.0388	$B1_{SUM}$	0.0664	$B2_{SUM}$	-0.145
$B1_1$	0.0131	$B2_0$	-0.112	$B5_0$	0.0744
$B1_2$	0.0125	$B2_1$	-0.00522	$B5_1$	-0.0155
$B1_3$	0.00201	$B2_2$	-0.0277	$B5_2$	0.0299
		$B2_3$	-0.000980	$B5_3$	0.0143
				$B5_{SUM}$	0.103

Regression statistics

Sample period: 1964Q2 2013Q4
Estimation date: August 2014
Estimation method: Least Squares

z1.13 ZPI10F: Expected cons. price infl., for FPXR eq. (10-yr mat.) (VAR exp.)

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ZPI10F= ZPI10

z1.14 ZPIC30: Expected cons. price infl., for REQ eq. (30-yr mat.) (VAR exp.)

ZPIC30 is a weighted average of future PCE price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a thirty-year bond. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

<td< td=""></td<>

ZPIC30= 1.00E-13
+ A1(L) {sum 0.0523 } * PICNIA $_t$
+ A2(L) {sum -0.0766 } * RFFE $_t$
+ 0.0766 * RTR
+ 0.948 * PTR
+ A5(L) {sum 0.0541 } * XGAP $_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	0.0377	$A1_{SUM}$	0.0523	$A2_{SUM}$	-0.0766
$A1_1$	0.00692	$A2_0$	-0.0585	$A5_0$	0.0382
$A1_2$	0.00661	$A2_1$	-0.00286	$A5_1$	-0.00753
$A1_3$	0.00103	$A2_2$	-0.0148	$A5_2$	0.0158
		$A2_3$	-0.000476	$A5_3$	0.00759
				$A5_{SUM}$	0.0541

Regression statistics

Sample period: 1964Q1 2013Q4
Estimation date: August 2014
Estimation method: Least Squares

z1.15 ZPIC58: Expected 4-qtr consumer price inflation (8 qtrs. in the future) (VAR exp.)

ZPIC58 is the expected four-quarter rate of PCE price inflation measured eight quarters in the future. The equation shown below is the reduced-form representation of this expectational computation based on the core part of the expectations VAR.

<td< td=""></td<>

ZPIC58= B1(L) {sum 0.418 } * PICNIA $_t$
+ B2(L) {sum -0.210 } * RFFE $_t$
+ 0.210 * RTR
+ 0.582 * PTR
+ B5(L) {sum 0.217 } * XGAP $_t$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$B1_0$	0.342	$B1_{SUM}$	0.418	$B2_{SUM}$	-0.210
$B1_1$	0.0503	$B2_0$	-0.0188	$B5_0$	0.153
$B1_2$	0.0428	$B2_1$	-0.0879	$B5_1$	-0.153
$B1_3$	-0.0172	$B2_2$	-0.0220	$B5_2$	0.128
		$B2_3$	-0.0816	$B5_3$	0.0893
				$B5_{SUM}$	0.217

Regression statistics

Sample period:	1964Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.16 ZPICXFE: Expected value of picxfe in the next quarter (VAR exp.)

The equation shown below for the expectation of core PCE price inflation one quarter in the future is the reduced-form representation of this expectation in the small linear model used to jointly estimate the PICXFE and PIECI equations.

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$$
\begin{aligned}
\textbf{ZPICXFE} = {} & A1(L)\ \{\text{sum } 0.332\} * PICXFE_{t-1} \\
& + A2(L)\ \{\text{sum } 0.179\} * PIECI_{t-1} \\
& + A3(L)\ \{\text{sum } -0.0326\} * RFFE_{t-1} \\
& + A4(L)\ \{\text{sum } 0.0232\} * XGAP2_{t-1} \\
& + 0.0326 * RTR_{t-1} \\
& + 0.489 * PTR_{t-1} \\
& + 19.1 * \log(QPCNIA_{t-1}/PCNIA_{t-1}) \\
& + 0.000205 * \log(QPL_{t-1}/PL_{t-1}) \\
& - 0.179 * (HLPRDT_{t-1} - 400*HUQPCT_{t-1}) \\
& + A10(L)\ \{\text{sum } -0.0287\} * (LUR_{t-1} - LURNAT_{t-1})
\end{aligned}
$$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	0.324	$A2_1$	0.0486	$A3_2$	-0.00764	$A4_3$	0.00346
$A1_1$	-0.00320	$A2_2$	0.0356	$A3_3$	0.00184	$A4_{SUM}$	0.0232
$A1_2$	0.000958	$A2_3$	0.0224	$A3_{SUM}$	-0.0326	$A10_0$	-0.0689
$A1_3$	0.0105	$A2_{SUM}$	0.179	$A4_0$	0.0408	$A10_1$	0.0401
$A1_{SUM}$	0.332	$A3_0$	-0.0259	$A4_1$	-0.00711	$A10_{SUM}$	-0.0287
$A2_0$	0.0728	$A3_1$	-0.000899	$A4_2$	-0.0140		

z1.17 ZPIECI: Expected value of pieci in the next quarter (VAR exp.)

The equation shown below for the expectation of the rate of growth of ECI hourly compensation one quarter in the future is the reduced-form representation of this expectation in the small linear model used to jointly estimate the PICXFE and PIECI equations.

<td< td=""></td<>

$$
\begin{aligned}
\textbf{ZPIECI} = {} & A1(L)\ \{\text{sum } -0.00362\} * PICXFE_{t-1} \\
& + A2(L)\ \{\text{sum } 0.689\} * PIECI_{t-1} \\
& + A3(L)\ \{\text{sum } -0.0409\} * RFFE_{t-1} \\
& + A4(L)\ \{\text{sum } 0.0417\} * XGAP2_{t-1} \\
& + 0.0409 * RTR_{t-1} \\
& + 0.315 * PTR_{t-1}
\end{aligned}
$$

- 3.16 * log($QPCNIA_{t-1}$/$PCNIA_{t-1}$)
+ 0.000325 * log(QPL_{t-1}/PL_{t-1})
+ 0.311 * ($HLPRDT_{t-1}$ - 400*$HUQPCT_{t-1}$)
+ A10(L) {sum -0.0720 } * (LUR_{t-1} - $LURNAT_{t-1}$)

Distributed lag coefficients

Name	**Value**	**Name**	**Value**	**Name**	**Value**	**Name**	**Value**
$A1_0$	-0.0174	$A2_1$	0.209	$A3_2$	-0.0139	$A4_3$	0.00616
$A1_1$	-0.00564	$A2_2$	0.221	$A3_3$	0.00328	$A4_{SUM}$	0.0417
$A1_2$	0.000750	$A2_3$	0.0355	$A3_{SUM}$	-0.0409	$A10_0$	-0.158
$A1_3$	0.0186	$A2_{SUM}$	0.689	$A4_0$	0.0716	$A10_1$	0.0856
$A1_{SUM}$	-0.00362	$A3_0$	-0.0298	$A4_1$	-0.0106	$A10_{SUM}$	-0.0720
$A2_0$	0.222	$A3_1$	-0.000446	$A4_2$	-0.0255		

z1.18 ZECO: Expected growth rate of target nondurables and nonhousing services, for ECO eq (VAR exp.)

The weighted average growth rate of expected future target consumption, ZECO, is computed from forecasts of the small-scale VAR model used in the estimation of the consumption (ECO) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

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ZECO=

B1(L) {sum -8.47E-05} * $PICNIA_{t-1}$
+ B2(L) {sum 5.53E-05} * $RFFE_{t-1}$
+ B3(L) {sum -0.000232} * $XGAP2_{t-1}$
+ 8.47E-05 * PTR_{t-1}
- 5.53E-05 * RTR_{t-1}
+ B6(L) {sum 3.30E-05} * $YHGAP_{t-1}$
+ B7(L) {sum -6.82E-06} * $YHTGAP_{t-1}$
+ B8(L) {sum -0.000104} * $YHPGAP_{t-1}$
+ 0.453 * (($HGGDPT_{t-1}$/400))
+ B10(L) {sum 0.0860 }

$* (\Delta(\log(QECO_{t-1})))$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$B1_0$	-8.30E-05	$B2_3$	6.46E-06	$B6_2$	0.000278	$B8_1$	-0.000199
$B1_1$	-8.48E-05	$B2_{SUM}$	5.53E-05	$B6_3$	-4.28E-05	$B8_2$	-3.68E-05
$B1_2$	-1.07E-05	$B3_0$	-0.000528	$B6_{SUM}$	3.30E-05	$B8_3$	-4.20E-05
$B1_3$	9.38E-05	$B3_1$	0.000260	$B7_0$	-7.10E-06	$B8_{SUM}$	-0.000104
$B1_{SUM}$	-8.47E-05	$B3_2$	0.000148	$B7_1$	1.19E-06	$B10_0$	0.0520
$B2_0$	2.67E-05	$B3_3$	-0.000112	$B7_2$	5.45E-05	$B10_1$	0.0189
$B2_1$	-4.15E-05	$B3_{SUM}$	-0.000232	$B7_3$	-5.54E-05	$B10_2$	0.00206
$B2_2$	6.36E-05	$B6_0$	-0.000445	$B7_{SUM}$	-6.82E-06	$B10_3$	0.0130
		$B6_1$	0.000243	$B8_0$	0.000173	$B10_{SUM}$	0.0860

Regression statistics

Sample period:	1968Q3 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.19 ZECD: Expected growth rate of target durable consumption, for ECD eq. (VAR exp.)

The weighted average growth rate of expected future target spending on consumer durables, ZECD, is computed from forecasts of the small-scale VAR model used in the estimation of the consumer durables (ECD) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZECD= $B1(L)$ {sum -0.00140} $* PICNIA_{t-1}$
$+ B2(L)$ {sum 0.000584} $* RFFE_{t-1}$
$+ B3(L)$ {sum -0.000645} $* XGAP2_{t-1}$
$+ 0.00140 * PTR_{t-1}$
$- 0.000584 * RTR_{t-1}$
$+ B6(L)$ {sum 0.000388} $* YHGAP_{t-1}$

+ B7(L) {sum 9.84E-05} * YHTGAP $_{t-1}$
+ B8(L) {sum 0.000318} * YHPGAP $_{t-1}$
+ 1.01 * (HGGDPT$_{t-1}$/400)
- 0.733 * (HGPCDR$_{t-1}$/400)
+ B11(L) {sum 0.0469 } * Δ(log(QECD $_{t-1}$))

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$B1_0$	-0.000584	$B2_3$	0.000598	$B6_2$	0.000150	$B8_1$	-0.000144
$B1_1$	-0.000489	$B2_{SUM}$	0.000584	$B6_3$	0.000127	$B8_2$	0.000121
$B1_2$	-0.000318	$B3_0$	-7.86E-05	$B6_{SUM}$	0.000388	$B8_3$	8.64E-05
$B1_3$	-1.15E-05	$B3_1$	-0.000272	$B7_0$	-6.04E-05	$B8_{SUM}$	0.000318
$B1_{SUM}$	-0.00140	$B3_2$	-1.08E-05	$B7_1$	3.62E-05	$B11_0$	0.0255
$B2_0$	-0.00152	$B3_3$	-0.000284	$B7_2$	0.000144	$B11_1$	0.0231
$B2_1$	0.00184	$B3_{SUM}$	-0.000645	$B7_3$	-2.16E-05	$B11_2$	-0.00614
$B2_2$	-0.000334	$B6_0$	-1.06E-05	$B7_{SUM}$	9.84E-05	$B11_3$	0.00447
		$B6_1$	0.000121	$B8_0$	0.000254	$B11_{SUM}$	0.0469

Regression statistics

Sample period:	1969Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.20 ZGAPC2: Expected output gap, for ECD eq. (VAR exp.)

The weighted average of expected future output gaps, ZGAPC2, is computed from forecasts of the small-scale VAR model used in the estimation of the consumer durables (ECD) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZGAPC2= B1(L) {sum -0.0240 } * PICNIA $_{t-1}$
+ B2(L) {sum -0.0150 } * RFFE $_{t-1}$
+ B3(L) {sum 0.0998 } * XGAP2 $_{t-1}$

+ 0.0240 * PTR_{t-1}

+ 0.0150 * RTR_{t-1}

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$B1_0$	-0.0164	$B1_{SUM}$	-0.0240	$B2_{SUM}$	-0.0150
$B1_1$	-0.00367	$B2_0$	-0.0436	$B3_0$	0.214
$B1_2$	-0.00803	$B2_1$	0.0112	$B3_1$	-0.0807
$B1_3$	0.00410	$B2_2$	0.0178	$B3_2$	-0.0212
		$B2_3$	-0.000348	$B3_3$	-0.0122
				$B3_{SUM}$	0.0998

Regression statistics

Sample period:	1969Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.21 ZEH: Expected growth rate of target residential investment, for EH eq. (VAR exp.)

The weighted average growth rate of expected future target housing investment, ZEH, is computed from forecasts of the small-scale VAR model used in the estimation of the housing (EH) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZEH=

B1(L) {sum -0.000164} * $PICNIA_{t-1}$

+ B2(L) {sum 0.000266} * $RFFE_{t-1}$

+ B3(L) {sum 7.28E-06} * $XGAP2_{t-1}$

+ 0.000164 * PTR_{t-1}

- 0.000371 * RTR_{t-1}

+ B6(L) {sum 0.000251} * $YHGAP_{t-1}$

+ B7(L) {sum 0.000131} * $YHTGAP_{t-1}$

+ B8(L) {sum 8.72E-05} * $YHPGAP_{t-1}$

+ 0.426 * ($HGGDPT_{t-1}$/400)
+ B10(L) {sum 0.000388} * Δ(log(QEH_{t-1}))

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$B1_0$	-0.000148	$B2_3$	4.67E-05	$B6_2$	-8.20E-06	$B8_1$	1.79E-05
$B1_1$	-3.03E-05	$B2_{SUM}$	0.000266	$B6_3$	-6.06E-06	$B8_2$	5.86E-05
$B1_2$	-4.47E-06	$B3_0$	9.32E-05	$B6_{SUM}$	0.000251	$B8_3$	3.62E-05
$B1_3$	1.84E-05	$B3_1$	6.85E-05	$B7_0$	1.64E-05	$B8_{SUM}$	8.72E-05
$B1_{SUM}$	-0.000164	$B3_2$	-5.10E-05	$B7_1$	2.90E-05	$B10_0$	0.00648
$B2_0$	8.46E-05	$B3_3$	-0.000103	$B7_2$	4.94E-05	$B10_1$	-0.000164
$B2_1$	9.93E-05	$B3_{SUM}$	7.28E-06	$B7_3$	3.62E-05	$B10_2$	-0.00364
$B2_2$	3.54E-05	$B6_0$	0.000201	$B7_{SUM}$	0.000131	$B10_3$	-0.00228
		$B6_1$	6.39E-05	$B8_0$	-2.56E-05	$B10_{SUM}$	0.000388

Regression statistics

Sample period:	1970Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.22 ZLHP: Expected growth rate of target aggregate hours (VAR exp.)

The weighted average growth rate of expected future target hours, ZLHP, is computed from forecasts of the small-scale VAR model used in the estimation of the hours (LHP) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZLHP= A1(L) {sum -0.000519} * $PICNIA_{t-1}$
+ A2(L) {sum -0.000318} * $RFFE_{t-1}$
+ 0.000318 * RTR_{t-1}
+ 0.000519 * PTR_{t-1}
+ A5(L) {sum -0.000278} * $XGAP_{t-1}$
+ 0.195 * (Δ(log(XGO_{t-1})) - (Δ(log($LPRDT_{t-1}$))))

+ 0.656 * (($HLEPT_{t-1}$ - $HQLWW_{t-1}$)/400)

Distributed lag coefficients

Name	Value	Name	Value	Name	Value
$A1_0$	-0.000252	$A1_{SUM}$	-0.000519	$A2_{SUM}$	-0.000318
$A1_1$	-5.10E-05	$A2_0$	-0.00101	$A5_0$	-0.000113
$A1_2$	-0.000255	$A2_1$	2.67E-05	$A5_1$	0.000210
$A1_3$	3.98E-05	$A2_2$	0.000752	$A5_2$	-3.81E-05
		$A2_3$	-8.71E-05	$A5_3$	-0.000338
				$A5_{SUM}$	-0.000278

Regression statistics

Sample period:	1965Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.23 ZVPD: Expected growth rate of capital-output ratio, for EPD (VAR exp.)

The weighted average growth rate of the expected future optimal capital-output ratio for equipment, ZVPD, is computed from forecasts of the small-scale VAR model used in the estimation of the equipment (EPD) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZVPD= -3.50E-16
+ A1(L) {sum 5.81E-05} * $PICNIA_{t-1}$
+ A2(L) {sum 8.62E-05} * $RFFE_{t-1}$
- 8.62E-05 * RTR_{t-1}
- 5.81E-05 * PTR_{t-1}
+ A5(L) {sum -0.000354} * $XGAP_{t-1}$
+ A6(L) {sum 5.07E-16} * $\Delta(\log(XBO_{t-1}))$
+ A7(L) {sum -0.00874} * $\Delta(\log(VPD_{t-1}))$
+ 0.239 * $HGVPD_{t-1}$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	-0.000256	$A2_1$	0.00107	$A5_2$	0.000140	$A6_3$	4.24E-16
$A1_1$	-0.000305	$A2_2$	-0.000721	$A5_3$	0.000332	$A6_{SUM}$	5.07E-16
$A1_2$	0.000275	$A2_3$	0.000656	$A5_{SUM}$	-0.000354	$A7_0$	-0.0278
$A1_3$	0.000344	$A2_{SUM}$	8.62E-05	$A6_0$	2.32E-15	$A7_1$	-0.00603
$A1_{SUM}$	5.81E-05	$A5_0$	-0.000904	$A6_1$	2.75E-15	$A7_2$	0.00839
$A2_0$	-0.000916	$A5_1$	7.76E-05	$A6_2$	-4.99E-15	$A7_3$	0.0167
						$A7_{SUM}$	-0.00874

Regression statistics

Sample period:	1976Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.24 ZVPI: Expected growth rate of capital-output ratio, for EPI (VAR exp.)

The weighted average growth rate of the expected future target optimal capital-output ratio for intellectual property, ZVPI, is computed from forecasts of the small-scale VAR model used in the estimation of the intellectual property (EPI) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZVPI= A1(L) {sum 8.92E-05} * $PICNIA_{t-1}$
+ A2(L) {sum -1.70E-05} * $RFFE_{t-1}$
+ 1.70E-05 * RTR_{t-1}
- 8.92E-05 * PTR_{t-1}
+ A5(L) {sum -6.93E-05} * $XGAP_{t-1}$
+ A6(L) {sum 1.74E-15} * $\Delta(\log(XBO_{t-1}))$
+ A7(L) {sum 0.000543} * $\Delta(\log(VPI_{t-1}))$
+ 0.146 * $HGVPI_{t-1}$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	3.87E-05	$A2_1$	5.16E-05	$A5_2$	4.95E-05	$A6_3$	-2.84E-17
$A1_1$	3.80E-06	$A2_2$	-6.83E-05	$A5_3$	1.70E-05	$A6_{SUM}$	1.74E-15
$A1_2$	2.61E-05	$A2_3$	2.67E-05	$A5_{SUM}$	-6.93E-05	$A7_0$	-0.000983
$A1_3$	2.06E-05	$A2_{SUM}$	-1.70E-05	$A6_0$	-3.59E-16	$A7_1$	0.000472
$A1_{SUM}$	8.92E-05	$A5_0$	-0.000143	$A6_1$	2.63E-15	$A7_2$	0.000542
$A2_0$	-2.70E-05	$A5_1$	6.90E-06	$A6_2$	-5.06E-16	$A7_3$	0.000512
						$A7_{SUM}$	0.000543

Regression statistics

Sample period: 1976Q1 2013Q4

Estimation date: August 2014

Estimation method: Least Squares

z1.25 ZVPS: Expected growth rate of des. capital-output ratio, for EPS eq. (VAR exp.)

The weighted average growth rate of the expected future target optimal capital-output ratio for nonresidential structures, ZVPS, is computed from forecasts of the small-scale VAR model used in the estimation of the nonresidential structures (EPS) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZVPS= A1(L) {sum 0.000863} * PICNIA $_{t-1}$
+ A2(L) {sum -0.000273} * RFFE $_{t-1}$
+ 0.000273 * RTR$_{t-1}$
- 0.000863 * PTR$_{t-1}$
+ A5(L) {sum -0.000648} * XGAP $_{t-1}$
+ A6(L) {sum -6.00E-15} * Δ(log(XBO $_{t-1}$))
+ A7(L) {sum 0.0754 } * Δ(log(VPS $_{t-1}$))
- 3.15E-16 * HGVPS$_{t-1}$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	0.000785	$A2_1$	0.000441	$A5_2$	0.00117	$A6_3$	-2.02E-15
$A1_1$	-0.000133	$A2_2$	-0.000214	$A5_3$	-8.29E-05	$A6_{SUM}$	-6.00E-15
$A1_2$	0.000106	$A2_3$	2.44E-05	$A5_{SUM}$	-0.000648	$A7_0$	0.0178
$A1_3$	0.000104	$A2_{SUM}$	-0.000273	$A6_0$	8.75E-15	$A7_1$	0.0217
$A1_{SUM}$	0.000863	$A5_0$	0.000747	$A6_1$	2.30E-14	$A7_2$	0.0251
$A2_0$	-0.000525	$A5_1$	-0.00248	$A6_2$	-3.57E-14	$A7_3$	0.0109
						$A7_{SUM}$	0.0754

Regression statistics

Sample period:	1976Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.26 ZXBD: Expected growth rate of buisiness output for EPD (VAR exp.)

The weighted average growth rate of expected future output for equipment, ZXBD, is computed from forecasts of the small-scale VAR model used in the estimation of the equipment (EPD) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZXBD= -2.52E-16
+ A1(L) {sum -0.000426} * PICNIA $_{t-1}$
+ A2(L) {sum -0.000335} * RFFE $_{t-1}$
+ 0.000335 * RTR $_{t-1}$
+ 0.000426 * PTR $_{t-1}$
+ A5(L) {sum 0.000152} * XGAP $_{t-1}$
+ A6(L) {sum 0.176 } * Δ(log(XBO $_{t-1}$))
+ A7(L) {sum -6.25E-17} * Δ(log(VPD $_{t-1}$))
+ 0.00979 * HGX $_{t-1}$/400

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	-0.000184	$A2_1$	4.16E-05	$A5_2$	2.13E-05	$A6_3$	-0.0223
$A1_1$	-9.21E-05	$A2_2$	0.000519	$A5_3$	-4.57E-05	$A6_{SUM}$	0.176
$A1_2$	-0.000169	$A2_3$	-0.000154	$A5_{SUM}$	0.000152	$A7_0$	-1.89E-16
$A1_3$	1.88E-05	$A2_{SUM}$	-0.000335	$A6_0$	0.176	$A7_1$	-7.54E-18
$A1_{SUM}$	-0.000426	$A5_0$	3.69E-05	$A6_1$	0.0258	$A7_2$	2.13E-17
$A2_0$	-0.000742	$A5_1$	0.000140	$A6_2$	-0.00421	$A7_3$	1.13E-16
						$A7_{SUM}$	-6.25E-17

Regression statistics

Sample period:	1976Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.27 ZXBI: Expected growth rate of business output, for EPI (VAR exp.)

The weighted average growth rate of expected future output for intellectual property, ZXBI, is computed from forecasts of the small-scale VAR model used in the estimation of the equipment (EPI) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZXBI=

A1(L) {sum -6.38E-05} * PICNIA $_{t-1}$
+ A2(L) {sum -1.71E-06} * RFFE $_{t-1}$
+ 1.71E-06 * RTR$_{t-1}$
+ 6.38E-05 * PTR$_{t-1}$
+ A5(L) {sum -6.88E-05} * XGAP $_{t-1}$
+ A6(L) {sum 0.0153 } * Δ(log(XBO $_{t-1}$))
+ A7(L) {sum 3.33E-16} * Δ(log(VPI $_{t-1}$))
+ 0.126 * HGX$_{t-1}$/400

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	-3.91E-05	$A2_1$	1.97E-05	$A5_2$	-1.39E-05	$A6_3$	-0.00215
$A1_1$	-1.54E-05	$A2_2$	1.97E-05	$A5_3$	-6.49E-06	$A6_{SUM}$	0.0153
$A1_2$	-1.05E-05	$A2_3$	8.99E-06	$A5_{SUM}$	-6.88E-05	$A7_0$	4.58E-17
$A1_3$	1.11E-06	$A2_{SUM}$	-1.71E-06	$A6_0$	0.0166	$A7_1$	7.29E-17
$A1_{SUM}$	-6.38E-05	$A5_0$	-0.000172	$A6_1$	0.00170	$A7_2$	1.43E-16
$A2_0$	-5.01E-05	$A5_1$	0.000123	$A6_2$	-0.000923	$A7_3$	7.13E-17
						$A7_{SUM}$	3.33E-16

Regression statistics

Sample period:	1976Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.28 ZXBS: Expected growth rate of business output, for EPS (VAR exp.)

The weighted average growth rate of expected future output for nonresidential structures, ZXBS, is computed from forecasts of the small-scale VAR model used in the estimation of the nonresidential structures (EPI) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

<td< td=""></td<>

ZXBS=

A1(L) {sum -0.000329} * $PICNIA_{t-1}$
+ A2(L) {sum -0.000197} * $RFFE_{t-1}$
+ 0.000197 * RTR_{t-1}
+ 0.000329 * PTR_{t-1}
+ A5(L) {sum -1.14E-05} * $XGAP_{t-1}$
+ A6(L) {sum 0.0795 } * $\Delta(\log(XBO_{t-1}))$
+ A7(L) {sum -8.60E-17} * $\Delta(\log(VPS_{t-1}))$
+ 0.0518 * $HGX_{t-1}/400$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value

$A1_0$	-0.000199	$A2_1$	0.000106	$A5_2$	-5.39E-05	$A6_3$	-0.0107
$A1_1$	-7.21E-05	$A2_2$	0.000177	$A5_3$	-6.49E-05	$A6_{SUM}$	0.0795
$A1_2$	-7.99E-05	$A2_3$	1.39E-05	$A5_{SUM}$	-1.14E-05	$A7_0$	-3.51E-17
$A1_3$	2.21E-05	$A2_{SUM}$	-0.000197	$A6_0$	0.0838	$A7_1$	-8.48E-17
$A1_{SUM}$	-0.000329	$A5_0$	-0.000165	$A6_1$	0.0101	$A7_2$	3.13E-17
$A2_0$	-0.000494	$A5_1$	0.000272	$A6_2$	-0.00364	$A7_3$	2.65E-18
						$A7_{SUM}$	-8.60E-17

Regression statistics

Sample period:	1976Q1 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.29 ZDIVGR: Expected growth rate of real dividends, for WPSN eq. (VAR exp.)

ZDIVGR is a weighted average of growth rates of future after-tax corporate profits. The weights sum to one and decline geometrically at a rate based on the infinite maturity of corporate equity and the average historical level of the nominal rate of interest. The equation shown below is the reduced-form representation of this expectational computation based on a small-scale VAR model.

<td< td=""></td<>

ZDIVGR= 1.51E-15
+ A1(L) {sum 0.0768 } * PICNIA $_t$
+ A2(L) {sum -0.0894 } * RFFE $_t$
+ 0.0894 * RTR
- 0.0768 * PTR
+ A5(L) {sum -0.0738 } * XGAP $_t$
+ A6(L) {sum 0.0188 } * (400*Δ(log((YNICPN $_t$-TFCIN $_t$-TSCIN $_t$)*.5/(.01*PXG $_t$))))
+ 0.981 * HGX

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	-0.00911	$A1_{SUM}$	0.0768	$A2_{SUM}$	-0.0894	$A5_{SUM}$	-0.0738

$A1_1$	0.0318	$A2_0$	-0.0732	$A5_0$	-0.393	$A6_0$	0.0149
$A1_2$	0.0283	$A2_1$	0.0206	$A5_1$	0.234	$A6_1$	0.00229
$A1_3$	0.0258	$A2_2$	-0.0815	$A5_2$	0.0190	$A6_2$	0.00213
		$A2_3$	0.0447	$A5_3$	0.0661	$A6_3$	-0.000522
						$A6_{SUM}$	0.0188

Regression statistics

Sample period:	1964Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.30 ZYNID: Expected rate of growth of target real dividends, for YNIDN eq. (VAR exp.)

The weighted average growth rate of expected future target dividends, ZYNID, is computed from forecasts of the small-scale VAR model used in the estimation of the dividends (YNIDN) PAC equation. The forward weights are those implied by the estimated PAC coefficients. The equation shown below is the reduced-form representation of this expectational computation.

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ZYNID = -5.18E-16

$+ A1(L)$ {sum 0.00100 } $*$ PICNIA $_{t-1}$

$+ A2(L)$ {sum -0.000692} $*$ RFFE $_{t-1}$

$+ 0.000692 *$ RTR $_{t-1}$

$- 0.00100 *$ PTR $_{t-1}$

$+ A5(L)$ {sum -0.00140} $*$ XGAP $_{t-1}$

$+ A6(L)$ {sum 0.0220 } $* \Delta(\log($QYNIDN $_{t-1}$/PXB $_{t-1}))$

$+ 1.11 * ($HGGDPT $_{t-1}/400)$

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$A1_0$	3.51E-05	$A1_{SUM}$	0.00100	$A2_{SUM}$	-0.000692	$A5_{SUM}$	-0.00140
$A1_1$	0.000435	$A2_0$	0.000187	$A5_0$	-0.00457	$A6_0$	0.00216
$A1_2$	0.000377	$A2_1$	-0.000501	$A5_1$	0.00199	$A6_1$	0.0117

$A1_3$	0.000155	$A2_2$	-0.000650	$A5_2$	5.64E-05	$A6_2$	0.0120
		$A2_3$	0.000272	$A5_3$	0.00113	$A6_3$	-0.00388
						$A6_{SUM}$	0.0220

Regression statistics

Sample period:	1965Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.31 ZYH: Expected level of real after-tax household income, for QEC eq. (VAR exp.)

Permanent household income (ZYH) is the scaled discounted stream of future household income (YH). The discount factor is 25 percent per year. The scaling factor is chosen so that ZYH and YH have the same value when YH is expected to grow steadily at 3 percent per year. The equation shown below is the reduced-form representation of this expectational computation based on a small-scale VAR used in the estimation of the main consumption (ECO) equation.

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log(ZYH) = B1(L) {sum 0.00171 } * PICNIA $_t$
+ B2(L) {sum -0.00172} * RFFE $_t$
+ B3(L) {sum 0.00382 } * XGAP2 $_t$
- 0.00171 * PTR
+ 0.00172 * RTR
+ B6(L) {sum 0.00537 } * YHGAP $_t$
+ log(ZYHST*XGDPT)

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$B1_0$	-0.000230	$B1_{SUM}$	0.00171	$B2_{SUM}$	-0.00172	$B3_{SUM}$	0.00382
$B1_1$	0.000729	$B2_0$	-0.00185	$B3_0$	0.00161	$B6_0$	0.00461
$B1_2$	0.000622	$B2_1$	0.000290	$B3_1$	0.00301	$B6_1$	0.000918
$B1_3$	0.000593	$B2_2$	-0.000499	$B3_2$	0.000641	$B6_2$	0.000108
		$B2_3$	0.000331	$B3_3$	-0.00144	$B6_3$	-0.000257

$B6_{SUM}$ 0.00537

Regression statistics

Sample period:	1966Q2 2013Q4
Estimation date:	August 2014
Estimation method:	Least Squares

z1.32 ZYHP: Expected level of real after-tax property income, for QEC eq. (VAR exp.)

Permanent household property income (ZYHP) is the scaled discounted stream of future household property income (YHP). The discount factor is 25 percent per year. The scaling factor is chosen so that ZYHP and YHP have the same value when YHP is expected to grow steadily at 3 percent per year. The equation shown below is the reduced-form representation of this expectational computation based on a small-scale VAR used in the estimation of the main consumption (ECO) equation.

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log(ZYHP) = B1(L) {sum 0.00325 } * PICNIA $_t$
+ B2(L) {sum -0.00218} * RFFE $_t$
+ B3(L) {sum 0.00276 } * XGAP2 $_t$
- 0.00325 * PTR
+ 0.00218 * RTR
+ B6(L) {sum 0.00553 } * YHGAP $_t$
+ B7(L) {sum 0.00169 } * YHPGAP $_t$
+ log(ZYHPST*ZYHST*XGDPT)

Distributed lag coefficients

Name	**Value**	**Name**	**Value**	**Name**	**Value**	**Name**	**Value**
$B1_0$	0.000384	$B2_1$	-0.000338	$B3_2$	0.00119	$B6_3$	-0.000649
$B1_1$	0.00121	$B2_2$	-0.000483	$B3_3$	-0.00129	$B6_{SUM}$	0.00553
$B1_2$	0.000962	$B2_3$	8.81E-05	$B3_{SUM}$	0.00276	$B7_0$	0.00211
$B1_3$	0.000697	$B2_{SUM}$	-0.00218	$B6_0$	0.00533	$B7_1$	0.000156
$B1_{SUM}$	0.00325	$B3_0$	-0.00112	$B6_1$	0.000473	$B7_2$	-0.000312
$B2_0$	-0.00145	$B3_1$	0.00397	$B6_2$	0.000371	$B7_3$	-0.000262

$B7_{SUM}$	0.00169

Regression statistics

Sample period: 1966Q2 2013Q4
Estimation date: August 2014
Estimation method: Least Squares

z1.33 ZYHT: Expected level of real transfer income, for QEC eq. (VAR exp.)

Permanent household transfer income (ZYHT) is the scaled discounted stream of future household transfer income (YHT). The discount factor is 25 percent per year. The scaling factor is chosen so that ZYHT and YHT have the same value when YHT is expected to grow steadily at 3 percent per year. The equation shown below is the reduced-form representation of this expectational computation based on a small-scale VAR used in the estimation of the main consumption (ECO) equation.

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log(ZYHT) = B1(L) {sum 0.000659} * $PICNIA_t$
+ B2(L) {sum -0.00240} * $RFFE_t$
+ B3(L) {sum 0.00814 } * $XGAP2_t$
- 0.000659 * PTR
+ 0.00240 * RTR
+ B6(L) {sum 0.00416 } * $YHGAP_t$
+ B7(L) {sum 0.00282 } * $YHTGAP_t$
+ log(ZYHTST*ZYHST*XGDPT)

Distributed lag coefficients

Name	Value	Name	Value	Name	Value	Name	Value
$B1_0$	-0.000538	$B2_1$	0.000740	$B3_2$	0.00237	$B6_3$	-7.57E-05
$B1_1$	0.000426	$B2_2$	-0.00130	$B3_3$	-0.000203	$B6_{SUM}$	0.00416
$B1_2$	0.000430	$B2_3$	0.000238	$B3_{SUM}$	0.00814	$B7_0$	0.00211
$B1_3$	0.000341	$B2_{SUM}$	-0.00240	$B6_0$	0.00302	$B7_1$	0.000484
$B1_{SUM}$	0.000659	$B3_0$	0.00167	$B6_1$	0.000794	$B7_2$	-8.22E-05
$B2_0$	-0.00208	$B3_1$	0.00430	$B6_2$	0.000420	$B7_3$	0.000309
						$B7_{SUM}$	0.00282

Regression statistics

Sample period: 1966Q2 2013Q4

Estimation date: August 2014

Estimation method: Least Squares

z1.34 ZYHST: Expected trend ratio of household income to GDP

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ZYHST= $ZYHST_{t-1}$ + 0.0500 [0.00]*(YHSHR-$ZYHST_{t-1}$)

z1.35 ZYHPST: Expected trend share of property income in household income

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ZYHPST= $ZYHPST_{t-1}$ + 0.0500 [0.00]*(YHPSHR-$ZYHPST_{t-1}$)

z1.36 ZYHTST: Expected trend share of transfer income in household income

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ZYHTST = $ZYHTST_{t-1}$ + 0.0500 [0.00]*(YHTSHR-$ZYHTST_{t-1}$)

z1.37 HGYNID: Growth rate of real after-tax corporate profits

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HGYNID = 400*Δ(log((YNICPN-TFCIN-TSCIN)*.5/PXG))

Model-Consistent Expectations

MC Expectations

This sector contains the identities that are used for expectational variables when the assumption of model-consisten expectations is employed. The form of each identity is determined by the structure and parameters of the sub-model that is used to estimate the structural equation in which the expectation appears. In most cases, the expectation is defined as a weighted sum of a variable over future quarters. The exceptions are in the wage-price block (ZPICXFE, ZPIECI), where expectations are for one period ahead.

Discounting weights determine the coefficient values in the typical expectations equation. 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 PAC equation's 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. The sum of the discounting weights in PAC expectations is not unity. For the expectational components of long-term interest rates and the required rate of return on equity, the discounting weights sum to unity and depend on the duration of the financial instrument. For the expectations of permanent income appearing in the target level of consumption, the discouting weights sum to unity and are based on a general discount factor of 25 percent per year.

z2.1 PTR: 10-year expected PCE price inflation (Survey of Professional Forecasters)

PTR gradually adjusts toward a weighted average of actual and target inflation.

Historical values of PTR come from several sources. Since 1991q4, the source is the Survey of Professional Forecasters (SPF), first for expected CPI inflation and then, when it becomes available in 2007, for expected PCE price inflation. PTR data from 1981q1 to 1991q3 is primarily from a survey conducted by Richard Hoey. The Hoey and SPF CPI observations are reduced by 40 basis to account for the average difference between CPI and PCE inflation. Values of PTR before 1981 are constructed in a manner similar to the one described in Kozicki and Tinsley (2001, section 3.3), "Term Structure Views of Monetary Policy under Alternative Models of Agent Expectations," Journal of Economic Dynamics and Control, 25: 149-184.

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PTR = $0.900 * PTR_{t-1} + 0.0500 * PICXFE_{t-1} + 0.0500 * PITARG_{t-1}$

z2.2 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.

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RRTR = $0.970 * RRTR_{t-1}$
$+ 0.0300 * RRFFE$

z2.3 RTR: Expected federal funds rate in the long run (Blue Chip)

Historical values of RTR since 1984q3 are based on data from the Blue Chip Survey. Prior to that, RTR = PTR + 2.0.

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RTR = RRTR + PTR

z2.4 ZRFF5: Expected federal funds rate, for RG5E eq. (5-yr mat.) (MCE exp.)

ZRFF5 is a weighted average of future federal funds rates. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond.

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ZRFF5 =

$$0.0548 * RFFE + 0.945 * ZRFF5_{t+1}$$

z2.5 ZRFF10: Expected federal funds rate, for RG10E eq. (10-yr mat.) (MCE exp.)

ZRFF10 is a weighted average of future federal funds rates. The weights sum to one and decline geometrically at a rate based on the average duration of a ten-year bond.

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ZRFF10 =

$$0.0301 * RFFE + 0.970 * ZRFF10_{t+1}$$

z2.6 ZRFF30: Expected federal funds rate, for RG30E eq. (30-yr mat.) (MCE exp.)

ZRFF30 is a weighted average of future federal funds rates. The weights sum to one and decline geometrically at a rate based on the average duration of a thirty-year bond.

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ZRFF30 =

$0.0141 * $ RFFE
$+ 0.986 * ZRFF30_{t+1}$

z2.7 ZGAP05: Expected output gap, for RG5E eq. (MCE exp.)

ZGAP05 is a weighted average of future output gaps. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond.

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ZGAP05 =

$0.0548 * $ XGAP
$+ 0.945 * ZGAP05_{t+1}$

z2.8 ZGAP10: Expected output gap, for RG10E eq. (MCE exp.)

ZGAP10 is a weighted average of future output gaps. The weights sum to one and decline geometrically at a rate based on the average duration of a ten-year bond.

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ZGAP10 =

$0.0301 * $ XGAP
$+ 0.970 * ZGAP10_{t+1}$

z2.9 ZGAP30: Expected output gap, for RG30E eq. (MCE exp.)

ZGAP30 is a weighted average of future output gaps. The weights sum to one and decline geometrically at a rate based on the average duration of a thirty-year bond.

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ZGAP30 =

$$ZGAP30 = 0.0141 * XGAP + 0.986 * ZGAP30_{t+1}$$

z2.10 ZPI5: Expected cons. price infl., for RCCD eq. (5-yr mat.) (MCE exp.)

ZPI5 a weighted average of future PCE price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond.

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ZPI5 =

$$ZPI5 = 0.0548 * PICNIA + 0.945 * ZPI5_{t+1}$$

z2.11 ZPIB5: Expected output price infl., for RPD eq. (5-yr mat.) (MCE exp.)

ZPI5 a weighted average of future business sector price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a five-year bond.

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ZPIB5 =

$$ZPIB5 = 0.0548 * 400 * \Delta(\log(PXB)) + 0.945 * ZPIB5_{t+1}$$

z2.12 ZPI10: Expected cons. price infl., for RCCH, RRMET, and YHPNTN eqs. (10-yr mat.) (MCE exp.)

ZPI10 a weighted average of future PCE price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a ten-year bond.

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ZPI10 =

$$0.0301 * PICNIA$$
$$+ 0.970 * ZPI10_{t+1}$$

z2.13 ZPI10F: Expected cons. price infl., for FPXR eq. (10-yr mat.) (MCE exp.)

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ZPI10F =

$$0.0301 * PICNIA$$
$$+ 0.970 * ZPI10F_{t+1}$$

z2.14 ZPIC30: Expected cons. price infl., for REQ eq. (30-yr mat.) (MCE exp.)

ZPIC30 a weighted average of future PCE price inflation. The weights sum to one and decline geometrically at a rate based on the average duration of a thirty-year bond.

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ZPIC30 =

$$0.0141 * PICNIA$$
$$+ 0.986 * ZPIC30_{t+1}$$

z2.15 ZPIC58: Expected 4-qtr consumer price inflation (8 qtrs. in the future) (MCE exp.)

ZPIC58 is the expected four-quarter rate of PCE price inflation measured eight quarters in the future.

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$$\mathbf{ZPIC58} = PIC4_{t+8}$$

z2.16 ZPICXFE: Expected value of picxfe in the next quarter (MCE exp.)

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$$\mathbf{ZPICXFE} = PICXFE_{t+1}$$

z2.17 ZPIECI: Expected value of pieci in the next quarter (MCE exp.)

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$$\mathbf{ZPIECI} = PIECI_{t+1}$$

z2.18 ZECO: Expected growth rate of target nondurables and nonhousing services, for ECO eq (MCE exp.)

ZECO is a weighted average of future growth rates of the target level of consumption. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated consumption (ECO) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual consumption in the ECO equation.

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$$\begin{aligned}\mathbf{ZECO} = \; & 0.114 * \Delta(\log(QEC/PCOR)) \\ & - 0.0504 * \Delta(\log(QEC_{t+1}/PCOR_{t+1})) \\ & + 1.33 * ZECO_{t+1}\end{aligned}$$

$- 0.443 * ZECO_{t+2}$

z2.19 ZECD: Expected growth rate of target durable consumption, for ECD eq. (MCE exp.)

ZECD is a weighted average of future growth rates of the target level of investment in consumer durables. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated consumer durables (ECD) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual investment in consumer durables in the ECD equation.

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ZECD =

$$0.174 * \Delta(\log(QECD))$$
$$+ 0.00978 * \Delta(\log(QECD_{t+1}))$$
$$+ 0.770 * ZECD_{t+1}$$
$$+ 0.0563 * ZECD_{t+2}$$

z2.20 ZGAPC2: Expected output gap, for ECD eq. (MCE exp.)

ZGAPC2 is a weighted average of future output gaps. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated consumer durables (ECD) equation.

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ZGAPC2 =

$$0.0269 * XGAP2$$
$$+ 0.770 * ZGAPC2_{t+1}$$
$$+ 0.0563 * ZGAPC2_{t+2}$$

z2.21 ZEH: Expected growth rate of target residential investment, for EH eq. (MCE exp.)

ZEH is a weighted average of future growth rates of the target level of housing investment. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated housing (EH) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual housing investment in the EH equation.

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ZEH =

$$0.0191 * \Delta(\log(QEH))$$
$$- 0.00647 * \Delta(\log(QEH_{t+1}))$$
$$- 0.00388 * \Delta(\log(QEH_{t+2}))$$
$$+ 1.32 * ZEH_{t+1}$$
$$- 0.136 * ZEH_{t+2}$$
$$- 0.203 * ZEH_{t+3}$$

z2.22 ZLHP: Expected growth rate of target aggregate hours (MCE exp.)

ZLHP is a weighted average of future growth rates of the target level of hours. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated hours (LHP) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual hours in the LHP equation.

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ZLHP =

$$0.265 * \Delta(\log(QLHP))$$
$$- 0.0380 * \Delta(\log(QLHP_{t+1}))$$
$$+ 0.876 * ZLHP_{t+1}$$
$$- 0.143 * ZLHP_{t+2}$$

z2.23 ZVPD: Expected growth rate of capital-output ratio, for EPD (MCE exp.)

ZVPD is a weighted average of future growth rates of the optimal capital-output ratio for equipment. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated equipment investment (EPD) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual investment in the EPD equation.

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ZVPD =

$$0.132 * \Delta(\log(VPD))$$
$$- 0.0554 * \Delta(\log(VPD_{t+1}))$$
$$- 0.0459 * \Delta(\log(VPD_{t+2}))$$
$$+ 1.26 * ZVPD_{t+1}$$
$$- 0.0717 * ZVPD_{t+2}$$
$$- 0.348 * ZVPD_{t+3}$$

z2.24 ZVPI: Expected growth rate of capital-output ratio, for EPI (MCE exp.)

ZVPI is a weighted average of future growth rates of the optimal capital-output ratio for intellectual property. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated intellectual property (EPI) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual investment in the EPI equation.

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ZVPI =

$$0.0117 * \Delta(\log(VPI))$$
$$- 0.00764 * \Delta(\log(VPI_{t+1}))$$
$$- 0.00195 * \Delta(\log(VPI_{t+2}))$$
$$+ 1.64 * ZVPI_{t+1}$$
$$- 0.485 * ZVPI_{t+2}$$
$$- 0.166 * ZVPI_{t+3}$$

z2.25 ZVPS: Expected growth rate of des. capital-output ratio, for EPS eq. (MCE exp.)

ZVPS is a weighted average of future growth rates of the optimal capital-output ratio for nonresidential structures. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated nonresidential structures (EPS) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual investment in the EPS equation.

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ZVPS =

$$0.0504 * \Delta(\log(VPS))$$
$$- 0.0259 * \Delta(\log(VPS_{t+1}))$$
$$- 0.0155 * \Delta(\log(VPS_{t+2}))$$
$$+ 1.45 * ZVPS_{t+1}$$
$$- 0.208 * ZVPS_{t+2}$$
$$- 0.307 * ZVPS_{t+3}$$

z2.26 ZXBD: Expected growth rate of buisiness output for EPD (MCE exp.)

ZXBD is a weighted average of future growth rates of business output. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated equipment investment (EPD) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual investment in the EPD equation.

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ZXBD =

$$0.132 * \Delta(\log(XBO))$$
$$- 0.0554 * \Delta(\log(XBO_{t+1}))$$
$$- 0.0459 * \Delta(\log(XBO_{t+2}))$$
$$+ 1.26 * ZXBD_{t+1}$$
$$- 0.0717 * ZXBD_{t+2}$$

$- 0.348 * ZXBD_{t+3}$

z2.27 ZXBI: Expected growth rate of business output, for EPI (MCE exp.)

ZXBI is a weighted average of future growth rates of business output. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated intellectual property (EPI) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual investment in the EPI equation.

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ZXBI =

$0.0117 * \Delta(\log(XBO))$

$- 0.00764 * \Delta(\log(XBO_{t+1}))$

$- 0.00195 * \Delta(\log(XBO_{t+2}))$

$+ 1.64 * ZXBI_{t+1}$

$- 0.485 * ZXBI_{t+2}$

$- 0.166 * ZXBI_{t+3}$

z2.28 ZXBS: Expected growth rate of business output, for EPS (MCE exp.)

ZXBS is a weighted average of future growth rates of business output. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated nonresidential structures (EPS) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual investment in the EPS equation.

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ZXBS =

$0.0504 * \Delta(\log(XBO))$

$- 0.0259 * \Delta(\log(XBO_{t+1}))$

$- 0.0155 * \Delta(\log(XBO_{t+2}))$

$+ 1.45 * ZXBS_{t+1}$

$- 0.208 * ZXBS_{t+2}$

$- 0.307 * ZXBS_{t+3}$

z2.29 ZDIVGR: Expected growth rate of real dividends, for WPSN eq. (MCE exp.)

ZDIVGR is a weighted average of growth rates of future after-tax corporate profits. The weights sum to one and decline geometrically at a rate based on the infinite maturity of corporate equity and the average historical level of the nominal rate of interest.

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$$\mathbf{ZDIVGR =} \; 0.00976 * HGYNID_{t+1} + 0.990 * ZDIVGR_{t+1}$$

z2.30 ZYNID: Expected rate of growth of target real dividends, for YNIDN eq. (MCE exp.)

ZYNID is a weighted average of future growth rates of the target level of dividends. The pattern of the weights is a function of the PAC adjustment coefficients in the estimated dividend (YNIDN) equation. The sum of the weights equals one minus the sum of the coefficients on lagged growth of actual dividends in the YNIDN equation.

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$$\begin{aligned}\mathbf{ZYNID =} \; & 0.112 * \Delta(\log((QYNIDN / PXG))) \\ & + 0.0146 * \Delta(\log(QYNIDN_{t+1} / PXG_{t+1})) \\ & + 0.758 * ZYNID_{t+1} \\ & + 0.131 * ZYNID_{t+2}\end{aligned}$$

z2.31 ZYH: Expected level of real after-tax household income, for QEC eq. (MCE exp.)

Permanent household income (ZYH) is the scaled discounted stream of future household income (YH). The discount factor is 25 percent per year. The scaling factor is chosen so that ZYH and YH have the same value when YH is expected to grow steadily at 3 percent per year.

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ZYH = (1 - (0.750 **.25)*exp(0.00750)) * YH
+ (0.750 **.25) * ZYH_{t+1}

z2.32 ZYHP: Expected level of real after-tax property income, for QEC eq. (MCE exp.)

Permanent household property income (ZYHP) is the scaled discounted stream of future household property income (YHP). The discount factor is 25 percent per year. The scaling factor is chosen so that ZYHP and YHP have the same value when YHP is expected to grow steadily at 3 percent per year.

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ZYHP = (1 - (0.750 **.25)*exp(0.00750)) * YHP
+ (0.750 **.25) * $ZYHP_{t+1}$

z2.33 ZYHT: Expected level of real transfer income, for QEC eq. (MCE exp.)

Permanent household transfer income (ZYHT) is the scaled discounted stream of future household transfer income (YHT). The discount factor is 25 percent per year. The scaling factor is chosen so that ZYHT and YHT have the same value when YHT is expected to grow steadily at 3 percent per year.

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ZYHT = (1 - (0.750 **.25)*exp(0.00750)) * YHT

$$+ (0.750 ^{**}.25) * ZYHT_{t+1}$$

z2.37 HGYNID: Growth rate of real after-tax corporate profits

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HGYNID = 400*Δ(log((YNICPN-TFCIN-TSCIN)*.5/PXG))

Definitions of all variables

Name	Definition	EQ
CENG	Consumption of crude energy (oil, coal, natural gas), 2009 $	c.5
D01Q4	Dummy, destruction of World Trade Center	
D2002	Dummy,	
D2003	Dummy,	
D69	Dummy, post-1968 indicator	
D79A	Dummy, post-1979 indicator	
D8095	Dummy, 1980-1995 indicator	
D81	Dummy, post-1980 indicator	
D83	Dummy, post-1983 indicator	
D86	Dummy, post-1985 indicator	
D87	Dummy, post-1986 indicator	
DCON	Dummy, 0 prior to 1986, 1 after 1988, with a linear trend in between	
DDOCKM	Dock strike dummy, import equation	
DDOCKX	Dock strike dummy, export equation	
DELRFF	Federal funds rate, first diff	i.14
DEUC	EUC switch: 1 for including EUC, 0 for not including	
DFMPRR	Dummy, Foreign monetary policy switch: Exogenous real interest rate	
DFPDBT	Fiscal policy switch: 1 for debt ratio stabilization	
DFPEX	Fiscal policy switch: 1 for exogenous personal income trend tax rates	
DFPSRP	Fiscal policy switch: 1 for surplus ratio stabilization	
DGLPRD	Switch to control for long-run productivity growth in the government sector	
DMPALT	Monetary policy switch: MA rule	
DMPEX	Monetary policy switch: exogenous federal funds rate	
DMPGEN	Monetary policy switch: Generalized reaction function	

DMPINTAY	Monetary policy switch: inertial taylor rule	
DMPRR	Monetary policy switch: exogenous real federal funds rate	
DMPSTB	Stabilization switch: 0 for standard applications, 1 for stochastic simulations	
DMPTAY	Monetary policy switch: Taylor's reaction function	
DMPTLR	Monetary policy switch: Taylor's reaction function with unemployment gap	
DMPTLUR	Monetary policy indicator for unemployment threshold	i.8
DMPTMAX	Monetary policy indicator for both thresholds	i.10
DMPTPI	Monetary policy indicator for inflation threshold	i.9
DMPTR	Monetary policy indicator for policy rule thresholds	i.11
DMPTRSH	Monetary policy threshold switch: 0 for no threshold, 1 for threshold	
DPADJ	Price inflation aggregation adjustment	g.27
DPGAP	Price inflation aggregation discrepancy	g.26
DRSTAR	RSTAR updating switch: 1 is on, 0 is off	
EC	Consumption, cw 2009$ (FRB/US definition)	a.17
ECD	Consumer expenditures on durable goods, cw 2009$	a.2
ECH	Consumer expenditures on housing services, cw 2009$	a.4
ECNIA	Personal consumption expenditures, cw 2009$ (NIPA definition)	a.9
ECNIAN	Personal consumption expenditures, current $ (NIPA definition)	a.10
ECO	Consumer expenditures on non-durable goods and non-housing services, cw 2009$	a.1
EGF	Federal government consumption and gross investment, cw 2009$	h.1
EGFI	Federal government gross investment, cw 2009$	h.3
EGFIN	Federal government gross investment, current $	h.4
EGFIT	Federal government gross investment, cw 2009$, trend	h.5
EGFL	Federal government employee compensation, cw 2009$	h.6
EGFLN	Federal government employee compensation, current $	h.7
EGFLT	Federal government employee compensation, cw 2009$, trend	h.8
EGFN	Federal government consumption and gross investment, current $	h.2
EGFO	Federal government consumption ex. employee comp., cw 2009$	h.9
EGFON	Federal government consumption ex. employee comp., current $	h.10
EGFOT	Federal government consumption ex. employee comp., cw 2009$, trend	h.11
EGPDIN	Gross private domestic investment	b.31
EGS	S&L government consumption and gross investment, cw 2009$	h.12
EGSI	S&L government gross investment, cw 2009$	h.14
EGSIN	S&L government gross investment, current $	h.15
EGSIT	S&L government gross investment, cw 2009$, trend	h.16
EGSL	S&L government employee compensation, cw 2009$	h.17
EGSLN	S&L government employee compensation, current $	h.18

EGSLT	S&L government employee compensation, cw 2009$, trend	h.19
EGSN	S&L government consumption and gross investment, current $	h.13
EGSO	S&L government consumption ex. employee comp., cw 2009$	h.20
EGSON	S&L government consumption ex. employee comp., current $	h.21
EGSOT	S&L government consumption ex. employee comp., cw 2009$, trend	h.22
EH	Residential investment expenditures, cw 2009$	a.3
EHN	Residential investment expenditures	a.11
EI	Change in private inventories, cw 2009$	b.5
EIN	Change in business inventories, current $	b.28
EM	Imports of goods and services, cw 2009$	c.9
EMN	Imports of goods and services, current $	c.8
EMO	Imports of goods and services ex. petroleum, cw 2009$	c.3
EMON	Imports of goods and services ex. petroleum	c.4
EMP	Petroleum imports, cw 2009$	c.6
EMPN	Petroleum imports, current $	c.7
EMPT	Petroleum imports trend, cw 2009$	d.15
EPD	Investment in equipment, cw 2009$	b.1
EPDN	Investment in equipment, current $	b.25
EPI	Investment in intellectual property, cw 2009$	b.2
EPIN	Investment in intellectual property, current $	b.26
EPS	Investment in nonresidential structures, cw 2009$	b.3
EPSN	Investment in nonresidential structures, current $	b.27
EX	Exports of goods and services, cw 2009 $	c.1
EXN	Exports of goods and services, current $	c.2
FCBN	US current account balance, current $	c.10
FCBRN	US current account balance residual, current $	c.11
FGDP	Foreign aggregate GDP (world, bilateral export weights)	j.2
FGDPT	Foreign aggregate GDP (world, bilateral export weights), trend	j.3
FNICN	Gross stock of claims of US residents on the rest of the world, current $	c.16
FNILN	Gross stock of liabilities of US residents to the rest of the world, current $	c.17
FNIN	Net stock of claims of US residents on the rest of the world, current $	c.12
FNIRN	Net stock of claims of US residents on the rest of the world, residual	c.22
FPC	Foreign aggregate consumer price (G39, import/export trade weights)	j.7
FPCM	Foreign aggregate consumer price (G39, bilateral non-oil import trade weights)	j.8
FPI10	Foreign consumer price inflation (G10)	j.4
FPI10T	Foreign consumer price inflation, trend (G10)	j.5
FPIC	Foreign consumer price inflation (G39, bilateral export trade weights)	j.6

FPITRG	Foreign target consumer price inflation (G10)	
FPX	Nominal exchange rate (G39, import/export trade weights)	j.14
FPXM	Nominal exchange rate (G39, bilateral import trade weights)	j.15
FPXR	Real exchange rate (G39, import/export trade weights)	j.12
FPXRR	Real exchange rate residual	j.13
FPXRRT	Real exchange rate residual, trend	
FRL10	Foreign long-term interest rate (G10)	j.11
FRS10	Foreign short-term interest rate (G10)	j.9
FRSTAR	Equilibrium real short-term interest rate used in foreign Taylor rule	j.10
FTCIN	Corporate taxes paid to rest of world, current $	c.13
FXGAP	Foreign output gap (world, bilateral export weights)	j.1
FYNICN	Gross investment income received from the rest of the world, current $	c.18
FYNILN	Gross investment income paid to the rest of the world, current $	c.19
FYNIN	Net investment income received from the rest of the world, current $	c.14
GFDBTN	Federal government debt stock, current $	h.23
GFDRT	Federal government target debt-to-GDP ratio	
GFINTN	Federal government net interest payments, current $	h.24
GFS	Federal government grants-in-aid to S&L government, deflated by PGDP	h.25
GFSN	Federal government grants-in-aid to S&L government, current $	h.26
GFSRPN	Federal government budget surplus, current $	h.27
GFSRT	Federal government target surplus-to-GDP ratio	
GFSUB	Federal government subsidies less surplus, deflated by PGDP	h.28
GFSUBN	Federal government subsidies less surplus, current $	h.29
GFT	Federal government net transfer payments, deflated by PGDP	h.30
GFTN	Federal government net transfer payments, current $	h.31
GFTRD	Deviation of ratio of federal transfers to GDP from trend ratio	h.32
GFTRT	Federal government, trend ratio of transfer payments to GDP	
GSDBTN	S&L government debt stock, current $	h.33
GSDRT	S&L government target debt-to-GDP ratio	
GSINTN	S&L government net interest payments, current $	h.34
GSSRPN	S&L government budget surplus, current $	h.35
GSSRT	State and local government, target surplus-to-GDP ratio	
GSSUB	S&L government subsidies less surplus, deflated by PGDP	h.40
GSSUBN	S&L government subsidies less surplus, current $	h.36
GST	S&L government net transfer payments, deflated by PGDP	h.38
GSTN	S&L government net transfer payments, current $	h.37
GSTRD	Deviation of ratio of S&L transfers to GDP from trend ratio	h.39
GSTRT	S&L government, trend ratio of transfer payments to GDP	

HGEMP	Petroleum imports, cw 2009$, trend growth rate	c.15
HGGDP	Growth rate of GDP, cw 2009$ (annual rate)	d.3
HGGDPT	Trend growth rate of XGDP, cw 2009$ (annual rate)	d.24
HGPCDR	Trend growth rate of price of consumer durable goods (relative to PCNIA)	
HGPDR	Trend Price Growth of PPDR	g.50
HGPIR	Trend Price Growth of PPIR	g.51
HGPKIR	Trend growth rate of PKIR	g.52
HGPPSR	Trend growth rate of PPSR	g.53
HGVPD	Trend Growth of VPD	b.23
HGVPI	Trend growth rate of VPI	b.32
HGVPS	Trend growth rate of VPS	b.24
HGX	Trend growth rate of XG, cw 2009$ (annual rate)	d.22
HGYNID	Growth rate of real after-tax corporate profits	z.37
HKS	Growth rate of KS, cw 2009$ (compound annual rate)	b.13
HKSR	Residual growth of capital services	
HLEPT	Trend growth rate of LEP (annual rate)	e.22
HLPRDT	Trend growth rate of output per hour	e.24
HMFPT	Trend growth rate of multifactor productivity	d.11
HQLFPR	Drift component of change in QLFPR	e.13
HQLWW	Trend growth rate of workweek	e.5
HUQPCT	Drift term in stochastic component of trend ratio of PCNIA to PXP	g.31
HUXB	Drift term in UXBT	d.19
HXBT	Trend rate of growth of XB , cw 2009$ (annual rate)	d.23
JCCACN	Consumption of fixed capital, corporate, current $	f.7
JCCAN	Consumption of fixed capital, current $	f.8
JKCD	Consumption of fixed capital, consumer durables	a.16
JRCD	Depreciation rate, consumer durables	
JRH	Depreciation rate, housing	
JRPD	Depreciation rate, equipment	
JRPI	Depreciation rate, intellectual property	
JRPS	Depreciation rate, nonresidential structures	
JYGFEN	CFC, federal government enterprises, current $	f.9
JYGFGN	CFC, federal government, general, current $	f.10
JYGSEN	CFC, state and local government enterprises, current $	f.11
JYGSGN	CFC, state and local government, general, current $	f.12
JYNCN	Noncorporate business CFC, current $	f.13
KCD	Stock of consumer durables, cw 2009$	a.12
KH	Stock of residential structures, cw 2009$	a.13

KI	Stock of private inventories, cw 2009$	b.4
KPD	Capital stock - Equipment, 2009$	b.10
KPI	Capital Stock - Intellectual Property, 2009$	b.11
KPS	Capital stock - nonresidential structures, 2009$	b.12
KS	Capital services, 2009 $	b.14
LEF	Federal civilian employment ex. gov. enterprise	e.8
LEFT	Federal civilian employment ex. gov. enterprise, trend	e.19
LEH	Civilian employment (break adjusted)	e.10
LEO	Difference between household and business sector payroll employment, less gov't emp.	e.7
LEP	Employment in business sector (employee and self-employed)	e.6
LEPPOT	Potential employment in business sector	e.21
LES	S&L government employment ex. gov. enterprise	e.9
LEST	S&L government employment ex. gov. enterprise, trend	e.20
LEUC	Emergency unemployment compensation (EUC)	
LF	Civilian labor force (break adjusted)	e.14
LFPR	Labor force participation rate	e.11
LHP	Aggregate labor hours, business sector (employee and self-employed)	e.1
LPRDT	Trend labor productivity	e.23
LQUALT	Labor quality, trend level	
LUR	Civilian unemployment rate (break adjusted)	e.15
LURBLS	Civilian unemployment rate (published)	e.16
LURNAT	Natural rate of unemployment	e.25
LURTRSH	Unemployment threshold	
LWW	Workweek, business sector (employee and self-employed)	e.3
MEI	Multiplicative discrepancy for the difference between XGDI and XGDO	i.39
MEP	Multiplicative discrepancy for the difference between XGDP and XGDO	i.41
MFPT	Multifactor productivity, trend level	d.12
N16	Noninstitutional population, aged 16 and over (break adjusted)	
PCDR	Price index for consumer durables, cw (relative to to PCNIA)	g.59
PCENG	Price index for aggregate energy consumption	g.37
PCENGR	Price index for aggregate energy consumption (relative to PXB)	g.36
PCER	Price index for personal consumption expenditures on energy (relative to PCXFE)	g.38
PCFR	Price index for personal consumption expenditures on food (relative to PCXFE)	g.39
PCFRT	Real PCE price of food, trend	
PCHR	Price index for housing services, cw (relative to to PCNIA)	g.57
PCNIA	Price index for personal consumption expenditures, cw (NIPA definition)	g.5

PCOR	Price index for non-durable goods and non-housing services, cw (relative to to PCNIA)	g.56
PCPI	Consumer price index,total	g.6
PCPIX	Consumer price index,excluding food and energy	g.7
PCSTAR	Target consumption price level (used in RFFGEN policy rule)	
PCXFE	Price index for personal consumption expendits ex. food and energy, cw (NIPA definition)	g.33
PGDP	Price index for GDP, cw	g.44
PGFIR	Price index for federal gov. investment, cw (relative to PXP)	g.17
PGFL	Price index for federal government employee compensation, cw	g.45
PGFOR	Price index for federal governemnt consumption ex. emp. comp., cw (relative to PXP)	g.18
PGSIR	Price index for S&L government investment (relative to PXP)	g.19
PGSL	Price index for S&L government employee compensation, cw	g.46
PGSOR	Price index for S&L government consumption ex. emp. comp., cw (relative to PXP)	g.20
PHOUSE	Loan Performance House Price Index	i.37
PHR	Price index for residential investment, cw (relative to PXP)	g.21
PIC4	Four-quarter percent change in PCE prices	g.60
PICNGR	Weighted growth rate of relative energy price	g.54
PICNIA	Inflation rate, personal consumption expenditures, cw	g.4
PICX4	Four-quarter percent change core in PCE prices	g.58
PICXFE	Inflation rate, personal consumption expenditures, ex. food and energy, cw	g.1
PIECI	Annualized rate of growth of EI hourly compensation	g.2
PIGDP	Inflation rate, GDP, cw	g.55
PIPL	Rate of growth of PL	g.8
PIPXNC	Inflation rate, price of adjusted final sales excluding consumption (annual rate)	g.3
PITARG	Target rate of consumption price inflation (used in policy reaction functions)	
PITRSH	Inflation threshold	
PKIR	Price index for stock of inventories, cw (relative to PXP)	
PKPDR	Ratio of price of equipment stock (KPD) to PXP	g.47
PL	Compensation per hour, business	g.9
PLMIN	Minimum wage	g.28
PLMINR	Ratio of hourly minimum wage to compensation per hour (times 100)	
PMO	Price index for imports ex. petroleum, cw	g.42
PMP	Price index for petroleum imports	g.35
POIL	Price of imported oil ($ per barrel)	g.34
POILR	Price of imported oil, relative to price index for bus. sector output	g.32

POILRT	Price of imported oil, relative to price index for bus. sector output, trend	
PPDR	Price level of EPD compared to PXP	g.22
PPIR	Price level of EPI compared to PXP	g.23
PPSR	Price index for nonresidential structures, cw (relative to PXP)	g.24
PTR	10-year expected PCE price inflation (Survey of Professional Forecasters)	z.1
PWSTAR	Equilibrium business sector price markup	g.11
PXB	Price index for business sector output	g.49
PXG	Price index for business output plus oil imports	g.48
PXNC	Price of adjusted final sales excluding consumption	g.10
PXP	Price index for final sales plus imports less gov. labor	g.16
PXR	Price index for exports, cw (relative to PXP)	g.25
QEC	Desired level of consumption (FRBUS definition)	a.5
QECD	Target level of consumption of durable goods, trending component	a.7
QECO	Desired level of consumption of nondurable goods and nonhousing services	a.6
QEH	Target level of residential investment	a.8
QEPD	Desired level of investment in equipment	b.6
QEPI	Desired level of investment in intellectual property	b.8
QEPS	Desired level of investment in structures	b.7
QKIR	Desired Inventory Sales Ratio	b.9
QLEOR	Desired ratio of employment discrepancy to the labor force	
QLEP	Desired level of business employment	e.17
QLF	Desired level of civilian labor force	e.18
QLFPR	Trend labor force participation rate	e.12
QLHP	Desired level of business labor hours	e.2
QLWW	Trend workweek, business sector (employee and self-employed)	e.4
QPCNIA	Desired level of consumption price	g.15
QPL	Desired level of compensation per hour, trending component	g.13
QPMO	Random walk component of non-oil import prices	g.43
QPXG	Desired price level of private output ex. energy, housing, and farm	g.12
QPXNC	Desired level of nonconsumption price	g.29
QPXP	Desired price level of adjusted final sales	g.14
QYNIDN	Desired level of dividends	f.18
RBBB	S&P BBB corporate bond rate	i.29
RBBBE	S&P BBB corporate bond rate (effective ann. yield)	i.28
RBBBP	S&P BBB corporate bond rate, risk/term premium	i.27
RCAR	New car loan rate at finance companies	i.30
RCCD	Cost of capital for consumer durables	a.14
RCCH	Cost of capital for residential investment	a.15

RCGAIN	Rate of capital gain on the non-equity portion of household wealth	i.36
REQ	Real expected rate of return on equity	i.33
REQP	Real expected rate of return on equity, premium component	i.32
RFF	Federal funds rate	i.13
RFFALT	Value of eff. federal funds rate given by estimated policy rule	i.4
RFFE	Federal funds rate (effective ann. yield)	i.12
RFFFIX	Federal funds rate given by fixed, pre-determined funds rate path	
RFFGEN	Value of eff. federal funds rate given by the generalized reaction function	i.5
RFFINTAY	Value of eff. federal funds rate given by the inertial Taylor rule	i.3
RFFMIN	Minimum nominal funds rate (set at 0 to impose zero lower bound)	
RFFRULE	Federal funds rate (effective ann. yield)	i.7
RFFTAY	Value of eff. federal funds rate given by the Taylor rule with output gap	i.1
RFFTLR	Value of eff. federal funds rate given by the Taylor rule with unemployment gap	i.2
RFNICT	Residual in FNICN equation	
RFRS10	Real foreign short-term interest rate	
RFYNIC	Average yield earned on gross claims of US residents on the rest of the world	c.20
RFYNIL	Average yield earned on liabilities of US residents on the rest of the world	c.21
RG10	10-year Treasury bond rate	i.23
RG10E	10-year Treasury bond rate (effective ann. yield)	i.22
RG10P	10-year Treasury bond rate, term premium	i.21
RG30	30-year Treasury bond rate	i.26
RG30E	30-year Treasury bond rate (effective ann. yield)	i.25
RG30P	30-year Treasury bond rate, term premium	i.24
RG5	5-year Treasury note rate	i.20
RG5E	5-year Treasury note rate (effective ann. yield)	i.19
RG5P	5-year Treasury note rate. term premium	i.18
RGFINT	Average rate of interest on existing federal debt	i.43
RGW	Approximate average rate of interest on new federal debt	i.42
RME	Interest rate on conventional mortgages (effective ann. yield)	i.31
RPD	After-tax real financial cost of capital for business investment	b.15
RRFFE	Real federal funds rate (effective ann. yield)	i.15
RRFIX	Real federal funds rate given by fixed, pre-determined real funds rate path	
RRMET	Real mortgage rate, trend	i.44
RRTR	Expected long-run real federal funds rate	z.2
RSPNIA	Personal saving rate	f.23
RSTAR	Equilibrium real federal funds rate (for monetary policy reaction functions)	i.6
RTB	3-month Treasury bill rate	i.17

RTBE	3-month Treasury bill rate (effective ann. yield)	i.16
RTINV	User cost of capital for inventories	b.19
RTPD	User cost of capital for equipment	b.16
RTPI	User cost of capital for intellectual property	b.17
RTPS	User cost of capital for nonresidential structures	b.18
RTR	Expected federal funds rate in the long run (Blue Chip)	z.3
T47	Time trend, begins in 1947q1 (0 before)	
TAPDAD	Proportion of investment in equipment using accelerated depreciation	
TAPDD	Present value of depreciation allowances for equipment	b.30
TAPDDP	Proportion of investment tax credit deducted from depr. base	
TAPDS	Tax service life of equipment	
TAPDT	Investment tax credit rate for equipment	
TAPSAD	Proportion of investment in nonresidential structures using accelerated depreciation	
TAPSDA	Present value of depreciation allowances for nonresidential structures	b.29
TAPSSL	Tax service life of nonresidential structures	
TFCIN	Federal corporate income tax accruals, current $	h.41
TFDIV	Federal income receipts on assets, dividends, current $	
TFIBN	Federal indirect business tax receipts, current $	h.42
TFPN	Federal personal income tax and nontax receipts, current $	h.43
TFSIN	Federal social insurance tax receipts	h.44
TRFCI	Average federal corporate income tax rate	h.45
TRFCIM	Marginal federal corporate income tax rate	
TRFIB	Average federal indirect business tax rate	
TRFP	Average federal tax rate for personal income tax and nontax receipts	h.46
TRFPM	Marginal federal personal income tax rate (at twice median family income)	
TRFPT	Average federal tax rate for personal income tax, trend	h.47
TRFPTX	Average federal tax rate for personal income tax, trend, policy setting	
TRFSI	Average federal social insurance tax rate	
TRSCI	Average S&L corporate income tax rate	h.48
TRSCIT	Average S&L corporate income tax rate, trend	
TRSIB	Average S&L indirect business tax rate	h.49
TRSIBT	Average S&L indirect business tax rate, trend	
TRSP	Average S&L tax rate for personal income tax and nontax receipts	h.50
TRSPP	Marginal S&L tax rate on personal property	
TRSPT	Trend S&L personal income tax rate	h.51
TRSPTX	Average state and local tax rate for personal income, trend	
TRSSI	Average S&L social insurance tax rate	h.52

TRSSIT	Average S&L social insurance tax rate, trend	
TRYH	Average tax rate on household income	h.59
TSCIN	S&L corporate income tax accruals, current $	h.53
TSIBN	S&L indirect business tax receipts, current $	h.54
TSPN	S&L personal income tax and nontax receipts, current $	h.55
TSSIN	S&L social insurance tax receipts, current $	h.56
UCES	Energy share of nominal consumption expenditures	g.40
UCFS	Food share of nominal consumption expenditures	g.41
UEMOT	Trend in ratio of EMON to XGDEN	
UEMP	Multiplicative factor in EMP identity	
UFCBR	Multiplicative factor in FCBRN identity	
UFNIR	Multiplicative factor in FNIRN identity	
UFPCM	Multiplicative factor in FPCM identity	
UFPXM	Multiplicative factor in FPXM identity	
UFTCIN	Multiplicative factor in FTCIN identity	
UGFDBT	Multiplicative factor in GFDBTN identity	
UGSDBT	Multiplicative factor in GSDBTN identity	
UGSINT	Multiplicative factor in GSINTN identity	
UGSSUB	Multiplicative factor in GSSUB identity	
UJCCA	Multiplicative factor in JCCAN identity	
UJCCAC	Multiplicative factor in JCCACN identity	
UJYGFE	Multiplicative factor in JYGFEN identity	
UJYGFG	Multiplicative factor in JYGFGN identity	
UJYGSE	Multiplicative factor in JYGSEN identity	
UJYGSG	Multiplicative factor in JYGSGN identity	
ULEF	Multiplicative factor in LEF identity	
ULES	Multiplicative factor in LES identity	
UPCPI	Multiplicative factor in PCPI identity	
UPCPIX	Multiplicative factor in PCPIX identity	
UPGFL	Multiplicative factor in PGFL identity	
UPGSL	Multiplicative factor in PGSL identity	
UPKPD	Multiplicative factor in PKPDR identity	
UPMP	Multiplicative factor in PMP identity	
UPXB	Multiplicative factor in PXB identity	
UQPCT	Stochastic component of trend ratio of PCNIA to PXP	g.30
UVEOA	Multiplicative factor in VEOA identity	
UVPD	Multiplicative factor in VPD identity	
UVPI	Multiplicative factor in VPI identity	

UVPS	Multiplicative factor in VPS identity	
UXBT	Stochastic component of trend ratio of XGDPT to XBT	d.18
UXENG	Multiplicative factor in XENG identity	
UYD	Multiplicative factor in YDN identity	
UYHI	Multiplicative factor in YHIN identity	
UYHLN	Multiplicative factor in YHLN identity	
UYHPTN	Multiplicative factor in YHPTN identity	
UYHSN	Multiplicative factor in personal saving identity (accounts for transfers to foreigners)	
UYHTN	Multiplicative factor in YHTN identity	
UYL	Multiplicative factor in YLN identity	
UYNI	Multiplicative factor in YNIN identity	
UYNICP	Multiplicative factor in YNICPN identity	
UYP	Multiplicative factor in YPN identity	
UYSEN	Multiplicative factor in YSEN identity	
VEO	Desired energy-output ratio	d.13
VEOA	Average energy-output ratio of existing capital stock	d.14
VPD	Desired equipment-output ratio	b.20
VPI	Desired intellectual property-output ratio	b.21
VPS	Desired structures-output ratio	b.22
WDNFCN	Net financial liabilities, nonfinancial nonfarm corporations	f.45
WPO	Household property wealth ex. stock market, real	i.40
WPON	Household property wealth ex. stock market, current $	i.38
WPS	Household stock market wealth, real	i.35
WPSN	Household stock market wealth, current $	i.34
XB	Business output (BEA definition), cw 2009$	d.8
XBN	Business output (BEA definition), current $	f.5
XBO	Business output, adjusted for measurement error, cw 2009$	d.6
XBT	Potential business output, cw 2009$	d.16
XENG	Crude energy production, cw 2009$	d.26
XFS	Final sales of gross domestic product, cw 2009$	d.1
XFSN	Final sales of gross domestic product, current $	f.3
XG	Output of business sector plus oil imports, cw 2009$	d.9
XGAP	Output gap for business plus oil imports (100*log(actual/potential)	d.20
XGAP2	Output gap for GDP (100*log(actual/potential)	d.21
XGDE	Domestic absorption, cw 2009$	d.4
XGDEN	Nominal Absorption, current $	f.4
XGDI	Gross domestic income, cw 2009$	d.27

XGDIN	Gross domestic income, current $	f.46
XGDO	Gross domestic product, adjusted for measurement error, cw 2009$	d.28
XGDP	GDP, cw 2009$	d.2
XGDPN	GDP, current $	f.2
XGDPT	Potential GDP, cw 2009$	d.17
XGDPTN	Potential GDP, current $	d.25
XGN	Output of business sector plus oil imports, current $	f.6
XGO	Output of business sector plus oil imports, adjusted for measurement error, cw 2009$	d.5
XGPOT	Potential output of business sector plus oil imports, cw 2009$	d.10
XP	Final sales plus imports less government labor, cw 2009$	d.7
XPN	Final sales plus imports less government labor, current $	f.1
YCSN	Net corporate cash flow with IVA and CCA	f.24
YDN	Disposable income	f.22
YGFSN	Federal government saving	h.57
YGSSN	State and Local government saving	h.58
YH	Income, household, total (real after-tax)	f.28
YHGAP	Income, household, total, ratio to XGDP, cyclical component (real after-tax)	f.29
YHIBN	Consumer interest payments to business	f.30
YHIN	Income, household, net interest and rent	f.31
YHL	Income, household, labor compensation (real after-tax)	f.32
YHLN	Income, household, labor compensation	f.33
YHP	Income, household, property (real after-tax)	f.34
YHPCD	Imputed income of the stock of consumer durables, 2009$	a.18
YHPGAP	Income, household, property, ratio to YH, cyclical component (real after-tax)	f.35
YHPNTN	Income, household, property, non-taxable component	f.36
YHPSHR	Income, household, property, ratio to YH (real after-tax)	f.37
YHPTN	Income, household, property, taxable component	f.38
YHSHR	Income, household, total, ratio to XGDP (real after-tax)	f.39
YHSN	Personal saving	f.40
YHT	Income, household, transfer (real after-tax), net basis	f.41
YHTGAP	Income, household, transfer, ratio to YH, cyclical component (real after-tax)	f.42
YHTN	Income, household, transfer payments. net basis	f.43
YHTSHR	Income, household, transfer, ratio to YH (real after-tax)	f.44
YKIN	Income from stock of inventories	f.25
YKPDN	Income from stock of equipment	f.26
YKPSN	Income from stock of nonresidential structures	f.27
YMSDN	Microsoft one-time dividend payout in 2004Q4	

YNICPN	Corporate profits (national income component)	f.20
YNIDN	Dividends (national income component)	f.19
YNIIN	Net interest and rental income (national income component)	f.17
YNILN	Labor income (national income component)	f.15
YNIN	National income	f.14
YNISEN	Propprietors' income (national income component)	f.16
YPN	Personal income	f.21
ZDIVGR	Expected growth rate of real dividends, for WPSN eq. (VAR exp.)	z.29
ZECD	Expected growth rate of target durable consumption, for ECD eq. (VAR exp.)	z.19
ZECO	Expected growth rate of target nondurables and nonhousing services, for ECO eq (VAR exp.)	z.18
ZEH	Expected growth rate of target residential investment, for EH eq. (VAR exp.)	z.21
ZGAP05	Expected output gap, for RG5E eq. (VAR exp.)	z.7
ZGAP10	Expected output gap, for RG10E eq. (VAR exp.)	z.8
ZGAP30	Expected output gap, for RG30E eq. (VAR exp.)	z.9
ZGAPC2	Expected output gap, for ECD eq. (VAR exp.)	z.20
ZLHP	Expected growth rate of target aggregate hours (VAR exp.)	z.22
ZPI10	Expected cons. price infl., for RCCH, RRMET, and YHPNTN eqs. (10-yr mat.) (VAR exp.)	z.12
ZPI10F	Expected cons. price infl., for FPXR eq. (10-yr mat.) (VAR exp.)	z.13
ZPI5	Expected cons. price infl., for RCCD eq. (5-yr mat.) (VAR exp.)	z.10
ZPIB5	Expected output price infl., for RPD eq. (5-yr mat.) (VAR exp.)	z.11
ZPIC30	Expected cons. price infl., for REQ eq. (30-yr mat.) (VAR exp.)	z.14
ZPIC58	Expected 4-qtr consumer price inflation (8 qtrs. in the future) (VAR exp.)	z.15
ZPICXFE	Expected value of picxfe in the next quarter (VAR exp.)	z.16
ZPIECI	Expected value of pieci in the next quarter (VAR exp.)	z.17
ZRFF10	Expected federal funds rate, for RG10E eq. (10-yr mat.) (VAR exp.)	z.5
ZRFF30	Expected federal funds rate, for RG30E eq. (30-yr mat.) (VAR exp.)	z.6
ZRFF5	Expected federal funds rate, for RG5E eq. (5-yr mat.) (VAR exp.)	z.4
ZVPD	Expected growth rate of capital-output ratio, for EPD (VAR exp.)	z.23
ZVPI	Expected growth rate of capital-output ratio, for EPI (VAR exp.)	z.24
ZVPS	Expected growth rate of des. capital-output ratio, for EPS eq. (VAR exp.)	z.25
ZXBD	Expected growth rate of buisiness output for EPD (VAR exp.)	z.26
ZXBI	Expected growth rate of business output, for EPI (VAR exp.)	z.27
ZXBS	Expected growth rate of business output, for EPS (VAR exp.)	z.28
ZYH	Expected level of real after-tax household income, for QEC eq. (VAR exp.)	z.31
ZYHP	Expected level of real after-tax property income, for QEC eq. (VAR exp.)	z.32
ZYHPST	Expected trend share of property income in household income	z.35

ZYHST	Expected trend ratio of household income to GDP	z.34
ZYHT	Expected level of real transfer income, for QEC eq. (VAR exp.)	z.33
ZYHTST	Expected trend share of transfer income in household income	z.36
ZYNID	Expected rate of growth of target real dividends, for YNIDN eq. (VAR exp.)	z.30
ZZZBLANK	empty slot	