DISCUSSION PAPER SERIES

No. 4584

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INTERNATIONAL MACROECONOMICS

Centre for Economic Policy Research

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Available online at: www.cepr.org/pubs/dps/DP4584.asp

ISSN 0265-8003

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Discussion Paper No. 4584
August 2004

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ABSTRACT

Forecasting (and Explaining) US Business Cycles*

This Paper uses multi-step forecasting models at horizons of 4 and 8 quarters to forecast and explain the growth of real *per capita* US GDP. In the modeling strategy, *a priori* sign restrictions play an important role. They are imposed not on impulse response functions but directly on the reduced form single or multi-step equations, unlike in recent work by Uhlig and Canova. This is possible because in this context, the reduced form inherits important structural sign properties; basically, that autonomous expenditure has positive effects on near future GDP. We consider an economically large class of variables, including effects from interest rates, the credit channel and asset prices, the real exchange rate, yield spreads, inflation and interest rate volatility, oil prices (including asymmetries), structural breaks in fiscal and monetary policy, the recent behaviour of consumption, investment and profitability, and the evolutionary effect of globalization on the balance of payments constraint. We follow a general to specific methodology, including the help of PCGETS (Hendry and Krolzig, 2001) to reduce general models to more parsimonious ones.

Relative to conventional VARs, our models imply longer lag structures than ever considered in VARs, as well as non-linearities, and so could never have been found with conventional VAR restrictions. Our results thus contradict the suggestion of Sims (1980) that VARs can resolve the problem of ‘incredible restrictions’ embodied in large macro econometric models. Our exercise of learning from the data through general to specific modeling is likely, in many cases, also to contradict the lag structures of such models. We present a range of models with remarkable recursive forecasting performance since 1982 and show that similar models could have been selected with 1982 data by applying similar methods then. Out of sample forecasts with such models since March 2001, when we forecast that 2001 would be a recession year, have also been successful.

JEL Classification: E32, E37, E52 and E63
Keywords: business cycles, fiscal policy, monetary policy, multi-step forecasting and oil shocks

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*This research has been supported by the ESRC under grant RES-000-23-0244 'Improving Methods for Macro-econometric Modelling', held with Adrian Pagan. We are grateful for helpful discussions with and comments from Mike Clements, David Hendry, Roland Meeks, Adrian Pagan, and Neil Shephard. We also thank Jason Cummins, David Reifschneider and other seminar participants at the Federal Reserve Board while the first author was a Visiting Scholar at the FRB. Responsibilities for errors rests with the authors.

Submitted 14 July 2004

1. Introduction

Loungani (2000) provides evidence on failures to forecast business cycles in OECD countries. He notes particularly the failure to forecast turning points. In the U.S., the belief that the 'The Business Cycle is Dead' gained ground at the end of the 1990s after the longest continuous expansion for a century. Even the Survey of Professional Forecasters failed badly to forecast the downturn in 2001. The Federal Reserve's own Green Book forecasts (released 5 years after they are made) had no better record than the SPF for output up to 1996, according to Sims (2002), though better on inflation. There is clearly a need for a practical forecasting model, which does not require the Fed's resources, and one with good economic stories. This paper provides such a model, indeed a set of such models. Earlier versions of our model forecast the 2001 U.S. recession on February 2001 data, and a robust upturn for 2002 in December 2001, when most forecasters were revising down their 2002 forecasts. Current versions respectively based on February and May 2004 data imply central forecasts of over 5 percent growth in 2004, spilling into 2005.

Our approach rests on the premise that prices are sticky and that quantity adjustment of expenditure to 'equilibrium' output and to capacity trend output takes time. There is a great deal of persistence in determinants of autonomous expenditure such as asset prices and interest rates, and, in some cases, because of adjustment costs and habits, there are lags in the response of expenditure to shocks in these determinants. In consequence, data on the determinants of autonomous expenditure are highly effective for forecasting at a one year horizon.

We model real GDP per head 4 and 8 quarters ahead, using multi-step models rather than VARs. Our approach incorporates more theory, and richer specifications than Stock and Watson's (2003) otherwise comprehensive examination of the role of asset prices and other variables in multi-step forecasting of GDP and inflation in the G7 economies. In our modelling strategy, a priori sign restrictions play an important role. They are imposed not on impulse response functions like Faust (1998), Uhlig

(1999), Canova (2002) and Canova and De Nicoló (2002), but directly on the reduced form multi-step equations. This is possible because these equations inherit important structural sign properties, basically that autonomous expenditure and factors causing it to rise have positive effects on near future GDP.

We consider an *economically* large class of variables, including effects from interest rates, the credit channel and asset prices, the real exchange rate, yield spreads, inflation and interest rate volatility, oil prices (including. asymmetries), structural breaks in fiscal and monetary policy, the recent behaviour of consumption, investment and profitability, and the evolutionary effect of globalisation on the balance of payments constraint. Note, however, that the information sets are not so large in a *statistical* sense (unlike the factor models of Stock and Watson, 2002b). We follow a general to specific methodology, including the help of *PcGets* (Hendry and Krolzig, 2001) to reduce general models to more parsimonious ones.

Explaining business cycle fluctuations in the U.S. in the last 45 years is one thing; out of sample forecasting is another. As Hendry (2004) and Clements and Hendry (1998 and 1999) emphasise, a well fitting model is not necessarily very useful for forecasting. For example, structural breaks or shifts in trend, selected with the hindsight of a long sample, are typically hard to detect ex ante.

We examine the recursive out of sample forecasting approach of a set of 6 alternative specifications from 1982 and compare these with conventional alternatives and the Survey of Professional Forecasters. We show that models close to ours would have been chosen on the basis of pre-1982 data, had our theoretical principles and our methods been used at that time, and that these models have excellent subsequent recursive out of sample forecasting performance.

Our models imply longer lag structures than usually considered in VARs, as well as non-linearities and so could not have been found with conventional VAR restrictions. Our results thus suggest that conventional VARs sometimes fail to resolve the problem of 'incredible restrictions' (Sims, 1980) embodied in large macro-econometric models. However, our exercise of learning from the data through general to specific modelling is likely, in many cases, also to contradict the lag structures of such policy models – certainly, if out of sample forecasting of such models is a criterion. Thus, while Sims was probably correct in criticising then current vintages of such models, conventional VARs themselves impose restrictions rejected on our 45-year U.S. data set.

2. Theory Background

Following Muellbauer (1996) output growth is captured in a dual adjustment process: first, output adjusts to equilibrium output, given by an income-expenditure model under sticky prices; and secondly, output adjusts to trend output, determined, in principle, by the state of technology and physical and human capital stocks. The adjustment process involves spontaneously occurring recovery forces operating in recessions, as well as monetary and fiscal policy feedback rules. The former might include real wages, commodity and investment goods prices falling far enough relative to productivity trends to make production, employment, and investment more profitable again, as well as rising replacement demand and low interest rates resulting from the low investment rates associated with recession. The reverse mechanisms operate in booms, together with the high marginal costs associated with over-time hour premia and, in the limit, sheer capacity or skilled labor supply constraints. Any shifts in the policy feedback rules could have implications for these tendencies for output to revert to trend.

Large macro-econometric models articulate many elements of these processes. In what follows they will be summarized by a single adjustment equation. The component of the rate of growth of output due to the income-expenditure adjustment is shown in Muellbauer (1996) to be approximately linearly related to:

$$A_t / Y_t - GSURR_t - TDEFR_t \qquad (1)$$

where *A* is autonomous expenditure, *Y* is real GDP, and *GSURR* and *TDEFR* are respectively, the ratios to GDP of the government surplus and trade deficit. The argument rests on the following approximation: in the income-expenditure model, equilibrium GDP, Y* is given by:

$$Y^* = a(Y^* - T) + A + G + X - M \qquad (2)$$

so that

$$\begin{aligned} Y^* &= \frac{1}{1-a}[A + G - aT + X - M] \\ &\approx \frac{1}{1-a}[A + G - T + X - M] \qquad (3) \end{aligned}$$

if a is of the order of 0.8 or more.

Since GSURR, the government surplus to GDP ratio is (-(*G*-*T*)/*Y*) while *TDEFR*, the trade deficit to GDP ratio or (-(*X*-*M*)/*Y*), dividing equation (3) by *Y* implies (1).

Trend income output (*TY*), depends on the level of technology, human and physical capital.

The dual adjustment process, discussed above, linking actual *Y* both with *Y** and with *TY* is

$$\Delta \ln Y_t = b_1(\ln Y_t^* - \ln Y_t) + b_2(\ln TY_{t-1} \ln Y_{t-1}) \qquad (4)$$

Substituting equation (1) in equation (4) and taking a log approximation gives:

$$\Delta \ln Y_t = b_0 + b_1(A_t / Y_t - GSURR_t - TDEFR_t) + b_2(\ln TY_{t-1} - \ln Y_{t-1}) \qquad (5)$$

This is the key to our model.

To convert this expression into a forecasting model effectively involves forecasting autonomous expenditure relative to GDP and the government surplus and trade deficit ratios. The latter are strongly persistent variables, so that lagged values should have valuable forecasting potential.[1] Embedded in the autonomous term, A_t, are credit, asset, uncertainty, expectations, and terms of trade variables, such as real oil prices, that influence consumption and investment, with obvious directions of effects (sign priors) from standard economic theory. Important proxies for these variables arise in

[1] A possible objection to the approximation in equation (2) is that T and M are also functions of Y*. In this case, GSURR would have to be replaced by -(G – autonomous tax revenue)/Y* and TDEFR by – (X – autonomous imports)/Y*. However, it is likely that lagged values of GSURR and TDEFR would still be strongly correlated with these concepts.

the context of empirical work on the monetary transmission mechanism[2], including the "credit channel"[3], Bernanke and Blinder (1992), Bernanke and Gertler (1995), or the "financial accelerator", Bernanke, Gertler, and Gilchrist (1996, 1999).

Asset prices should play an important role in the transmission mechanism, whether one takes a "conventional" asset markets view, see Taylor (1999), or the credit channel view. Recently, Stock and Watson (2003) have examined the role of asset prices, including equity prices, bond prices, yield gaps, spreads, and exchange rates in forecasting both output and inflation in seven OECD economies, with plausible findings for output forecasts. Output effects of the terms of trade are widely acknowledged, for example, real oil price effects have been studied in the U.S. by Hamilton (1983, 1996, 2003).

In addition to these effects, lagged values of the ratios to GDP of consumption and investment should help forecast A/Y: habits and adjustment costs help explain the persistence of consumption and investment spending. But in addition, persistent shifts in consumption or investment due, for example, to shifts in the structure of credit markets or in the tax code, not captured in the other explanatory variables, will be reflected in these lagged values, and should improve the robustness of the model to regime changes and structural breaks.

The forecasting equation will implicitly incorporate both monetary and fiscal feedback rules and is therefore subject to the Lucas critique (Lucas, 1976). It is important therefore to build in parameter shifts reflecting such regime changes and to test for parameter stability.

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2 Studies examining effects of short-term interest rates or other monetary policy indicators on subsequent output growth using VARs include Sims (1980, 1992), Todd (1990) and Friedman and Kuttner (1992).

3 Credit conditions have been proxied using spreads between corporate and government bonds as one proxy for such credit terms, see Gertler and Lown (1999); others have interpreted such spreads as a proxy for uncertainty.

3. Some Methodological Issues

Sims (1980) criticised standard macro-econometric policy models for embodying 'incredible restrictions', particularly given the rational expectations hypothesis.

As an alternative, Sims recommended the use of unrestricted Vector Autoregressive Models (VARs), now widely-used tools in academic and central bank macro-econometrics. More recently, SVARs models with minimal restrictions have been widely used to permit more 'structural' interpretations, see Sims (1996).

However, in practice VARs *are* highly restricted, and there are major difficulties in interpreting and using VARs for policy and forecasting. These are related to omitted variables, omitted structural breaks, omitted relevant lags and non-linearities. In addition SVARs often rely on doubtful identifying restrictions in order to interpret shocks.

This paper proposes extending the VAR approach to overcome these objections. The imposition of credible sign priors, as discussed above, and "general to specific" model selection are key to our approach. We also consider other restrictions to aid parsimony and test for non-linearities and structural breaks. The next few subsections explain some important features.

3.1 The Treatment of Lags

In most VARs, lag lengths are restricted to 1 or 2 quarters; very rarely beyond 4. The longer the lag, the less likely is it that the precise timing can be estimated or indeed that forecast performance will be very sensitive to the precise choice e.g., between effects at t-5, t-6 and t-7. This supports the case for allowing the possibility of longer lags, but restricting the effects to 4-quarter changes, $\Delta_4 X_{t-4}$ and $\Delta_4 X_{t-8}$, or 4-quarter moving averages at t-4 and t-8. For a variable such as the current account to GDP ratio, or the real exchange rate, both subject to erratic movements but strong persistence, annual changes or moving averages tend to smooth out erratic jumps in the data, and we check for such restrictions at shorter lags as well.

3.2 The Treatment of Dynamics in Model Selection

It is unfortunate if apparently wrong-signed dynamic variables are eliminated: often signs are not wrong but have other plausible interpretations. For example, a common mistake in model selection can be illustrated as follows.

Consider the following equilibrium correction model (see, for example, Engle and Granger, 1987, Hendry 1995):

$$\Delta Y_t = \gamma(\alpha_0 + \alpha X_{t-1} - Y_{t-1}) + \sum_{j=1}^{k} \beta_j \Delta X_{t-j} + \sum_{i=1}^{k} \lambda_i \Delta Y_{t-i}$$

The estimated version of such a model may contain the following term with "wrong-signed" dynamics: $0.1X_{t-1} - 0.05\Delta X_{t-1}$. Instead of eliminating the "wrong-signed" second term, note that the expression simplifies to $0.1X_{t-1}(ma2)$. Analogously, the term $0.1X_{t-1} - 0.075\Delta X_{t-2} - 0.05\Delta X_{t-3} - 0.025\Delta X_{t-4}$ simplifies to $0.1X(ma4)_{t-1}$.

Other simplifying restrictions can involve shifting level terms back or forward, e.g. $0.1X_{t-1} - 0.1\Delta X_{t-1} = 0.1X_{t-2}$, for the former.

3.3 Checking for asymmetries

If ΔX is the change in the log oil price, we can test for asymmetries by including: $\beta_1 \Delta X + \beta_2 |\Delta X|$. If $\beta_2 = \beta_1$, the effect of a fall in the oil price is zero, while the effect of a rise is $2\beta_1$. The $|\Delta X|$ effect can also be interpreted as an oil price volatility effect.

3.4 The *PcGets* Methodology

Let us consider a data generating process (DGP):

$$y_t = \sum_{j=1}^{m} \beta_j z_{j,t} + \varepsilon_t \text{ where } \varepsilon_t \sim IN(0, \sigma_\varepsilon^{\ 2})$$

nested in a general unrestricted model (GUM) of the following form:

$y_t = \sum_{i=1}^{n} \gamma_i z_{i,t} + v_t$ where $v_t \sim IN(0, \sigma_v^{\ 2})$ with $m \leq n$ and $t=1,...,T$. The formulation of the GUM is assumed to be overparametrized with respect to the DGP and is based on theory, institutional knowledge and previous evidence. Under standard assumptions, OLS estimates $\hat{\gamma}$ are unbiased but inefficient if some of the γ_i are zero.

PcGets estimation has three basic stages[4]: These are estimation and testing of the GUM; search process; and thirdly, post-search evaluation.

Once a relatively orthogonal specification for the GUM is identified, *PcGets* commences testing for mis-specification and congruency of the model, i.e. for the adequacy of the model at characterizing the data. Pre-search reduction tests are undertaken in order to reduce the complexity of the search process. A multiple reduction search path is activated from the new GUM from each feasible initial deletion in order to avoid path-dependent selections. If reduction and diagnostic tests are acceptable and all remaining variables are significant, that model becomes a terminal model and the next path search commences. When all variables are mutually orthogonal, the *PcGets* selection procedure amounts to ranking the squared t-tests on each variable z_i in the GUM and retaining only those that exceed a pre-set significant level c_α. In this case the selection takes place in one single decision. When variables are not mutually orthogonal a multi-path search procedure is activated and a sequence of such transforms is implemented. When a set of variables is eliminated, this is equivalent to dropping their orthogonal component relative to the retained variables. When all paths have been explored all terminal models are tested against their union in order to find an encompassing contender. Rejected models are eliminated and the union of the remaining terminal models becomes the new GUM and a new multi-path search starts until a unique choice is identified. Finally the significance of every variable in the final model is checked over two overlapping sub-samples.

Two alternative testing strategies are offered by *PcGets*. A `liberal' strategy equates the chances of dropping relevant explanatory variables and retaining irrelevant. A `conservative' strategy minimises retention of irrelevant. These correspond to a null rejection frequency per candidate variable of about 5% and 1% respectively.

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[4] See Hendry and Krolzig (1999, 2003), and Hoover and Perez (1999) for an earlier approach.

Campos, Hendry and Krolzig (2003) discuss the consistency property of automated model selection using the *PcGets*' algorithm. Monte Carlo experiments show that the *PcGets* procedure is consistent as it ensures that a DGP nested within a model, will be selected with probability unity as *T* diverges relative to *n*. This is equivalent, in large samples, to the Schwarz (1978) Information Criterion (SIC) and Hannan and Quinn (1979) selection algorithm (HQ). In finite samples the *PcGets* algorithm ensures that a congruent model is selected and can outperform SIC and HQ in special cases without ad hoc adjustments[5].

In our use of *PcGets*, we incorporate the points made in sections 3.1-3.3 about imposing sign priors, allowing for four quarter rates of change and four-quarter moving average effects, and testing for non-linearities in oil price effects. Sign priors are imposed by sequentially omitting, most significant first, wrong signed effects from the GUM when *PcGets* selects a parsimonious model including such effects. Four-quarter simplifications of lag structures are checked by, for example, including a level effect at t, 1-quarter change effects at t and at t-1, an ma4 at t and the 4-quarter change at t. Note that these 5 variables are equivalent in linear combination to levels of the variable at lags from 0 to 4. This parameterisation ensures that *PcGets* can find the four quarter simplifications if they are empirically relevant.

4. Empirical Specifications

The forecasts will implicitly incorporate monetary and fiscal policy feedback rules and are therefore subject to the Lucas critique. Among the key regime changes are likely to have been the end of Bretton-Woods pegged exchange rate system in 1971-1973, and the shift in the monetary policy regime at end of 1979 (See Clarida, Gali, Gertler and Clarida, 1998), as well as 1980 and 1981 legislation implying a shift away from interest rate ceilings, liquidity ratios on banks, to a more interest rate focused policy (see Mishkin 1991). We might expect the latter to have altered the role of real

[5] See Campos, Hendry and Krolzig (2003).

and nominal interest rates in influencing subsequent growth. For example, if liquidity ratios or other instruments to influence credit were used coincidentally with nominal interest changes before 1980, but not after, one might expect a larger coefficient on nominal interest rates before 1980, reflecting the correlation with the excluded variables.[6]

We take the key shift in fiscal policy, to take more seriously the Government budget constraint, to occur in 1989-92. Although short-term fiscal policy shifted under Johnson, Reagan and others, this period marks the most systematic shift towards concern over government debt. The 1980's saw increasing international concern among macroeconomists and latterly policy makers about the long-run sustainability of fiscal policy, see Federal Reserve Bank of Kansas City (1995) and Bryant et al (1993). Correspondingly, in the US, there was a shift in the attitude of policymakers to the federal government's budget deficit. This was signalled by the passing in late 1985 of the first of the Gramm-Rudman Amendments. However, most observers e.g., White and Wildavsky (1991), see especially the Postscript, agree that the Budget Enforcement Act of 1990 was the most important milestone. It also coincides with the end of the Cold War, and the decline in defence spending which followed. Taking debt more seriously means that we expect a more pronounced negative effect from the government debt to GDP ratio on subsequent growth from this period onwards as the private sector increasingly realised that higher debt meant higher future taxes or lower future expenditure.

We define LGDPQW= log real GDP per working age population. In order to explain $\Delta 4LGDPQW_{t+4}$ (D4LGDPQW4 from now on) we expect signs as follows:

(-) LGDPQW: this is a key component of the equilibrium correction mechanism, capturing, for example, tendencies for trend reversion.

[6] See Aron and Muellbauer (2002) for a similar point in the admittedly more extreme context of South Africa., where there is evidence for just such a shift. In parallel work on the U.K., we also find such an effect.

(+) TREND, (-) TREND69, (-) TREND73, (?) TREND80, (+) TREND95: these are the trend and split trends[7], beginning respectively in the first quarters of 1969, 1973, 1980 and 1995. One expects a positive TREND effect and TREND69 or TREND73 to have negative coefficients reflecting the well-known productivity slowdown of the period, see Griliches (1994). However, one would expect TREND95 to have a non-negative coefficient, reflecting the improvement in productivity growth of the time.

(+) D12LGDPQW: 3-year per capita growth rate to capture persistent changes in productivity growth.

(+) UT: log employment/workforce=log (1-UR/100), where UR is the unemployment rate. We expect positive effects via consumption as stronger employment relative to output should improve consumer confidence about labor incomes and security of employment. Note that if an equilibrium correction term via LGDPQW and trends is excluded, UT would have a negative effect as a proxy for such an ECM or output gap.

(+) WHOURSD2: deviation of average hours of work from the annual moving average. This is likely to play a similar role to UT and may also be an indicator of employment and investment trends.

(+) D8LWAPOP: 2-year change in log of working age population. This generates investment demand to maintain the capital stock per head and so should be positive for the growth outlook.

(+) SPINDEXQ: log real S&P index. The S&P 500 index deflated by the consumer expenditure deflator should have a positive coefficient reflecting the wealth, credit channel, cost of capital and expectations effect of real stock prices.

(-) ΔIR: the change in the short-term interest rate increased by the nominal 3-month T-bill yield. On a credit channel interpretation, this squeezes cash flows of existing floating rate borrowers and of new borrowers and so has a negative effect on expenditure.

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[7] For example, TREND69 is zero up to 1968Q4 and increases linearly with time from 1969Q1.

(-) ΔIRB80: ΔIR times a dummy which is 1 before 1980, and 0 from 1980Q1 to reflect a bigger negative effect of rises in nominal rates before 1980 when credit conditions were less liberal.

(-) RIR: the real 3-month T-bill rate, defined as the nominal rate in annual terms minus $\Delta_4 \log p_t$ the retrospective 4-quarter change in the log of the consumer expenditure deflator. The negative effect reflects the cost of capital, and inter-temporal substitution.

(-) RIRA80: RIR times a dummy which is zero before 1980 and 1 from 1980Q1: a bigger negative effect after 1980 could reflect a bigger role of market rates in more liberal financial markets.

(-) ΔRIR: if no levels RIR effect can be found, a negative change effect is expected.

(-) ABINFIMA: this indicator of inflation volatility is defined as the 4-quarter moving average of abs($\Delta_4$logpc$_t$ -.$\Delta_4$logpc$_{t-4}$). This is likely to be associated with greater volatility of real incomes and of interest rates, both likely to be negative for investment and consumption.

(-) ABD4LIRMA: an indicator of the volatility of short-term interest rates. This is defined as the 4-quarter moving average of the absolute value of the 4-quarter change in the log of the T-bill rate minus the 4-quarter change lagged 4 quarters. Note this is defined in terms of log-changes rather than changes in basis points.

(+) YLDSPD: the yield spread defined as the10-year Treasury bond yield minus the 3-month T-bill yield. This is widely believed to be an indicator of future growth, as both credit demand and interest rate feedback rules should then imply higher expected short-run interest rates relative to current short rates and so a rise in the spread, see Campbell (1995), Estrella and Mishkin (1998), Bernard and Gerlach (1998), and Peel and Taylor (1998).

(-) CORPSPD: the yield on Moody's credit rating agency baa rated corporate bonds minus the yield on aaa rated corporate bonds. This is an indicator of the differential cost of capital to less and more credit-worthy corporate borrowers. This differential could reflect a deteriorating default outlook or a tightening of credit conditions due to other factors. Either way, the impact on investment and growth should be negative.

(-) LREERMA: log multilateral real exchange rate. Since a more overvalued exchange rate should reduce net exports, we expect a negative effect.[8]

(-) TLEERMA in interaction with the split trend from 1963. Our real exchange rate data begin in 1963. We define TLREERMA=TREND63*(LREERMA-LREERMA(1963)), where TREND63 is 0 before 1963, 1 in 1963Q1, 2 in 1963Q2 etc. The trend proxies the trend increase in import penetration, which might be expected to amplify the impact of the exchange rate.

(-) LROILP: the log of the real oil price (West Texas light) scaled by the GDP deflator.

(-) LROILPD: defined as LROILP – average of previous 4 years LROILP, to capture the shock effect of an oil price change.

(-) LROILPDA: defined as abs(LROILPD). This would imply a negative short run effect of any shock to oil prices, up or down. In combination with an effect from LROILP or LROILPD, it would imply an asymmetric oil price effect. Related asymmetries have been found by Mork (1989), Hamilton (2003) and others.

(-) DLROILP: the 1-quarter change in LROILP.

(-) DLROILPA: the absolute value of DLROILP, another specification of asymmetry.

(-) LRULC: log unit labor cost in the private sector/GDP deflator. We expect a negative effect via profitability and investment. The potential positive effect via labor income and consumer expenditure should already have been controlled for by real GDP and the consumption to GDP ratio.

(+) CONSR: ratio of consumer spending/GDP, both nominal. This captures persistence effects e.g., from habits, household expectations, structural changes in credit markets or taxes not otherwise in the model.

[8] A high real exchange rate can be a symptom of economic success, but given a rich specification of other growth drivers, we expect the negative effect via net exports to prevail.

(+) INVR: ratio of private business fixed capital formation in nominal terms to nominal GDP. This captures persistent business expectations or other persistent factors affecting investment e.g. changes in business tax regime not included in the model.

(+) CASHFR: the ratio of corporate cash-flow/GDP. This variable can be interpreted both as a credit channel measure and as an indicator of future profitability, given persistence in cash flows. According to the first view, high cash flows relative to GDP imply that companies have access to low cost internal funds, with a positive impact on investment.

(-) GSURR: primary federal government surplus/GDP. We expect a positive persistence effect of deficit spending for short horizons and so a negative coefficient on the GSURR. The sign prior for longer horizons is less certain. Depending on the fiscal policy feedback rule and the effect on private sector expectations, a surplus could predict lower taxes and/or higher future spending, with a positive growth effect.

(-) GDEBTR: federal government debt/GDP. We expect a negative effect because of the government budget constraint and standard 'Ricardian' arguments.

(-) GDEBTR89: GDEBTR* 1989dummy, which is 0 pre-1989, and increases linearly from 1989Q1 to 1991Q4, to reflect increased concern over the federal budget position from this time.[9]

(-) TDEFRMA: ratio of trade deficit/GDP, as a 4-quarter moving average. This reflects import leakages and is an indicator of the domestic financing position. The trade deficit reflects the net financial position of the household, business and

[9] As noted above, the shift in fiscal policy was widely discussed at the time, as was the wider question of what caused the 1990-91 recession. The American Economic Review Symposium, with articles by Blanchard, Hall and Hansen and Prescott, published in May 1993, Walsh (1993), and Runkle (1991, 1992), all suggest that modellers were looking for a 'missing factor' to help explain the depth of the downturn. Bernanke and Lown(1991) favour a credit crunch as a part explanation. While we favour the fiscal policy rule shift, it is conceivable that other factors not in our model may have contributed.

government sectors. The (negative) sign prior is clear, given the well known persistence of this variable, its reflection of terms of trade shocks and its potential role in reflecting excess capacity.

(-) TDEFKR (TDEFRMA scaled by a gobalisation index, defined as the 3-year moving average of OECD or G7 gross capital flows/GDP, lagged 1 year. Globalisation has reduced the negative impact of the financing constraint.

5. Empirical Results for Four Quarter Ahead Forecasting Models

5.1 Parameter Estimates

In our model selection procedure, we made selective use of PC-GETS. We switched off the test for residual autocorrelation given that our 4-quarters ahead dependent variable implies positively autocorrelated residuals. We chose a liberal selection strategy, applying our sign priors sequentially, eliminating wrong signed terms in order of significance. Although PC-GETS is a powerful tool, it is not completely reliable when there are a large number of very collinear variables in the general unrestricted model. The use of sign priors was quite helpful in overcoming these colinearity problems. Towards the end of the selection process we switched to manual methods using heteroscedasticity and autocorrelation (HAC) corrected t-ratios in PCGIVE, see Hendry and Doornik (1999), (which are not used by PC-GETS).

Table 1 presents results for five variants of a basic specification plus another, even more general one, which includes real unit labor costs. Column 1 shows results from our preferred model which is the most general specification excluding real unit labor costs[10]. Column 2 excludes GDEBTR89, our proxy for the shift in fiscal policy. Column 3 excludes the ratios to GDP of consumption and investment, partly to see what may be revealed about other factors to which these two variables may be responding. Column 4 imposes the constraint that nominal interest rates play no role,

[10] Participants at the FRB seminar, where his research was presented, expressed some scepticism about the relevance and sign prior of this variable..

though real rates and spreads matter. Column 5 shows the results when real unit labor costs are added to the general specification. Column 6 uses the model that would probably have been selected on data up to 1981:4 (forecasting up to 1982:4), using the same general to specific reduction method.

In column 1, the first group of nine terms can be thought of mainly as an output gap effect. The coefficient of -1.82 on LGDPQW together with 2.01 on the log employment rate UT, is equivalent to around -1 on LGDPQW alone. However, the employment ratio carries important forecasting information: a high level of employment relative to real GDP is positive for the growth outlook. This is consistent with evidence for such effects on consumption, but could also have other interpretations. The linear trend, TREND, contributes about 1 percentage points per annum to the long-run growth rate of output/head. Other trending variables, such as the real stock market index, the lagged 3-year growth rate of GDP/head, and the ratio of consumption to GDP account for the rest of the trend. The negative coefficient on TREND69, indicates that the long-run trend declined in 1969, in line with the productivity slowdown of the time. However, the post-1995 upturn is not significant, suggesting that it has been fully discounted by the stock-market and other variables such as the ratios to GDP of consumption and investment[11]. The deviation of hours of work from their annual average enters as an annual change and could be interpreted in terms of consumer confidence in job security and/or as an indicator of hiring trends and so of business confidence, output expectations and investment intentions. The 2-year change in log working age population, LWAPOP, has the anticipated positive effect, probably connected with the investment implications of higher population growth.

The group of interest rate effects is intriguing, suggesting that nominal and real interest rate changes over quite long durations – 3 and 2 years, respectively, and recent interest rate volatility, have important implications for the growth outlook.

[11] The high degrees of significance of the two trends and the level of log GDP/head strongly support the notion of trend reversion, see Rudebusch (1993).

Given the well-known negative effects of interest rates on the stock-market, investment and consumption, it is hard to believe that monetary policy is irrelevant, given this evidence. The Treasury bond yield spread is also quite significant, consistent with its well-known interpretation as a proxy for the growth outlook: anticipating higher rates ahead as the economy recovers, or lower rates as the economy declines.

The real exchange rate, interacted with a linear trend, has the negative effect expected. The ratio of imports to GDP has been trending upwards fairly linearly since the 1960s, and the interaction is a simple way of allowing for the enhanced effect of the real exchange rate with increasing trade openness. Real oil prices have their anticipated negative effects, entering as a 4-quarter moving average. Alternative specifications of short-term non-linearities were thoroughly explored. The absolute value of the current quarter's change in the log real oil price DLROILPA is always significant, but there is also evidence for a somewhat more persistent asymmetry allowed for through the variable LROILPDA, the absolute value of the deviation of the current log real price from the 4-year moving average, lagged one year. The evidence thus suggests that shocks, whether positive or negative, have short term negative effects on growth, in addition to the negative effect from the real level of oil prices.[12]

Figure 1 shows the partial contributions of the different explanatory factors, measured by the product of the regression coefficient and the variable, grouped as shown in Table 1, plotted against the 4-quarter head per capita growth rate. The 'output gap' term in Figure 1a is the linear combination of the nine variables including constant, trends, LGDPQW etc. It is not strictly an output gap, having a negative trend, matched by positive trends in other variables already noted. Figure 1a shows the composite interest rate effects, including interest rate volatility. For example, since 2001 the direct effect of the reduction in interest rates on real GDP is

[12] Hamilton uses the positive deviation of the oil price from its previous 12 quarter moving average to capture this non-linearity.

around 3 percent. However, if the short-run effects of lower interest rates on the stock market, the consumption, investment and corporate cash flow to GDP ratios, are all positive, as seems likely, and the offsetting effects via the trade balance are small and appear with a long lag, it seems likely that the net effect on GDP of the easing of monetary policy was far greater.

The composite direct oil price effects shown in Figure 1b are large, e.g. accounting for a 5 percent drop in GDP between 1972 and 1981. Once again, it seems likely that the indirect effects, via the stock market, consumption, investment, corporate cash flows and the trade balance tend to go in the same direction, suggesting this as a key determinant of business cycle fluctuations.

The upward drift of consumer spending as a fraction of nominal GDP since the early 1980s, perhaps resulting from a mix of relative price changes, easing of credit, lower inflation and interest rate volatility, demographic changes and developments in health and retirement benefits, see Gokhale et al (1996), has accounted for a substantial rise in real GDP.

Figure 1c shows the important joint cyclical contribution of business investment and cash flows, reflecting a mix of short term persistence and credit channel influences. Also shown here is the direct fiscal policy effect, which since 2001 has contributed over 5 percent to GDP. It seems plausible that it may also have had indirect effects via the stock market and yield spreads.

Perhaps the most surprising picture is the effect of the trade balance to GDP ratio, weighted, as noted above, by the index of capital account globalisation. Despite record trade deficits, the model suggests only a small impact on GDP.

The Federal Reserve Chairman, Alan Greenspan recently remarked: “Expanding globalization, has apparently enabled the United States to finance and, hence, incur so large a current account deficit….A U.S. current account deficit of 5 percent or more of GDP would probably not have been readily fundable a half-century ago or perhaps even a couple of decades ago".[13] Our model effectively incorporates this view about globalisation.

Figure 1c also shows the offsetting government debt effect, as yet trivial in magnitude. It is clear that the main effect of this variable is represented by its 1989-92 change. Since a dummy with a similar 1989-92 shift and constant thereafter would have performed similarly, the size of the debt effect is unlikely to have been estimated robustly.[14]

Figure 2a shows plots of fitted and actual values, scaled residuals and their density for model 1. Figure 2b shows residual correlations (positive at a 1-quarter lag, negative at 2 and 3-quarter lags) and evidence for parameter stability from the recursive error sum of squares, recursive Chow tests and recursive residuals. Figure 3 shows more evidence for parameter stability from the recursively estimated betas. Parameter stability is also good estimating on post-Bretton Woods data, suggesting that the drift factors embodied in the real exchange rate and the trade deficit to GDP ratio adequately account for any parameter shifts associated with floating exchange rates.

Column 2 shows the model selected subject to GDEBTR89 being omitted. The fit deteriorates markedly, though in most respects the specification and the parameter estimates for the other variables are very similar to those found in column 1. One difference is the term D4IRP80, which suggests that nominal interest rate changes had a larger impact before 1980, as suggested by our discussion of priors above.

Column 3 shows the results when CONSGRPMA and INVRMA are omitted. Not surprisingly the fit deteriorates, though inflation volatility and a longer lag on the real oil price now enter to compensate, while the nominal interest change has a larger

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[13] Speech on May 8th 2004 on Globalisation and Innovation at Chicago Federal Reserve.

[14] Including the dummy, which has an insignificant positive coefficient, changes the coefficient on GDEBTR89 from -0.08 to -0.11. Including GDEBTR itself always gives insignificant coefficients varying from close to zero to -0.05 in a range of specifications. It is perfectly possible, therefore, for the true post-1991 effect of GDEBTR to be as high as -0.2 rather than the -0.08 estimated in column 1. Given the smoothly trending nature of GDEBTR, it is perhaps not surprising that robust estimation is difficult.

coefficient. This suggests that lagged consumption and/or investment are significantly negatively affected by higher inflation volatility, higher nominal interest rates and higher oil prices. The GDEBTR89 coefficent also becomes more negative, suggesting that some of the fiscal policy shift operates on GDP via lagged consumption and investment, as one would expect.

Column 4 shows the results when all changes in nominal interest rates are excluded, since many economists argue that only real rates matter. The fit is slightly worse but most of the coefficients are very close to the ones of column 1, with the notable exception of the Treasury yield spread variable coefficient that more than doubles, and the inclusion of a significant corporate yield spread. Since this can also be given a credit channel interpretation, like the omitted change in the nominal T-bill rate, this looks like evidence in favour of the credit channel story as one element of monetary transmission.

Column 5 shows the results when real unit labor costs are added to the general specification. In this specification, inflation volatility becomes significant unlike in all the other columns, and the fit improves further. Again the model is very stable.

Column 6 uses the model that would probably have been selected on data up to 1981:4 using the same general to specific reduction method. Apart from the yield spread variable and D8RIRI, that are not significant, the specification is very much in line with column 1.

A remarkable feature of all these results is indeed the similarity of the coefficients in the six columns, suggesting a surprising degree of orthogonality between the regressors. Another remarkable feature is the high t-ratios (corrected for heteroscedasticity and up to 4th order serial corrrelation), reflecting both the richness of the specification – note for example the significance of interest rate volatility, a variable seldom incorporated in forecasting models, and the relative orthogonality of most of the included regressors.

5.2 Recursive Forecasting Performance

The recursive rmse's reported in Table 1 do not correctly capture the out of sample forecasting performance of these models for three main reasons: first, they work with the 2004 Q1 data vintage rather than with the national accounts data as perceived at the time genuine out of sample forecasts would have been made. In Figure 3, we compare the 4-quarter rates of growth of GDP for the first vintage of data, available one quarter after the date to which the growth rate refers, the vintage as seen 4 quarters later, and the 2004Q1 data vintage. Data revisions have been substantial, but the underlying pattern of fluctuations is similar for all three data vintages. It is beyond the scope of this paper to seriously address the issue posed by data revisions, see Romer and Romer (2000), but see the discussion of the Survey of Professional Forecasters below. The second reason why the quoted rmse's do not correctly represent out of sample rmse's is the following. The forecasts can be written in the form $\Delta_4 \hat{Y}_{t+4} = \beta_t X_t$, where $\Delta_4 \hat{Y}_{t+4}$ is the fitted value, using the β estimated with data on Y_t, X_{t-4}. For example, in 2004Q2, we have data up to 2004Q1. We can forecast growth between 2004Q1 and 2005Q1 from our model, using estimates of β based on data for Y up to 2004Q1 and X up to 2003Q1. The residuals between these fitted values and actual 4-quarter changes in Y will tend to be larger than the in-sample residuals using fitted values generated by data up to t+4. The latter residuals benefit from the fact that the estimate of β_{t+4} used in generating them is based on knowledge of Y_{t+4}.

The third reason why the in-sample recursive residuals will be smaller than the out of sample residuals concerns the structural break captured through GDEBTR89. That is, we assume that the forecaster of the time would only have included the effect from 1992Q1, forecasting 1993Q1 relative to 1992Q1. Thus the in-sample residuals reflect the inclusion of the effect from 1989 while the out of sample residuals benefit only from 1992Q1.

In Table 2 we present the out of sample recursive residuals for each of our six models computed from 1982Q1 to 2003Q1, forecasting 4 quarters ahead. For the full 21 years, these are around twice as high as the in-sample recursive residuals.

However, for the past 15 years, the recursively estimated β's have become even more stable, i.e. computed for 1988Q1 on, forecasting 4 quarters ahead, the out of sample recursive residuals have much more satisfactory rmse's, as low as 0.0094 for our preferred model 1. For the same period, the Survey of Professional Forecasters has a rmse of 0.0150 for the final vintage of GDP data and 0.0126 for the first estimates, which, one can argue, is what the SPF was trying to match.[15] Choosing this as the performance criterion for the SPF, model 1 is significantly better over the full 21 years, and notably so in the last 15 or 10.

However, our model has the further important advantage of capturing most turning points in the data far better than the Survey of Professional Forecasters, see Figure 4. Figure 3 made it clear that turning points were actually rather well reflected in the first vintage of data, produced some 6 weeks after the end of each quarter. This suggests that our models used in real time would have captured well these turning points, despite data revisions. It is also important to note the prevelance of 4-quarter moving averages in most of our national accounts variables, other than GDP itself. This means that our forecasts will not be very sensitive to revisions of the flash estimates, or to measurement errors in quarterly national accounts estimates.

We have compared results also for two other forecasting alternatives. The first is a simple univariate AR5-type multistep model. Here the 4-quarter ahead change of log GDP/head is regressed on a constant and 5 quarterly changes of log GDP/head at lags of 0 to 4. This, as Clements and Hendry (2002) argue, should be robust to regime changes which induce a shift in the intercept of the log GDP/head process. The out of sample recursive rmse for the last 15 years is 0.0142 and 0.0159 for the last 21, substantially worse than model 1.

A second approach replicates roughly a VAR-type multistep model. The dependent variable is as before. The regressors include a constant, the same 1973 dummy

[15] Choosing this as the criterion is an informal way of correcting for the fact that our model uses the current data vintage rather than the real time data available to actual forecasters. However, this is by no means a rigorous correction. Incidentally, these SPF forecasts are made at time t for t+3 relative to t-1, using the t-1 data set, and are therefore comparable to ours in timing.

included in the Table 1 results, quarterly changes in log GDP/head, in log real S&P index, in log real oil prices, in the log real exchange rate, in the nominal T-bill rate, and levels of the inflation rate (defined by the consumer expenditure deflator), and the yield and corporate spreads as defined above.[16] Using the AIC criterion, the real exchange rate can be eliminated, and a specification with lags running from 0 to 4 reduced to one with a lag only of 0 (meaning only variables dated t are used to forecast for t+4). This is worse for out of sample forecasts than any of the other methods. A clue to why this is so can be found in the recursive β's from this model which are quite unstable. Stock and Watson (2003) too find that their models frequently perform worse than simple univariate AR specifications.

A criticism that can be levelled against the out of sample performance shown in Table 1 is that model 1 would not have been chosen on data up to 1981:4. As we argue above, it is plausible that model 6 would have been chosen up to 1981:4. With repeated general to specific specification search as time moved on, our results suggest model 1 would eventually have been chosen by 1992. If we therefore use model 6 (excluding GDEBTR89) for recursive out of sample forecasting until 1991:4 and then switch to model 1, we find that the out of sample rmse for the full 21 years, and the 15 year sub-period is virtually the same as that reported for model 1.

6. Empirical Results for Eight Quarter Ahead Forecasting Models

Bearing in mind our results for the 4-quarters ahead model, we estimate an 8-quarters ahead model using the same general to specific procedure. Again, we can generate a range of models corresponding to the columns of Table 1. We illustrate with just one example:

[16] This is broadly similar to the set of variables used by Stock and Watson (2003) in bivariate and trivariate multi-step forecasting models for G7 output and inflation. However, they pool the forecasts from these models rather than include all the explanatory variables in a multivariate specification as we have done.

```
D8LGDPQW8 =    -6.17   + 0.90 TREND   -0.36 TREND69  -0.14 D73Q3MA(+4)
               (14.9)   (13.5)       (6.5)          (5.3)
        -1.32 LGDPQW   +0.01 SPINDEXQ -0.48 D4IR     -0.26 D4IR_4
         (15.4)        (1.6)         (5.1)          (2.8)
        -0.28 D4RIRI_1 -0.03 ABD4LIRMA-0.01 ABD4LIRMA_4 -0.03 LROILPMA
        (4.0)          (4.3)         (2.5)             (5.1)
        +1.83 CONSGDPMA_4 -0.30 GSURRMA -0.76 GDEBTRMA  +0.77 GDEBTRMA_4
        (7.6)             (1.6)         (7.2)          (5.9)
        -0.07 GDEBTR89(+2)  -0.80 TDEFKR -0.61 LRULCMA      -0.26 LRULCMA_4
        (4.3)          (2.1)         (5.9)          (2.2)
```

There are considerable similarities with the 4-quarter ahead models.[17] Changes in nominal and real interest rates, and interest rate volatility are still important, as are real oil prices, real unit labor costs, the consumption to GDP ratio, the weighted trade deficit to GDP ratio, and the fiscal policy shift, but the stock market and the current fiscal policy stance have little forecasting power over the 8-quarter horizon, given the other effects.

One effect not found at the 4-quarter horizon, but important here, is a strong negative influence from the rise relatively to the previous year in the government debt to GDP ratio (GDEBTRMA). This is likely to be of some importance in the current forecasts from this model shown in Figure 8.

Unsurprisingly, it is harder to forecast for a longer horizon: the standard error of the in-sample residuals is 0.01087, i.e. almost doubled with respect to the 4-quarters ahead model. The recursive forecast performance is also worse, with a RMSE equal to, respectively, 0.0271, 0.0205 and 0.0144 over the last 21, 15 and 10 years.

7. Conclusions

Four distinctive features mark the approach to modeling the U.S. business cycle developed in this paper. First, we use multi-step, in this case 4 and 8 quarters ahead, single equations with general to specific model selection from a rich menu of potential variables. Second, the economic theory on which the model is based is a sticky price view of the economy, combining the income-expenditure approach to

[17] D8LGDPQW8 is the 8-quarter lead of the 8-quarter change of log GDP per capita, and D73Q3MA(+4) the 4-quarter lead of D73Q3MA.

determining equilibrium output, with lagged adjustment to capacity output. Given lagged adjustment and the persistence of many of the determinants of autonomous expenditure, economics suggests sign priors for many coefficients in forecasting over a 4-quarter horizon. These sign priors are imposed in model selection. Third, we check for unconventionally long lags, overcoming the 'curse of dimensionality' by restricting lags longer than 4 to 4-quarter moving average and 4-quarter change forms. Finally, we check for and where necessary, incorporate non-linearities.

We show that these models for U.S. GDP have remarkable properties in fit, parameter stability, out of sample forecasting performance, and particularly in capturing turning points in the business cycle. More conventional alternatives and the consensus of professional forecasters are far less successful in these dimensions. Indeed, our forecasts could be considered alternatives to conventional leading indicators, which also weight a large number of component series.[18] By analysing a variety of specifications, we show that many of the parameters estimates are robust to changes in other parts of the model. This suggests a remarkable degree of orthogonality between the different effects in our model, despite the commonly held view that macroeconomic time series are so correlated that it is hard to find accurate estimates when so many parameters are being estimated. Our findings of the relevance of long lags and non-linearities would not have been possible with currently conventional VAR methods.

Moreover, in parallel work on the U.K., we find strong similarities in the specifications and even lag structures useful for forecasting U.K. GDP, but also some differences consistent with differences in institutions and history: for example, an earlier shift in the implicit fiscal policy reaction function and more pronounced differences in the impact of interest rates, pre and post 1980.[19]

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[18] See Stock and Watson (1989), and Stock and Watson (2003) on the failure of leading indicators to forecast the 2001 recession.

[19] The latter shift is also more pronounced in South Africa, see Aron and Muellbauer (2002).

Reduced form forecasting models can never fully explain business cycle fluctuations and indeed many of the effects estimated in our model will involve a mixture of factors. For example, the evidence for the credit channel view, while strong, is circumstantial and cannot be said to imply that a certain proportion of the change in interest rates operates through this compared with other channels. Nevertheless, the economic story consistent with our estimates seems a very reasonable one. It highlights oil shocks, and their short-term asymmetric impact and provides strong evidence for the power of monetary and fiscal policy. It provides evidence that, as Federal Reserve Chairman Alan Greenspan has argued, globalisation has reduced the balance of payments constraints on U.S. growth.

Be that as it may, on a 4-quarter ahead view, using 2004Q1 data, the real time forecasts are surprisingly upbeat, though subsequent rises in oil prices are likely to dampen the more recent one year ahead outlook. The 8-quarter ahead view is more subdued, in part because of role of the rise in government debt over that horizon.

Blanchard and Simon (2001) have documented the reduction in the volatility of quarterly GDP growth rates in the U.S. since the early 1980s. The causes for this have been much discussed, see Stock and Watson (2002a), Bernanke (2004) and the proceeding of the 2003 Jackson Hole Conference of the Federal Reserve of Kansas City. Our findings contribute to the debate over whether monetary policy played an important role in the 'great moderation', as Bernanke terms it, in two ways. First, we add another strand to the argument by demonstrating a correlation between lower interest rate volatility, and higher growth four quarters later, with a t-ratio of 8.5 after controlling for many other influences. Second, we would argue that the greater gradualism of interest rate setting by the Federal Reserve since the early 1980s was deliberate and reduced interest rate volatility. So part of the reduction in interest rate volatility can be attributed to better policy, and according to our estimates had a notable effect in reducing output volatility.[20]

[20] Of course, part of the reduction in interest rate volatility will be due to lower inflation volatility, itself the likely consequence both of better policy and of global forces. There is a prima facia case for lower interest rates volatility contributing to lower output volatility, given our evidence of the connection

The consistency of our findings with standard DSGE models remains a topic for future research. It is surely consistent with important frictions of the kind Christiano, Eichenbaum and Evans (2003) build into their models. Whether the lag lengths we find relevant are consistent with the standard model-consistent expectations view or, more plausibly, with relaxations of these informational assumptions suggested by Mankiw and Reis (2002) and Reis (2004), is another important question.

between interest rates and growth. Furthermore, in a separate modelling exercise explaining output volatility in terms of volatilities of interest rates, inflation, stock returns and real oil prices, interest rate volatility is highly significant.

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Table 1: six variants of a 4-quarter ahead forecasting model for $\Delta_4$log(GDP/head)

		Dependent variable: D4LGDPQW(+4)					
		General	No Gdebt89	No cons, invest	No nominal r	With labour cos	Selected 1982:1
		(1)	(2)	(3)	(4)	(5)	(6)
Output Gap	Constant	-8.000	-5.911	-7.084	-8.342	-7.429	-8.124
		(25.23)	(12.65)	(24.86)	(25.58)	(26.52)	(22.63)
	TREND	1.039	0.769	1.020	1.106	0.971	1.052
-		(23.38)	(11.48)	(19.81)	(23.21)	(24.16)	(20.87)
	TREND69	-0.291	-0.234	-0.152	-0.334	-0.219	-0.293
		(7.53)	(4.01)	(6.01)	(8.62)	(5.25)	(6.99)
	D73Q3MA	-0.082	-0.091	-0.107	-0.087	-0.078	-0.099
		(6.18)	(4.89)	(7.10)	(5.48)	(6.03)	(7.81)
	LGDPQW	-1.824	-1.339	-1.831	-1.890	-1.736	-1.849
		(22.59)	(12.86)	(24.52)	(23.71)	(25.03)	(22.42)
	DLGDPQW	0.594		0.605	0.622	0.528	0.594
		(6.03)		(6.54)	(6.22)	(5.85)	(6.03)
	D12LGDPQW(-1)	0.186	0.148 [1]	0.237	0.117	0.129	0.199
		(5.42)	(2.33)	(8.83)	(3.55)	(4.63)	(6.00)
	UT(-1)	2.009	1.131	1.866	1.939	1.881	2.038
		(9.97)	(4.93)	(10.17)	(10.28)	(11.40)	(10.37)
	D4WHOURSSAD2	0.013	0.014	0.009	0.014	0.012	0.014
		(5.85)	(5.27)	(3.92)	(6.10)	(5.84)	(6.35)
Pop. Growth	D8LWAPOPY(-2)	1.461	0.624	2.230	0.987	1.909	1.585
		(3.53)	(0.99)	(8.85)	(2.74)	(4.55)	(3.87)
Stock Market	SPINDEXQ	0.054	0.028	0.043	0.062	0.043	0.055
		(8.87)	(3.10)	(6.79)	(8.69)	(6.17)	(7.83)
Interest rates,	D12IR(-1)	-0.235	-0.257	-0.415		-0.223	-0.344
volatility and spreads		(5.75)	(4.62)	(11.57)		(5.66)	(8.78)
	D8RIRI(-1)	-0.137	-0.115		-0.146	-0.169	
		(4.69)	(2.52)		(4.62)	(4.48)	
	D4IRP80(-1)		-0.425				
			(3.08)				
	ABD4LIRMA	-0.029	-0.032	-0.015	-0.028	-0.023	-0.029
		(9.25)	(6.72)	(6.04)	(8.26)	(6.78)	(9.73)
	RIRIMA			-0.133			
				(2.16)			
	ABDINFIMA(-1)			-0.738		-0.366	
				(6.26)		(2.87)	
	YLDSPDMA	0.004			0.009	0.005	
		(3.57)			(7.92)	(3.99)	
	CORPSPD				-0.009		
					(2.53)		
Real exchange rate	TLREER(-5)	-0.092		-0.036	-0.069	-0.083	-0.083
		(8.75)		(3.57)	(4.79)	(6.96)	(6.44)
Real oil prices	LROILPMA	-0.040	-0.033	-0.029	-0.045	-0.035	-0.040
		(9.77)	(4.97)	(5.92)	(10.14)	(7.99)	(9.32)
	LROILPMA(-4)			-0.012		-0.007	
				(2.43)		(1.74)	
	LROILPDA	-0.008	-0.016				-0.007
		(2.41)	(3.65)				(2.03)
	DLROILPA	-0.017		-0.022	-0.021	-0.021	-0.017
		(2.70)		(3.14)	(3.56)	(3.86)	(2.46)
Consumption	CONSRMA(-1)	1.304	0.959		1.329	0.974	1.379
		(5.53)	(3.28)		(5.00)	(3.44)	(5.71)
Investment	INVRMA(-1)	1.192	0.846		1.562	0.969	1.046
and cash flow		(6.45)	(3.64)		(8.65)	(4.43)	(4.97)
	CASHFRMA(-1)	1.216	1.582	1.544	1.292	1.023	1.324
		(6.79)	(4.60)	(6.52)	(6.90)	(5.04)	(7.28)
Gov. surplus	GSURRMA	-1.023	-0.619	-0.826	-0.980	-0.985	-1.146
		(8.45)	(3.06)	(7.18)	(7.86)	(8.80)	(9.92)
Gov. debt	GDEBTR89(-2)	-0.087		-0.099 [2]	-0.091 [3]	-0.092	-0.085
		(14.05)		(12.82)	(12.11)	(14.31)	(10.25)
Trade balance	TDEFKR(-5)	-2.332	-1.344	-2.443	-2.594	-2.336	-2.192
		(10.88)	(3.48)	(11.72)	(11.95)	(11.59)	(9.46)
Labour Cost	LRULCMA(-4)					-0.234	
						(3.68)	
	Observations	181	181	181	181	181	181
	Sigma	0.00626	0.00823	0.00673	0.00653	0.00599	0.00661
	R2adj	0.92779	0.87529	0.91654	0.92149	0.93386	0.91958
	Recursive RMSE	0.011902	0.016344	0.013050	0.012424	0.012059	0.012501
	DW Test	1.52	0.996	1.43	1.39	1.55	1.49

Table 2: Comparison of alternative models

		Professional forecasts			AR-type multi-step	VAR-type multi-step
Recursive RMSE		**GDP 1st est.**	**GDP 4q est.**	**GDP final**		
Within sample (45 years)					**0.022610**	**0.017590**
Out of sample (21 years)		**0.013456**	**0.015824**	**0.016052**	**0.015867**	**0.019653**
Out of sample (15 years)		**0.012625**	**0.015013**	**0.014997**	**0.014215**	**0.018471**
Out of sample (10 years)		**0.013686**	**0.013044**	**0.015731**	**0.013069**	**0.015219**
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Recursive RMSE						
Within sample (45 years)	**0.006259**	**0.008226**	**0.006729**	**0.006527**	**0.005990**	**0.006605**
Out of sample (21 years)	**0.011902**	**0.016344**	**0.013050**	**0.012424**	**0.012059**	**0.012501**
Out of sample (15 years)	**0.009425**	**0.014883**	**0.010899**	**0.011245**	**0.011946**	**0.011158**
Out of sample (10 years)	**0.007915**	**0.013639**	**0.007978**	**0.008612**	**0.007395**	**0.009830**

Table 3: 4-quarter ahead forecasts for the 4-quarter change in log GDP/head for recent quarters

	Model 1		Model 2		Model 3	
Horizon	Forecast	(SE)	Forecast	(SE)	Forecast	(SE)
2004-2	0.039	0.0079	0.045	0.0136	0.048	0.0080
2004-3	0.029	0.0079	0.036	0.0136	0.041	0.0080
2004-4	0.041	0.0079	0.052	0.0136	0.049	0.0080
2005-1	0.048	0.0079	0.060	0.0136	0.054	0.0080
	Model 4		Model 5		Model 6	
Horizon	Forecast	(SE)	Forecast	(SE)	Forecast	(SE)
2004-2	0.035	0.0086	0.042	0.0074	0.043	0.0098
2004-3	0.026	0.0086	0.034	0.0074	0.036	0.0098
2004-4	0.038	0.0086	0.044	0.0074	0.048	0.0098
2005-1	0.047	0.0086	0.047	0.0074	0.056	0.0098

Note: forecasts made 4 quarters before stated horizon. Standard error is out of sample rmse for last 10 years. Population growth is approx. 0.01

Table 4: Summary of the data 1959Q1 to 2003Q1

Variable	Obs	Mean	Std. Dev.	Min	Max
D4LGDPQW4	181	0.020646	0.023293	-0.04479	0.080172
TREND	181	0.82	0.523943	-0.08	1.72
TREND69	181	0.522265	0.455112	0	1.37
D73Q3MA	181	0.005525	0.036854	0	0.25
LGDPQW	181	-3.36806	0.247816	-3.87535	-2.94685
DLGDPQW	181	0.004967	0.009287	-0.02955	0.03347
D12LGDPQW	181	0.059161	0.04003	-0.04675	0.144263
UT	181	-0.06131	0.015623	-0.1128	-0.03459
D4WHOURSSAD2	181	0.008472	0.421593	-1.11667	1.358334
D8LWAPOP	181	0.0256	0.007672	0.013447	0.036798
SPINDEXQ	181	1.308629	0.509378	0.581409	2.608266
D12IR	181	0.000473	0.027764	-0.05247	0.087233
D8RIRI	181	-3.1E-05	0.020099	-0.06085	0.075969
ABD4LIRMA	181	0.335611	0.24681	0.032576	1.362884
YLDSPDMA	181	1.369765	1.066804	-0.99583	3.578333
TLREERMA	181	-0.15654	0.158994	-0.49355	0.013129
LROILPMA	181	-1.55737	0.487806	-2.15959	-0.39057
LROILPDA	181	0.226471	0.244342	0.001434	0.934526
DLROILPA	181	0.060819	0.098101	0	0.823425
CONSRMA	181	0.641848	0.025144	0.607954	0.706007
INVRMA	181	0.160709	0.013622	0.133398	0.194546
CASHFRMA	181	0.090841	0.007417	0.073631	0.107038
GSURRMA	181	0.012447	0.016814	-0.02453	0.049392
GDEBTR89	181	0.171287	0.272396	0	0.673
TDEFKR	181	0.000849	0.00544	-0.01042	0.013043
KFLOWR	181	3.757813	3.594769	1	15.27995
ABINFIMA	181	0.009625	0.00843	0.001392	0.045072

Figure 1a: Contribution of different factors to 4-quarter ahead change in log GDP/head from model 1

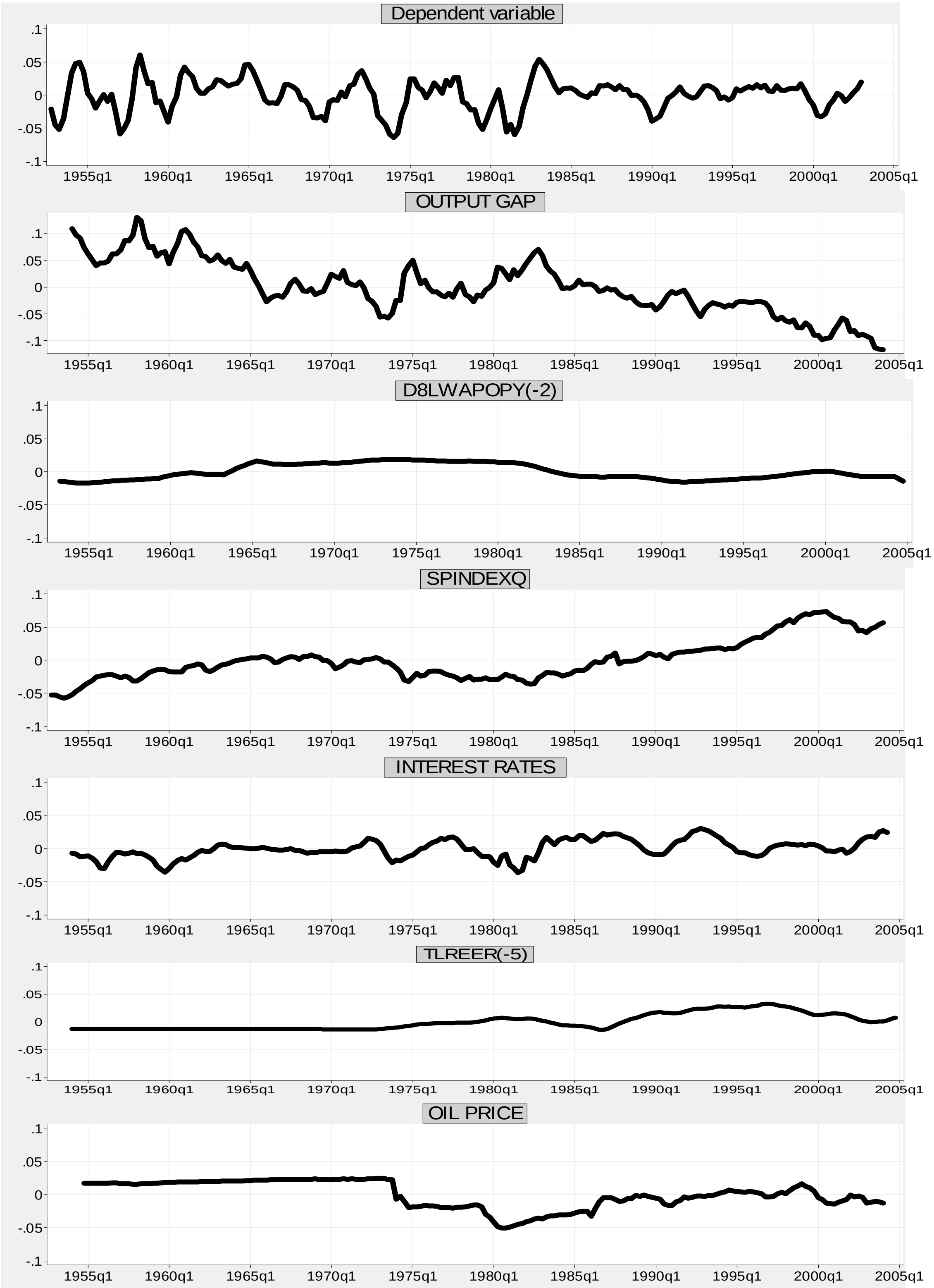


Figure 1b: Contribution of different factors to 4-quarter ahead change in log GDP/head from model 1, cont'd.

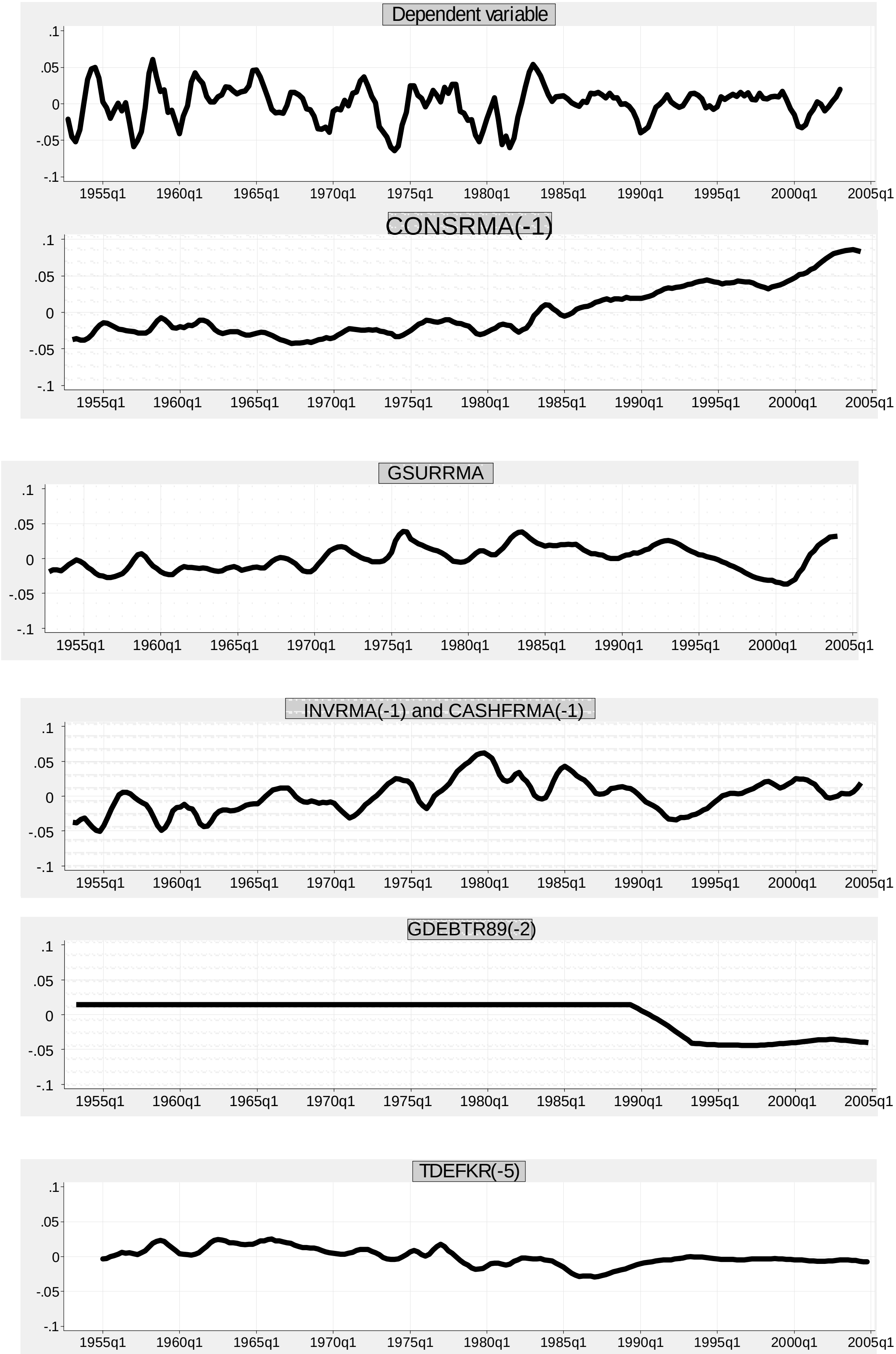


Figure 2a: Graphic analysis for model 1.

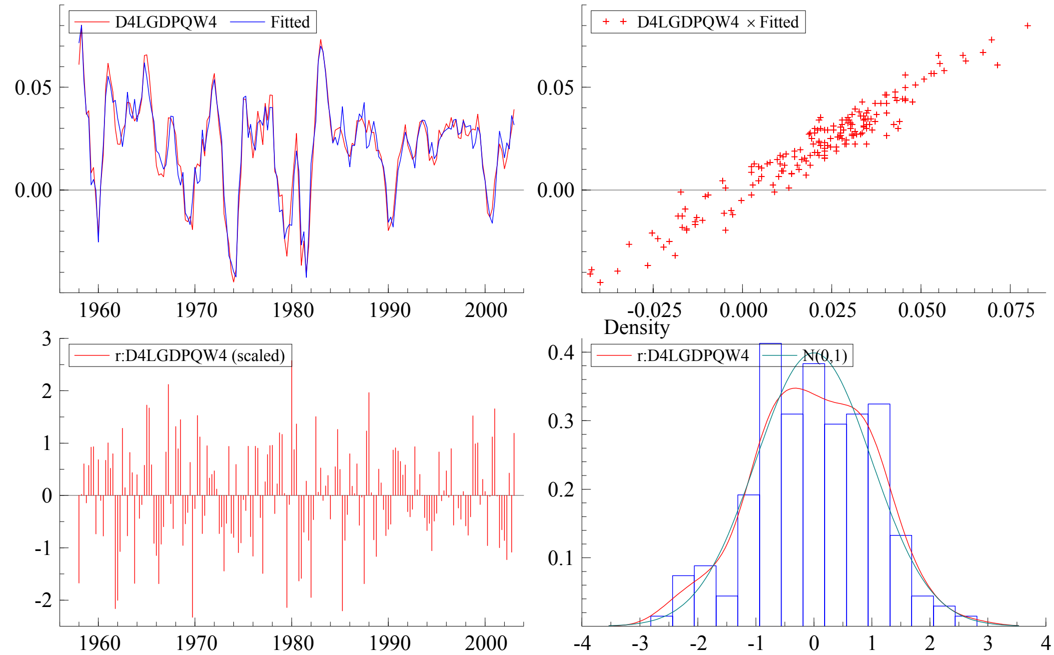


Figure 2b: Graphic analysis for model 1 cont'd.

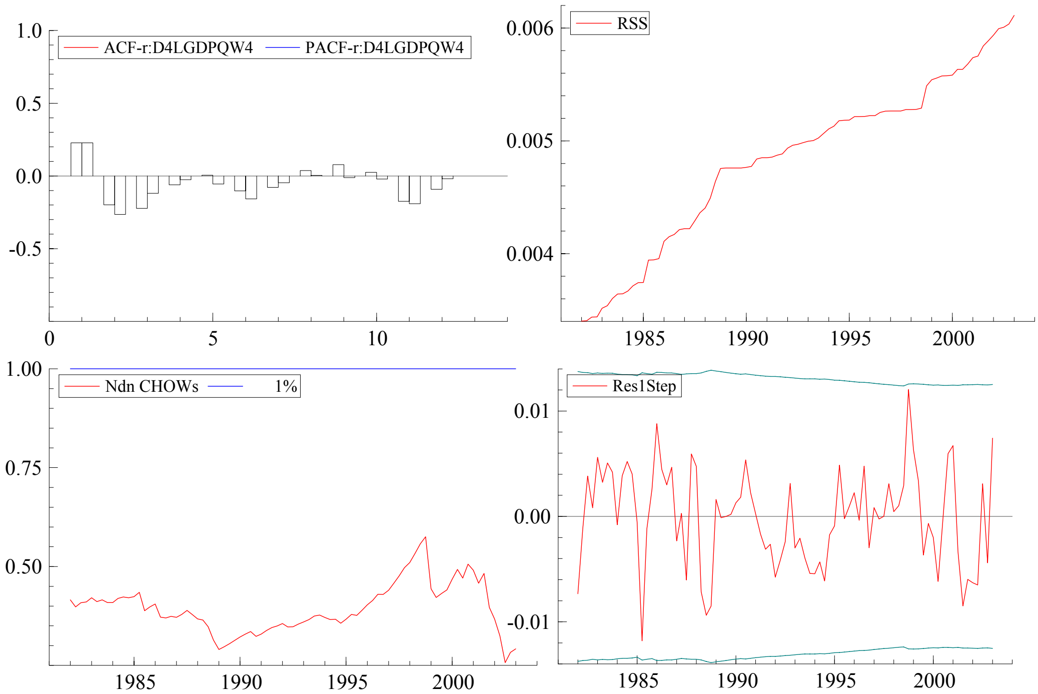


Figure 3: Recursive Beta coefficients for model 1

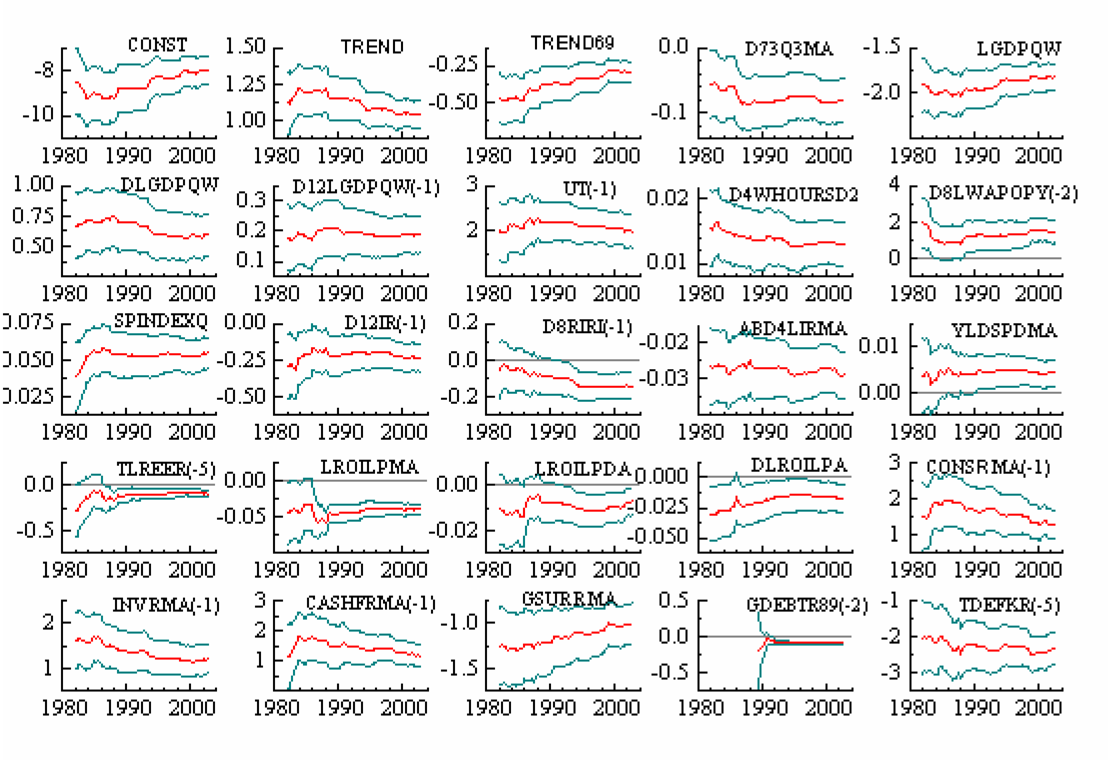


Figure 4: US GDP 4–quarter growth rates from different data vintages

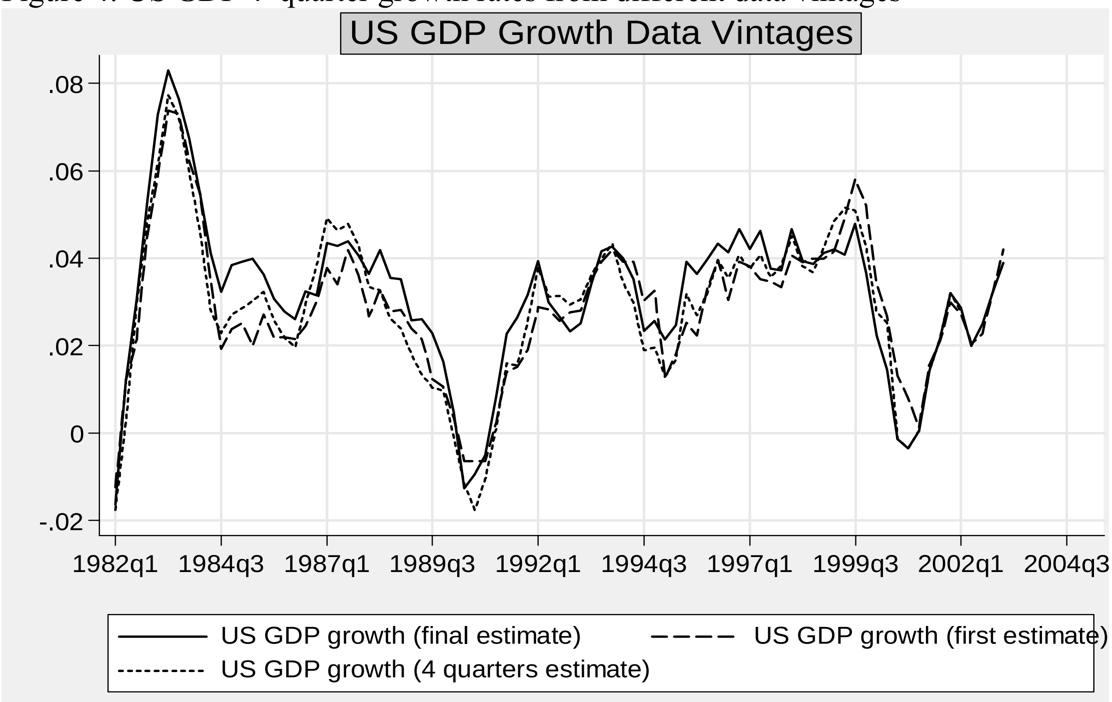


Figure 5: US GDP 4-quarter growth rates comparing 4-quarter ahead forecasts from the Survey of Professional Forecasters with data of different vintages

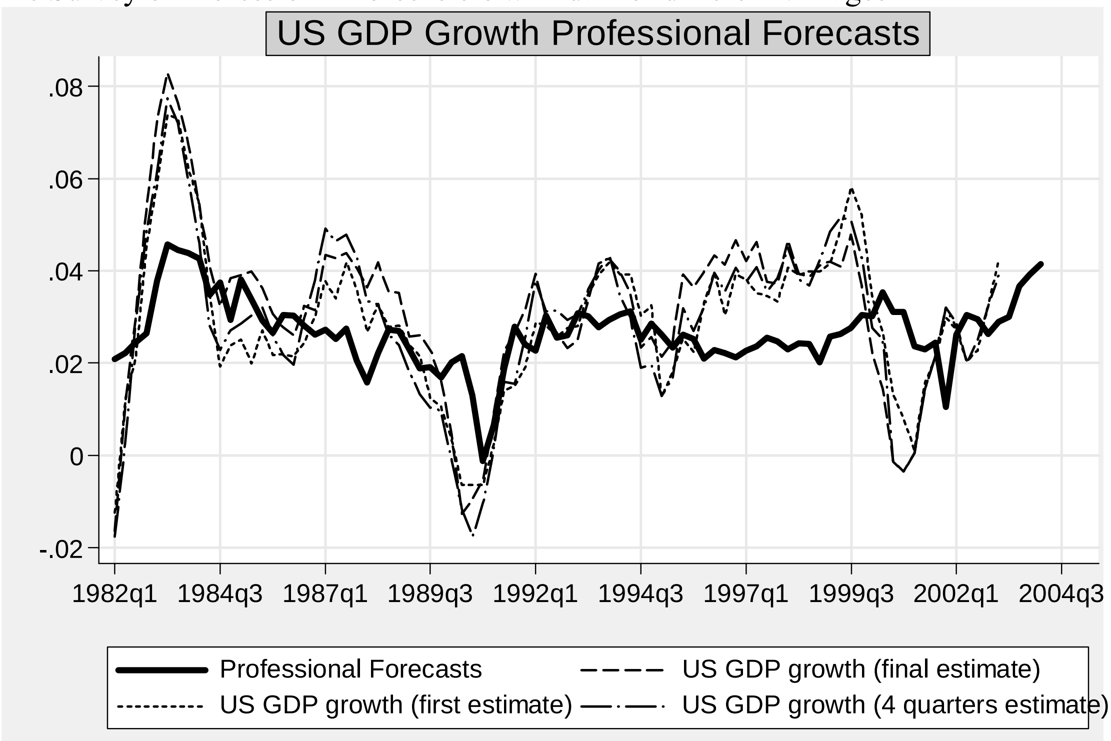


Figure 6: Recursive 4-quarter ahead forecasts for 4-quarter change in log GDP/head

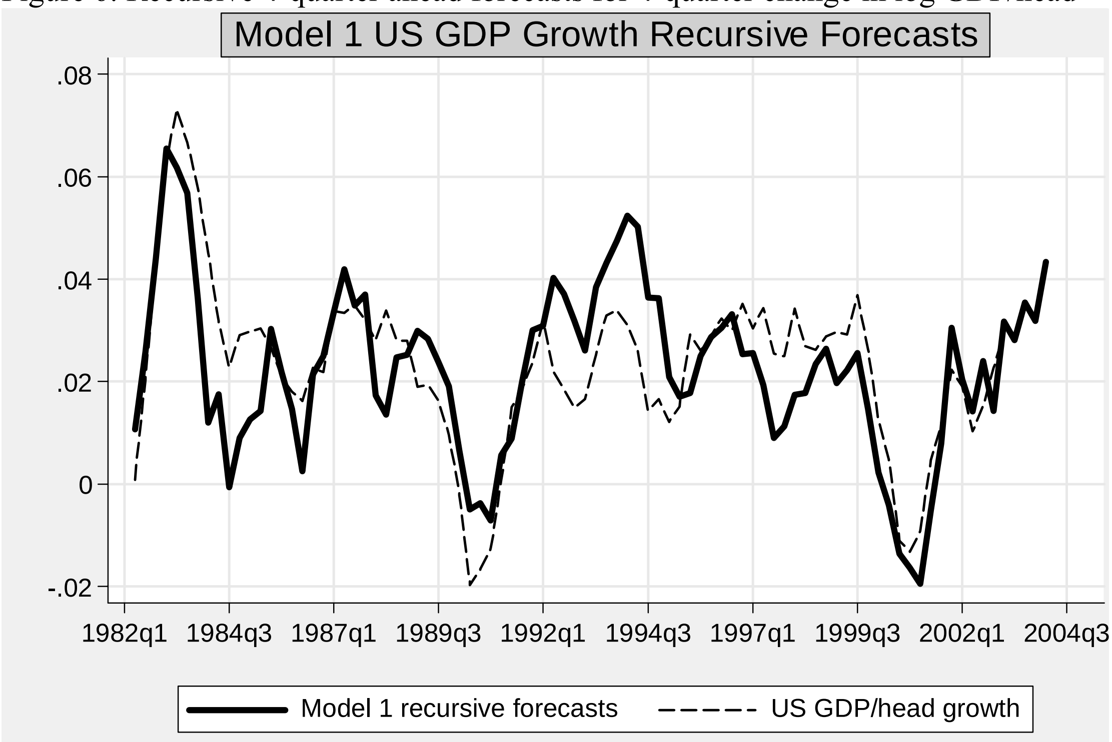


Figure 7: 4-quarter ahead forecasts of 4-quarter change in log GDP/head for model 1 for recent quarters

Figure 8: Recursive 8-quarter ahead forecasts of 8-quarter change in log GDP/head

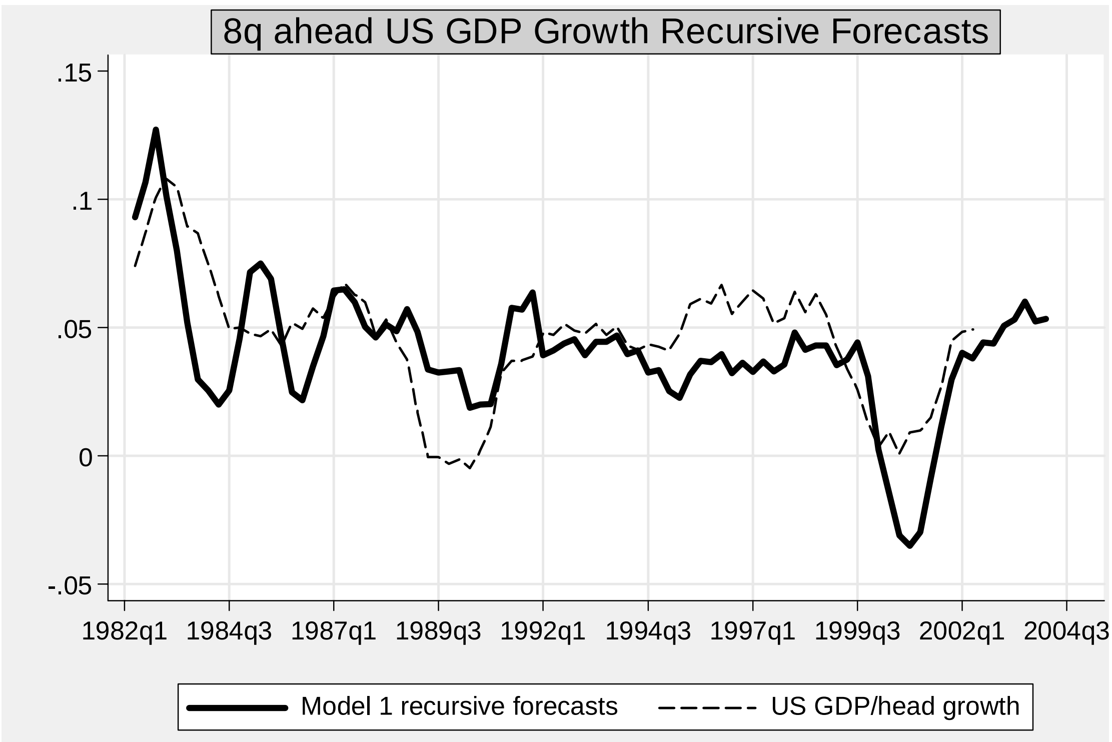
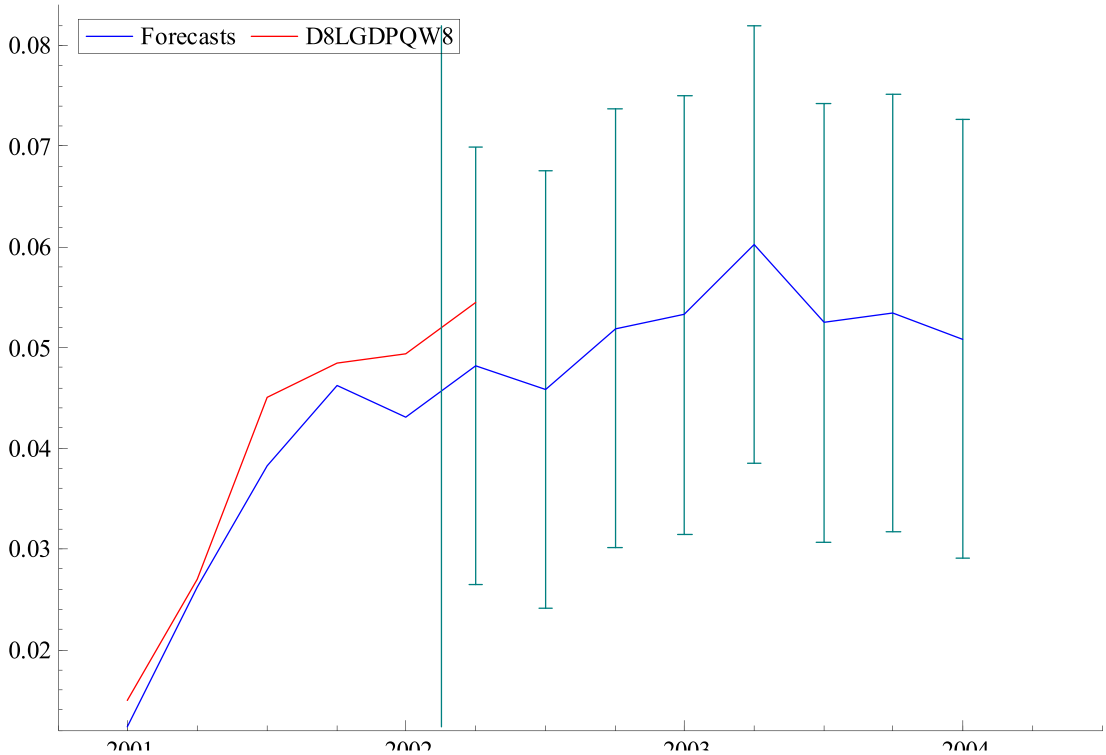


Figure 9: 8-quarter ahead forecasts of 8-quarter change in log GDP/head for recent quarters



Appendix 1: The data, definitions and sources

TREND: Linear time trend/100=0 in 1959Q1.

TREND69: Split linear trend/100 from 1969q1, = 0 before.

D73Q3MA: 4 quarters moving average of dummy=1 in 1973q3.

WAPOP: working age population, 4 quarters moving average of yearly data (end of year population). Source: U.S. Department of Labor: Bureau of Labor Statistics.

GDP: Gross Domestic Product, current prices. Seasonally Adjusted Annual Rate. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

GDP96: Real Gross Domestic Product, 1. Seasonally Adjusted Annual Rate. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

LGDPQW=log(GDP96)-log(WAPOP), log(realGDP/head).

D4LGDPQW= LGDPQW- LGDPQW(-4).

D12LGDPQW=LGDPQW-LGDPQW(-12).

UR: Civilian Unemployment Rate. Seasonally Adjusted. Source: U.S. Department of Labor: Bureau of Labor Statistics.

UT = log(1-UR/100).

WHOURSSA: Seasonally adjusted average weekly hours of production or nonsupervisory workers in manufacturing.

WHOURSSAD2 = WHOURSSA-annual average of WHOURSSA.

D4WHOURSSAD2 = WHOURSSAD2- WHOURSSAD2(-4).

D8LWAPOP = log(WAPOP)- log(WAPOP)(-8).

CDEF: Personal Consumption Deflator. Seasonally Adjusted. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

SP: Standard and Poor's S&P500 Stock Index, quarterly average of end of month closing values, from economagic.com.

SPINDEXQ = log (SP/CDEF).

IR: 3-Month Treasury Bill: Secondary Market Rate, quarterly average of monthly data (average of business days). Source: Board of Governors of the Federal Reserve System.

D12IR = IR-IR(-12).

RIRIMA = 4 quarters moving average of RIRI.

D4LCDEF = log(CDEF)-log(CDEF(-4)), annual inflation rate from ?? consumption deflator..

RIRI = IR-D4LCDEF real T-bill rate.

D8RIRI = RIRI-RIRI(-8).

LIR = log(IR).

D4LIR = LIR-LIR(-4).

ABD4LIR = abs(D4LIR-D4LIR(-4)).

ABD4LIRMA = 4 quarters moving average of ABD4LIR.

D4IR = IR-IR(-4).

D80: 1 from 1980q1 onward.

D4IRP80 = (1-D80)*D4IR.

ABINFI = abs(D4LCDEF-D4LCDEF(-4)).

ABINFIMA = 4 quarters moving average of ABDINFI.

TC10YQ: 10-Years Treasury Constant Maturity Rate. Source: Board of Governors of the Federal Reserve System .

YLDSPD = TC10YQ-IR.

YLDSPDMA = 4 quarters moving average of YLDSPD.

RAAA: Moody's Seasoned Aaa Corporate Bond Yield. Source: Moody's Investors Service.

RBAA: Moody's Seasoned Baa Corporate Bond Yield. Source: Moody's Investors Service.

CORPSPD = RBAA-RAAA.

LREER: Log Real Exchange Rate. Price-adjusted Broad Dollar Index. The broad index is a weighted average of the foreign exchange values of the U.S. dollar against the currencies of a large group of major U.S. trading partners. Source: Board of Governors of the Federal Reserve System and BIS before 1975.

TLREERMA = (LREERMA-value of LREERMA in 1963q1)*(TREND- value of TREND in 1963q1).

OILP: Spot Oil Price: West Texas Intermediate. Source: Dow Jones Energy Service. Copyright.

LROILP = log(OILP/CDEF), log real oil price.

LROILPMA = 4 quarters moving average of LROILP.

LROILPMA8 = 8 quarters moving average of LROILP.

LROILPD=LROILP-LROILPMA16(-4).

LROILPDA= abs(LROILPD).

DLROILP= LROILP- LROILP(-1).

DLROILPA= abs(DLROILP).

CONS: Personal Consumption Expenditures, current prices. Seasonally Adjusted. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

CONSRMA = 4 quarters moving average of CONS/GDP.

INV: Real Gross Private Domestic Investment, current prices. Seasonally Adjusted Annual Rate. Source: U.S. Department of Commerce: Bureau of Economic Analysis .

INVRMA = 4 quarters moving average of INV/GDP.

CASHF: Corporate Net Cash Flow. Seasonally Adjusted Annual Rate. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

CASHFRMA = 4 quarters moving average e of CASHF/GDP.

GSUR: Primary Government Surplus. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

GSURRMA = 4 quarters moving average of GSUR/GDP.

GDEBTR89: Federal debt (end of period), Gross Federal, proportion of GDP. Source: Department of the Treasury and Office of Management and Budget. Interacted with the dummy D89. The latter is zero up to 1988, 0.25 in 1989, 0.5 in 1990, 0.75 in 1991 and 1 from 1992 onwards.

KFLOWR: rates of (absolute value of all capital flows)/GDP for G7 economies from Garrett (2000) normalised to be 1 before 1971. The variable is updated by authors from 1998 onward using the same criteria.

KFLOWRMA = 4 quarters moving average of KFLOWR.

KFLOWRM=(KFLOWRMA +KFLOWRMA(-4) +KFLOWRMA(-8))/3.

NETEXP: Net Exports of Goods & Services. Seasonally Adjusted Annual Rate. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

TDEFR = -NETEXP/GDP.

TDEFKR = TDEFMA/KFLOWRM(-4).

LRULC: Log Unit Labor Costs, deflated by GDP deflator. Nonfinancial Corporations. Source: U.S. Department of Labor: Bureau of Labor Statistics.

LRULCMA = 4 quarters moving average of LRULC.