Research Rap
Special Report

# Real-Time Performance of GDPplus and Alternative Model-Based Measures of GDP: 2005–2014

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Like most macroeconomic variables, real gross domestic product is subject to measurement error. Because the U.S. Bureau of Economic Analysis lacks complete information at the time it publishes its initial GDP estimates, revisions are often substantial.[2] Analysts concerned about the accuracy of these early estimates for expenditure GDP could focus instead on gross domestic income, the BEA's measure of U.S. output on the income side of the national accounts.[3] Conceptually, GDP on the expenditure side should equal GDP on the income side, and there should be no choice to make between the two series. As a practical matter, however, the two measures can differ by a significant amount because each measure is constructed using "largely independent" source data, which themselves are "less than perfect" [BEA (2014)].

Since November 2013, the Federal Reserve Bank of Philadelphia's Real-Time Data Research Center has been publishing GDPplus, a new measure of U.S. real GDP growth that combines the BEA's official estimates of expenditure GDP and gross domestic income. Based on the work of Aruoba, Diebold, Nalewaik, Schorfheide, and Song (2013, henceforth ADNSS), GDPplus represents an appealing complement to the BEA's official estimates because it combines information in those estimates in a statistically optimal manner.

GDPplus combines the information in expenditure and income GDP using a signal extraction method based on the Kalman filter. In the ADNSS framework, true GDP is treated as an unobserved variable. At the

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[2] The components of expenditure GDP are personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government consumption expenditures and gross investment.
[3] The components of gross domestic income include wages and salaries, supplements to wages and salaries, proprietors' income, rental income, corporate profits, and some additional measures.

same time, the BEA's official estimates for income and expenditure GDP are thought to be measured with error but contain a common signal about latent GDP. The Kalman filter estimates the common component that drives the BEA's official estimates. There is, however, no unique way to estimate the common component. Different assumptions about the nature of measurement errors produce different estimates of the common component.

In this report, I estimate four alternative ADNSS models on latest-vintage data and real-time vintage data from the Philadelphia Fed's real-time data set for macroeconomists. The models, one of which represents GDPplus, differ in the identifying assumptions they make about measurement errors in the BEA's official estimates.[4] Using my real-time estimates, I track parameter stability over time, compare revisions to alternative estimates of GDP with revisions to expenditure GDP, and document differences between the forecast performance of models that use the BEA's official measure of expenditure GDP and that of my alternative GDP estimates. I also analyze whether the model-based estimates offer any improvement over a simple weighted average of expenditure and income GDP. The key findings are:

- The correlation between model-based real GDP growth and nonfarm payroll employment growth exceeds the correlation between the BEA's estimate of real expenditure GDP growth and employment growth. The models for estimating alternative measures of GDP have surprisingly stable coefficient estimates over vintage history from February 2005 through July 2014.
- Revisions to the model-based GDP estimates are similar in size to the revisions the BEA makes to its estimates of expenditure GDP.
- Model-based measures of GDP are predictive for both expenditure GDP itself and for nonfarm payroll employment. The predictions conditioned on model-based GDP outperform those conditioned on expenditure GDP, suggesting model-based GDP estimates carry useful information about the U.S. economy that is not contained in the BEA's expenditure estimates. Moreover, predictions for employment using model-based GDP outperform predictions using simple weighted averages of expenditure GDP and income GDP.

Taken together, the findings suggest that the model-based estimates of GDP, including the Philadelphia Fed's GDPplus series, are reliable and useful additions to the array of indicators that analysts can use to assess current and future macroeconomic conditions. The preliminary evidence on their forecasting ability enhances the case for monitoring the Philadelphia Fed's monthly updates of GDPplus.

[4] The real time data set for macroeconomists is available at www.philadelphiafed.org/research-and-data/real-time-center/real-time-data/. The data set includes the series used in this paper with the exception of the monthly vintages for nominal gross domestic income and nominal personal income. These series, available on request, exist in my personal stock of real-time data but not in the Philadelphia Fed's official data set. The Philadelphia Fed's GDPplus series is available at www.philadelphiafed.org/research-and-data/real-time-center/gdpplus/.

**Four Models for Estimating Real GDP via Signal Extraction**

The ADNSS modeling framework assumes that true real GDP growth is unobserved but follows an autoregressive process given by

$$GDPg_t = \mu(1-\rho) + \rho GDPg_{t-1} + \varepsilon_{g\,t}$$

where $GDPg_t$ represents quarter-over-quarter growth, $\mu$ is a parameter capturing steady-state growth, $\rho$ is the first-order autoregressive parameter, and $\varepsilon_{gt}$ is the innovation to unobserved growth. We extract a signal about unobserved real GDP growth by relating it to BEA's estimates for the growth in expenditure real GDP and income real GDP, according to

$$\begin{pmatrix} GDPe_t \\ GDPi_t \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \end{pmatrix} GDPg_t + \begin{pmatrix} \varepsilon_{e\,t} \\ \varepsilon_{i\,t} \end{pmatrix},$$

where $GDPe$ and $GDPi$ are the BEA's official estimates for growth in expenditure real GDP and income real GDP, and the innovations $\varepsilon_e$ and $\varepsilon_i$ are measurement errors. Alternatively, ADNSS consider adding the unemployment rate as a variable that could inform the estimates for unobserved real GDP growth, according to

$$\begin{pmatrix} GDPe_t \\ GDPi_t \\ \Delta U_t \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \kappa \end{pmatrix} + \begin{pmatrix} 1 \\ 1 \\ \lambda \end{pmatrix} GDPg_t + \begin{pmatrix} \varepsilon_{e\,t} \\ \varepsilon_{i\,t} \\ \varepsilon_{u\,t} \end{pmatrix},$$

where $\Delta U_t$ represents the quarter-over-quarter first-difference of the quarterly-average level of the monthly unemployment rate, $\kappa$ and $\lambda$ are parameters to estimate, and $\varepsilon_{u\,t}$ reflects measurement error. All innovations are mean zero and serially uncorrelated, with the elements of the variance-covariance matrix given by

$$V\begin{pmatrix}\varepsilon_{g\,t}\\ \varepsilon_{e\,t}\\ \varepsilon_{i\,t}\\ \varepsilon_{u\,t}\end{pmatrix}=\begin{pmatrix}\sigma_{gg} & \sigma_{ge} & \sigma_{gi} & \sigma_{gu}\\ \sigma_{eg} & \sigma_{ee} & \sigma_{ei} & \sigma_{eu}\\ \sigma_{ig} & \sigma_{ie} & \sigma_{ii} & \sigma_{iu}\\ \sigma_{ug} & \sigma_{ue} & \sigma_{ui} & \sigma_{uu}\end{pmatrix}$$

As noted above, no unique way exists for estimating GDP, even in the ADNSS framework, without imposing additional restrictions on the parameters. The first three models exclude the unemployment rate but impose alternative assumptions on the covariances between shocks. Model 1 assumes all shocks are contemporaneously uncorrelated, implying that the covariances are zero between the model's shocks $(\sigma_{ge}=\sigma_{gi}=\sigma_{ei}=0)$. Model 2 allows correlation between the measurement errors $(\sigma_{ei}\neq 0)$ but rules out correlation with the shock to unobserved GDP $(\sigma_{ge}=\sigma_{gi}=0)$. Model 3, the model behind the Philadelphia Fed's GDPplus series, restores all shock correlations but fixes the variance of unobserved GDP growth at 80 percent of the variance of expenditure GDP growth.[5] Model 4 adds the unemployment rate but rules out correlation between the unemployment shock and the measurement errors for expenditure and income real GDP $(\sigma_{eu}=\sigma_{iu}=0)$.

Model estimation of the state-space representation proceeds via the method of maximum likelihood on the vintage of data available in June 2014 over the sample period from 1960 Q1 to 2014 Q1. Given the parameter estimates, I follow ADNSS in using the Kalman smoother to extract time series estimates of GDP.[6] Figures 1–4 show the Kalman-smoothed estimates (GDPg) and the BEA's official estimates for expenditure real GDP (GDPe) and income real GDP (GDPi). All series covary positively, but the model-based estimates appear smoother than the BEA's estimates for expenditure GDP. Moreover, it is obvious that the model-based estimates are not simple averages of the BEA's estimates for expenditure and income GDP because the model-based estimates often fall outside the range defined by the BEA's estimates. Indeed, the models estimate the 2007–09 recession as less severe than the BEA does (Figure 4).

The contemporaneous correlations between alternative model estimates, based on rolling 60-quarter fixed-window samples, confirm the visual impressions given by the figures. The correlations are well above 0.7, and with the exception of the correlations with model 4, are stable over time (Figure 5). As noted by

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[5] This restriction can be parameterized as a restriction among $\sigma_{gg}$, the autoregressive parameter for unobserved real GDP growth ( $\rho$ ) , and the remaining elements of the variance-covariance matrix of shocks in the following way: $\sigma_{gg}=\left(\eta/(1-\eta)\right)(1-\rho^2)(2\sigma_{ge}+\sigma_{ee})$, where $\eta=0.8$.

[6] I compute growth rates as 400 times the quarter-over-quarter first difference of the natural logarithms of the levels of real expenditure GDP and real gross domestic income (income GDP). The level of real gross domestic income is nominal gross domestic income divided by the ratio of nominal expenditure GDP to real expenditure GDP. The quarter-over-quarter first difference of the unemployment rate is computed from the quarterly average level of the monthly values expressed in percentage points and multiplied by four.

ADNSS, the models' estimates are more highly correlated with the BEA's estimates of income GDP than they are with expenditure GDP (Figure 6). Additionally, the correlations with income GDP are stable over time while those with expenditure GDP are not.

What is perhaps most significant and surprising is that the correlation between model-estimated GDP growth and employment growth exceed that between expenditure GDP growth and employment growth. Figure 7 shows that model-based real GDP has a correlation with employment of roughly 0.7, which uniformly exceeds the correlation estimates between expenditure GDP and employment.  This finding suggests that model-based GDP could be more predictive than expenditure GDP for employment.

## Real-Time Estimation, Coefficient Evolution, and Revisions

The preceding analysis was retrospective in nature because it relied upon the latest-available data and therefore did not incorporate the influence of data revisions. Revisions could have a significant effect on the model-based GDP estimates.  The reason is that model-based GDP is subject to revisions that do not affect the BEA's estimates.  Of course, there is a direct effect on the model-based estimates when the BEA revises its data. In addition, the model-based estimates are subject to revision when the underlying models' estimated parameters change in response to the BEA's data revisions. Finally, the model-based estimates are subject to revision due to the two-sided nature of the Kalman smoother. This last effect operates in much the same way as Orphanides (2001, 2003, 2004) and Orphanides and van Norden (2002) have documented in the context of estimates for the output gap.  It stands to reason that many business and research economists would like to know about the sensitivity of the models' parameter estimates to vintage data and, more generally, the properties of revisions to the model-based estimates compared with the revisions to expenditure GDP.

One convenient feature of the latest techniques in the literature on Kalman filtering is that econometricians can estimate the parameters of the ADNSS state-space representation given by

$$\begin{pmatrix} GDPg_t \\ \varepsilon_{e\,t} \\ \varepsilon_{i\,t} \\ \varepsilon_{u\,t} \end{pmatrix} = \begin{pmatrix} \mu(1-\rho) \\ 0 \\ 0 \\ 0 \end{pmatrix} + \begin{pmatrix} \rho & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} GDPg_{t-1} \\ \varepsilon_{e\,t-1} \\ \varepsilon_{i\,t-1} \\ \varepsilon_{u\,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{g\,t} \\ \varepsilon_{e\,t} \\ \varepsilon_{i\,t} \\ \varepsilon_{u\,t} \end{pmatrix}$$

$$\begin{pmatrix} GDPe_t \\ GDPi_t \\ \Delta U_t \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \kappa \end{pmatrix} + \begin{pmatrix} 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ \lambda & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} GDPg_t \\ \varepsilon_{e\,t} \\ \varepsilon_{i\,t} \\ \varepsilon_{u\,t} \end{pmatrix}$$

$$V \begin{pmatrix} \varepsilon_{g\,t} \\ \varepsilon_{e\,t} \\ \varepsilon_{i\,t} \\ \varepsilon_{u\,t} \end{pmatrix} = \begin{pmatrix} \sigma_{gg} & \sigma_{ge} & \sigma_{gi} & \sigma_{gu} \\ \sigma_{eg} & \sigma_{ee} & \sigma_{ei} & 0 \\ \sigma_{ig} & \sigma_{ie} & \sigma_{ii} & 0 \\ \sigma_{ug} & 0 & 0 & \sigma_{uu} \end{pmatrix}$$

and extract a signal about the latest observation for GDPg even when not all observations exist for expenditure GDP (GDPe) and income GDP (GDPi).[7] Such a situation exists in the U.S. national accounts because the BEA delays the release income GDP relative to the release of expenditure GDP.

Using monthly vintages of real-time data for expenditure GDP, income GDP, and the unemployment rate, I re-estimate the ADNSS models monthly on an expanding window of observations and reapply the Kalman smoother signal extraction method. To be precise, each month I re-estimate the entire time series history for the alternative model-based GDP series. Along the way, I examine the evolution of the most important maximum likelihood parameter estimates and track selected releases of model-based GDP and expenditure GDP. Vintage history runs from the vintage available at the end of January 2005 to the vintage available at the end of June 2014.[8]

Figure 8 tracks the real-time estimates of the autoregressive parameter $(\rho)$ for model-based GDP (GDPg). For comparison, I also plot real-time estimates for AR(1) and ARMA(1,1) models estimated on real expenditure GDP growth [denoted GDPe AR(1)] and GDPe ARMA(1,1), respectively]. The plot shows all model-based estimates have a larger coefficient than that of the AR(1) model for expenditure GDP. Notably, the autoregressive coefficient for the corresponding ARMA(1,1) model on expenditure GDP is comparable to the coefficients for the model-based estimates. Overall, the real-time autoregressive coefficients are remarkably stable over time, except around mid-2009, when the BEA released a comprehensive revision to the U.S. national accounts.

[7] The state-space representation is for the fourth model. The state-space representations for the first three models require the obvious modifications and the imposition of alternative identifying restrictions on the elements of the variance-covariance matrices.

[8] The real-time analysis begins with the vintage available at the end of January 2005 and ends with the vintage available at the end of June 2014. Thus, vintage history begins with the vintage that includes the BEA's advance release for 2004 Q4 expenditure GDP and ends with the vintage that includes the BEA's third release (second revision) for 2014 Q1 expenditure GDP. Note that the timing of the BEA's release of gross domestic income (GDPi) differs slightly from that of expenditure GDP (GDPe). The first release of gross domestic income occurs one month after the first release of expenditure GDP, when the observation covers the first, second, or third quarter. The BEA publishes its first estimate of gross domestic income with a two-month lag when the observation is for the fourth quarter.

Figure 9 shows the estimated error variances for the GDPg state equation and the GDPe and GDPi observation equations. I also plot the covariance between the measurement errors in the two observation equations. In general, the variance estimates are stable over time, with two notable exceptions. First, the measurement error variances for the third model (the one on which the Philadelphia Fed's GDPplus series is based), show some variability around a constant level. Second, the estimated covariance between measurement errors in the third model shows similar variation around a fixed level.

Overall, the estimated coefficients appear to exhibit a comforting degree of stability over time. This result is important for a number of reasons. First, because the span of real-time vintages includes two comprehensive revisions to the U.S. national accounts (in July 2009 and July 2013) and seven annual revisions (occurring in July in 2005, 2006, 2007, 2008, 2010, 2011, and 2012), the coefficient stability suggests the models for estimating unobserved GDP are reasonably robust to the BEA's revisions. Second, it suggests that one might not need to re-estimate the models as often as monthly. Third, revisions to model-based GDP will not be dominated by revisions to the parameter estimates on which they are based.

Table 1 provides summary statistics for revisions to model-based GDP and expenditure GDP. The table reports the mean revisions, as well as the standard deviations and the mean absolute revisions over the period from 2004 Q4 to 2013 Q1. (I restrict the sample to maintain the same number of observations across alternative definitions of revisions and to exclude revisions that equal zero because the observation has not yet been subject to revision.) I report statistics for a number of alternative revision types, including the revision from the first release to the second (1to2), the second release to the third (2to3), and cumulative revisions from the first release to the latest available release (1toL).

Overall, revisions to the model-based estimates are comparable across models. The exception is that model 4's revisions are noticeably smaller, a likely reflection of the important role the unemployment rate plays in signal extraction plus small revisions to the unemployment rate itself. It is also clear that model-based revisions are roughly comparable to those of expenditure GDP.

Focusing on the standard deviations and mean absolute revisions for cumulative revisions (panels 1.B and 1.C), it is clear revisions to expenditure GDP are a bit smaller than the revisions to model-based GDP over the first three releases. Notably, as we increase the window for cumulating revisions, model-based revisions look smaller than the revisions to expenditure GDP, depending on the model. This effect is most pronounced for the revisions from the third release to the latest release (3toL).

Figure 10 shows the cumulative revisions over the first three releases for model-based and expenditure GDP. The two series track each other well, with revisions to model-based GDP sometimes larger and sometimes smaller than revisions to expenditure GDP.

## Is Model-Based GDP Predictive in Real Time?

Model-based GDP is predictive for expenditure GDP and employment in real time, but my estimates are notably imprecise. I first compare ARMA(1,1) forecasts for expenditure GDP growth with those implied by the four state-space models. The ARMA(1,1) specification is motivated by the results of Figure 8, which showed the estimated coefficient on lagged expenditure GDP growth close to the estimates of the autoregressive coefficient in the state-space models. From a forecasting perspective, the ARMA(1,1) specification appears as an appealing alternative to the state-space models. The model-based projections for expenditure GDP growth follow naturally from the state-space representation, which implies that expenditure GDP (GDPe) equals model-based GDP (GDPg) plus an unpredictable measurement error, with projections for model-based GDP based on the state equation, using real-time Kalman-smoothed jump-off values. The second forecast experiment compares projections for employment using competing, long-horizon, non-nested VARs. The first specification uses a constant, lags of employment growth, and lags of expenditure GDP growth. The competing specification substitutes model-based GDP for expenditure GDP.

The experimental design replicates the real-time data environment in effect at the forecast jump-off point. At the end of each month (on the day of the BEA's release of data for the U.S. national accounts), I estimate the parameters of the state-space models, compute the time-series history for Kalman smoothed model-based GDP, estimate the forecast models, and generate the projections for the current quarter and the following three quarters. As noted above, monthly vintage history runs from February 2005 to June 2014. Estimation proceeds in an expanding-window fashion, beginning with the observation for 1960 Q1 and using additional quarterly observations as they become available in the BEA's releases. It is worth emphasizing that I generate an initial projection for the next four quarters at the end of the first month of each quarter. Forecast updates follow at the end of the next two months when the BEA releases its data revisions to the national accounts. Real-time realizations are those for the first, second, and third releases of expenditure GDP and nonfarm payroll employment.

Table 2 presents root-mean-square error ratios and, in parentheses, the Harvey-Leybourne-Newbold (1997) and Diebold-Mariano (1995) two-sided p-values for testing the null hypothesis of no difference between alternative projections for expenditure real GDP growth. Ratios less than unity imply that GDPg is more predictive (for GDPe) than GDPe itself is. At the one-quarter-ahead horizon, model-based GDP improves forecast accuracy 2 to 10 percentage points (measured in terms of the root-mean-squared error) over the ARMA model (Table 2). This suggests that GDPg carries useful information about one-quarter-ahead expenditure GDP and confirms the potential value of monitoring the Philadelphia Fed's GDPplus estimates (model 3), even when an analyst's main interest remains with the BEA's official estimates. (The only exception is that model-based GDP from the fourth model, which includes unemployment, consistently underperforms the ARMA specification.) Note, however, that relatively high p-values caution against relying too much on the model-based estimates.

It is of interest that the estimates for the GDPplus specification (model 3) indicate the root-mean-square error ratios for predicting the BEA's advance release fall from 0.982 when the projection is made at the end of the first month of the quarter, to 0.944 at the end of the second month and 0.909 at the end of the third month, suggesting improvement in the relative accuracy of the GDPplus specification as the BEA revises its data. Similar results hold for predicting the first and second revisions and across models 1 and 2. Model 1 (diagonal variance-covariance matrix) stands out because it shows statistically significant gains over the ARMA at the two-quarter-ahead horizon.

Table 3 presents the results for predicting quarter-over-quarter employment growth. I find one-quarter-ahead forecast improvement of 4 percent to 16 percent in the models that use GDPg over models that use GDPe. Improvement of 3 percent or better often obtains at the two-quarter-ahead horizon. As above, the estimates are largely imprecise, but it is interesting that the one-quarter-ahead predictions using GDPg from model 1 stand out as more precise than the others. It is also notable that the employment predictions using GDPg from model 4 are among the most accurate, in contrast with the results for predicting expenditure GDP, where model 4 produced the worst predictions.

## Convexity or Complexity?

Thus far, I have documented some evidence that model-based GDP is predictive for expenditure GDP and nonfarm payroll employment. What is not so clear is whether such a complex procedure as Kalman filtering is necessary to achieve the gains in forecast performance. One simple alternative is to replace model-based GDP with a convex combination of expenditure GDP and income GDP. I consider such convex combinations given by

$$GDPc_t = \omega \, GDPe_t + (1-\omega) \, GDPi_t$$

where GDPc represents a convex combination of expenditure GDP growth (GDPe) and income GDP growth (GDPi), using alternative weights $(\omega)$ of 0.25, 0.50, and 0.75 on expenditure GDP. As above, I construct full time-series, monthly-vintage estimates of GDPc.[9]

An advantage of the Kalman filter over the convex combination is that it produces a statistically optimal estimate of GDP even when the BEA has not yet released the latest observation for income GDP. (Recall that the BEA releases income GDP with a one-month lag relative to the release of expenditure GDP when the observation covers the first, second, or third quarter. The fourth-quarter observation is released with a two-month lag.) My convex combinations rely on forecasts for income GDP when BEA has not yet

[9] Aruoba, Diebold, Nalewaik, Schorfheide, and Song (2011) consider optimal convex combinations in constructing historical estimates of GDP that improve upon the BEA's official estimates for expenditure and income GDP. Their analysis did not focus on forecasting or on revisions to the data.

released the latest observation. I form the projection from a regression, re-estimated monthly on real-time vintage data on an expanding window of quarterly observations beginning with that for 1960 Q1, given by

$$GDPi_t = \gamma_0 + \sum_{j=1}^{2} \gamma_j GDPi_{t-j} + \delta_1 GDPe_t + \delta_2 PI_t + \eta_t$$

where GDPi and GDPe are quarter-over-quarter growth rates (as defined previously) and PI is quarter-over-quarter growth in real personal income (defined as the growth in nominal personal income minus the growth in the GDP deflator, the same price index used to deflate nominal income GDP). [10]

My real-time forecasting results suggest complexity reigns supreme over convexity (Table 4). I consider long-horizon VAR forecasts for the growth in nonfarm payroll employment as a function of a constant, two lags of employment growth and two lags of, alternatively, model-based GDP and GDP constructed as the convex combination shown above. Table 4 reports the one- through four-quarter-ahead results for the ratio of the root-mean square error of the complex model-based forecasts (using the Kalman filter) to the forecasts using convex combinations of GDPe and GDPi. Ratios less than unity indicate that model-based GDP is more predictive for employment than GDP constructed as the convex combination. I find that most point estimates of relative forecast performance are imprecisely estimated because the two-sided p-values are large. That said, it is clear that almost all point estimates are less than unity, indicating that model-based, Kalman-smoothed estimates of GDP carry forecasting benefits (for employment) over the convex combinations. It is worth noting that the relative benefit of the Kalman-smoothed estimates is greatest when the weight on expenditure GDP is 0.75 rather than 0.5 or 0.25, suggesting that the convex combination is a poor predictor for employment when the weight on expenditure GDP is large. The implication is that if one were inclined to use the convex combination method for constructing an estimate of unobserved GDP, a low weight on expenditure GDP should be used.

Finally, it is worth asking whether my employment forecast comparisons are biased in favor of the model-based estimates. Such bias could occur if my projections for income GDP are inaccurate and produce poor estimates of the convex combination. One answer is that the BEA's lag in releasing income GDP represents a serious drawback in constructing early estimates of GDP based on the convex combination of income and expenditure GDP. This answer suggests that the forecast comparisons are legitimate because they accurately incorporate the lack of real-time information on income GDP. Another, potentially more satisfying, answer comes from inspecting the results for projections made at the end of the second and third months of the quarter, when the BEA has released its early estimates for income GDP (Table 4). The results for these projections suggest the employment forecasts using model-based GDP continue to outperform those

[10] Over the entire monthly vintage history of estimation on quarterly observations, the estimated coefficient on GDPe is roughly 0.6 and hugely significant. The coefficient on PI is roughly 0.4, also hugely significant.

based on convex combinations of the BEA's published estimates. The implication is that employment forecasts are slightly more accurate when they are conditioned on the ADNSS model-based estimates of GDP than when they are conditioned on a simple convex combination of expenditure and income GDP. Evidently, the payoff for the complexity of estimating the ADNSS models over the simplicity of convex combination is improved forecast accuracy.

## Concluding Remarks

In this report, I use real-time data to track the performance of GDPplus and three related series since 2005. I find revisions to the model-based estimates are similar in size to those the BEA makes to its expenditure estimates.

However, the results also suggest the model-based estimates of GDP have a higher correlation with employment than that between the BEA's estimate of expenditure GDP and employment. Indeed, predictions for employment conditioned on model-based GDP outperform those conditioned on expenditure GDP. Notably, the model-based estimates are more than just weighted averages of the BEA's official estimates. I find that predictions for employment conditioned on model-based GDP estimates are more accurate than those based on simple convex combinations of expenditure and income GDP.

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**Table 1. Statistics for Revisions to Quarter-over-Quarter Real GDP Growth Expenditure GDP (GDPe) and Four Model-Based GDP Measures (GDPg)**

**Annualized Percentage Points**
**2004 Q4 – 2013 Q1**

## 1.A. Mean Revisions

| Revision | GDPe | GDPg1 | GDPg2 | GDPg3 | GDPg4 |
|---|---|---|---|---|---|
| 1to2 | 0.036 | -0.117 | -0.086 | -0.157 | -0.070 |
| 2to3 | -0.025 | 0.034 | 0.036 | 0.067 | 0.000 |
| | | | | | |
| 3to4 | n.a. | -0.094 | -0.149 | -0.171 | 0.020 |
| 4to5 | n.a. | -0.034 | -0.030 | -0.043 | 0.005 |
| 5to6 | n.a. | 0.003 | 0.001 | 0.004 | -0.003 |
| | | | | | |
| 1to3 | 0.011 | -0.082 | -0.049 | -0.090 | -0.069 |
| 1toL | -0.430 | -0.495 | -0.533 | -0.608 | -0.117 |
| 3toL | -0.441 | -0.412 | -0.484 | -0.518 | -0.048 |

## 1.B. Standard Deviation of Revisions

| Revision | GDPe | GDPg1 | GDPg2 | GDPg3 | GDPg4 |
|---|---|---|---|---|---|
| 1to2 | 0.702 | 0.809 | 0.582 | 0.900 | 0.296 |
| 2to3 | 0.266 | 0.719 | 0.521 | 0.921 | 0.207 |
| | | | | | |
| 3to4 | n.a. | 0.392 | 0.354 | 0.422 | 0.580 |
| 4to5 | n.a. | 0.943 | 0.652 | 1.147 | 0.257 |
| 5to6 | n.a. | 0.025 | 0.104 | 0.099 | 0.017 |
| | | | | | |
| 1to3 | 0.745 | 1.222 | 0.883 | 1.406 | 0.377 |
| 1toL | 1.541 | 1.654 | 1.368 | 1.727 | 0.885 |
| 3toL | 1.327 | 1.351 | 1.120 | 1.500 | 0.802 |

**Table 1 (continued). Statistics for Revisions to Quarter-over-Quarter Real GDP Growth Expenditure GDP (GDPe) and Four Model-Based GDP Measures (GDPg)**

**Annualized Percentage Points**
**2004 Q4 – 2013 Q1**

## 1.C. Mean Absolute Revisions

| Revision | GDPe | GDPg1 | GDPg2 | GDPg3 | GDPg4 |
|---|---|---|---|---|---|
| 1to2 | 0.478 | 0.500 | 0.341 | 0.543 | 0.193 |
| 2to3 | 0.168 | 0.509 | 0.365 | 0.653 | 0.150 |
| | | | | | |
| 3to4 | n.a. | 0.355 | 0.273 | 0.363 | 0.377 |
| 4to5 | n.a. | 0.550 | 0.377 | 0.671 | 0.157 |
| 5to6 | n.a. | 0.017 | 0.074 | 0.068 | 0.013 |
| | | | | | |
| 1to3 | 0.490 | 0.814 | 0.590 | 0.897 | 0.235 |
| 1toL | 0.998 | 1.049 | 0.965 | 1.262 | 0.533 |
| 3toL | 0.865 | 0.732 | 0.675 | 0.973 | 0.442 |

Notes. The panels report summary statistics for revisions to quarter-over-quarter growth in expenditure real GDP (GDPe) and model-based GDP (GDPg1,…,GDPg4). Growth rates are defined as 400 times the first difference of the log level. GDPg1 is the ADNSS model that imposes a diagonal variance-covariance matrix. GDPg2 is the model that imposes a block-diagonal variance-covariance matrix. GDPg3 corresponds with the Philadelphia Fed's GDPplus series and imposes a restriction on the ratio of the variance of GDPg to the variance of GDPe. GDPg4 is the ADNSS model that adds the unemployment rate to the system of observation equations. The revisions are those for the first release to the second (1to2), the second release to the third (2to3), the third release to the fourth (3 to 4), the fourth release to the fifth (4 to5), the fifth release to the sixth (5to6), the cumulative revision from the first release to the third (1to3), the cumulative revision from the first release to the latest release (1toL), and the cumulative revision from the third release to the latest (3toL). The latest vintage is that available at the end of June 2014. Some statistics are not provided for expenditure GDP because they are zero by definition. The timing of the first release is that of the BEA's advance estimate of expenditure GDP. The timing of the second and third releases corresponds with the BEA's second and third estimates of expenditure GDP (formerly called "preliminary" and "final").

**Table 2. Forecasting Expenditure Real GDP Growth: 2005 – 2014 (One Quarter Ahead)**

| | GDPg Model 1 | | | GDPg Model 2 | | | GDPg Model 3 | | | GDPg Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **1 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 0.962 | 0.928 | 0.899 | 0.973 | 0.939 | 0.913 | 0.982 | 0.944 | 0.909 | 1.079 | 1.064 | 1.053 | 37 |
| | (0.124) | (0.082) | (0.179) | (0.346) | (0.184) | (0.245) | (0.261) | (0.201) | (0.280) | (0.423) | (0.484) | (0.593) | |
| | (0.110) | (0.070) | (0.165) | (0.333) | (0.170) | (0.231) | (0.247) | (0.187) | (0.266) | (0.411) | (0.473) | (0.585) | |
| First Rev. | 0.969 | 0.933 | 0.917 | 0.976 | 0.939 | 0.923 | 0.983 | 0.939 | 0.918 | 1.043 | 1.031 | 1.021 | 37 |
| | (0.123) | (0.087) | (0.164) | (0.305) | (0.140) | (0.197) | (0.213) | (0.151) | (0.229) | (0.620) | (0.713) | (0.808) | |
| | (0.110) | (0.074) | (0.150) | (0.291) | (0.126) | (0.183) | (0.199) | (0.137) | (0.215) | (0.612) | (0.707) | (0.804) | |
| Second Rev. | 0.974 | 0.940 | 0.928 | 0.977 | 0.942 | 0.931 | 0.983 | 0.942 | 0.928 | 1.040 | 1.031 | 1.022 | 37 |
| | (0.142) | (0.099) | (0.184) | (0.275) | (0.132) | (0.197) | (0.187) | (0.148) | (0.239) | (0.620) | (0.688) | (0.784) | |
| | (0.128) | (0.086) | (0.170) | (0.261) | (0.118) | (0.183) | (0.172) | (0.134) | (0.225) | (0.613) | (0.682) | (0.779) | |

Notes. The tables report the ratio of the root-mean-square error of projections for quarter-over-quarter expenditure real GDP growth using model-based GDP (models 1 to 4) to the projections using an ARMA (1,1) on expenditure GDP growth itself. Ratios less than unity indicate model-based GDP outperforms expenditure GDP. The projections run from one-quarter ahead to four-quarters ahead. A set of two-sided p-values accompanies each statistic. The first is for the Harvey- Leybourne-Newbold (1997) statistic, using a truncation lag equal to the forecast step minus unity. The second is for the Diebold-Mariano (1995) statistic, using a truncation lag twice the size of the one for the HLN statistic. The HLN p-value is recorded as NA when the estimated standard error is negative for the underlying statistic. The projections are generated in real-time at the end of the first, second, and third months of the quarter following the BEA's release of the U.S. national accounts for the previous quarter. Realizations are the BEA's advance release for expenditure real GDP growth and, alternatively, the first and second revised values. Quarterly growth rates are for quarter-over-quarter growth, using the formula for continuous compounding. The model-based projections are those for the diagonal variance-covariance matrix (model 1), the block-diagonal variance-covariance matrix (model 2), t he GDPplus specification, which imposes a restricted variance-covariance matrix (model 3), and the model that adds the unemployment rate (model 4). The forecast models are estimated in real time on an expanding window of observations, beginning with that for 1960 Q1.

**Table 2 (continued). Forecasting Expenditure Real GDP Growth: 2005 – 2014 (Two and Three Quarters Ahead)**

| | GDPg Model 1 | | | GDPg Model 2 | | | GDPg Model 3 | | | GDPg Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **2 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 0.999 | 0.976 | 0.981 | 0.997 | 0.972 | 0.979 | 1.002 | 0.969 | 0.979 | 1.053 | 1.030 | 1.036 | 36 |
| | (0.931) | (0.103) | (0.297) | (0.887) | (0.425) | (0.604) | (0.566) | (0.157) | (0.468) | (0.544) | (0.728) | (0.685) | |
| | (0.927) | (0.080) | (0.269) | (0.881) | (0.399) | (0.585) | (0.546) | (0.131) | (0.444) | (0.523) | (0.714) | (0.669) | |
| First Rev. | 1.001 | 0.980 | 0.985 | 0.997 | 0.975 | 0.981 | 1.004 | 0.972 | 0.981 | 1.033 | 1.011 | 1.017 | 36 |
| | (0.920) | (0.086) | (0.265) | (0.858) | (0.409) | (0.574) | (0.298) | (0.179) | (0.446) | (0.659) | (0.882) | (0.820) | |
| | (0.916) | (0.065) | (0.238) | (0.851) | (0.383) | (0.553) | (0.270) | (0.152) | (0.421) | (0.643) | (0.876) | (0.810) | |
| Second Rev. | 1.003 | 0.981 | 0.985 | 0.996 | 0.973 | 0.979 | 1.003 | 0.971 | 0.979 | 1.033 | 1.010 | 1.015 | 36 |
| | (0.783) | (0.072) | (0.243) | (0.759) | (0.339) | (0.494) | (0.292) | (0.156) | (0.380) | (0.626) | (0.878) | (0.823) | |
| | (0.772) | (0.053) | (0.215) | (0.747) | (0.312) | (0.470) | (0.265) | (0.131) | (0.354) | (0.608) | (0.871) | (0.814) | |
| **3 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 1.007 | 0.994 | 0.999 | 1.002 | 0.990 | 0.997 | 1.005 | 0.987 | 0.995 | 1.043 | 1.026 | 1.032 | 35 |
| | (0.565) | (0.603) | (0.906) | (0.851) | (0.580) | (0.902) | (0.383) | (0.246) | (0.591) | (0.248) | (0.484) | (0.423) | |
| | (0.531) | (0.571) | (0.898) | (0.838) | (0.547) | (0.894) | (0.341) | (0.204) | (0.559) | (0.206) | (0.446) | (0.383) | |
| First Rev. | 1.007 | 0.998 | 1.001 | 1.001 | 0.992 | 0.996 | 1.005 | 0.991 | 0.996 | 1.034 | 1.020 | 1.025 | 35 |
| | (0.449) | (0.782) | (0.930) | (0.962) | (0.616) | (0.830) | (0.293) | (0.372) | (0.650) | (0.244) | (0.504) | (0.441) | |
| | (0.410) | (0.764) | (0.924) | (0.959) | (0.586) | (0.816) | (0.250) | (0.330) | (0.622) | (0.202) | (0.467) | (0.401) | |
| Second Rev. | 1.009 | 0.999 | 1.001 | 1.000 | 0.990 | 0.993 | 1.006 | 0.992 | 0.995 | 1.030 | 1.016 | 1.020 | 35 |
| | (0.287) | (0.900) | (0.859) | (0.994) | (0.544) | (0.696) | (0.172) | (0.334) | (0.523) | (0.248) | (0.554) | (0.487) | |
| | (0.244) | (0.891) | (0.847) | (0.994) | (0.510) | (0.672) | (0.133) | (0.291) | (0.487) | (0.205) | (0.519) | (0.449) | |

**Table 2 (continued). Forecasting Expenditure Real GDP Growth: 2005 – 2014 (Four Quarters Ahead)**

| | GDPg Model 1 | | | GDPg Model 2 | | | GDPg Model 3 | | | GDPg Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **4 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 1.007 | 1.002 | 1.004 | 1.000 | 0.995 | 0.999 | 1.004 | 0.997 | 1.001 | 1.031 | 1.023 | 1.024 | 34 |
| | (0.144) | (0.475) | (NA) | (0.975) | (0.575) | (0.924) | (0.057) | (0.510) | (0.886) | (0.014) | (0.090) | (0.138) | |
| | (0.095) | (0.421) | (0.194) | (0.972) | (0.528) | (0.915) | (0.028) | (0.458) | (0.872) | (0.004) | (0.052) | (0.090) | |
| First Rev. | 1.007 | 1.003 | 1.004 | 0.999 | 0.994 | 0.996 | 1.004 | 0.997 | 1.000 | 1.022 | 1.016 | 1.017 | 34 |
| | (0.025) | (NA) | (NA) | (0.765) | (0.503) | (0.805) | (0.000) | (0.580) | (0.976) | (0.014) | (0.152) | (0.238) | |
| | (0.009) | (0.384) | (0.229) | (0.737) | (0.450) | (0.781) | (0.000) | (0.533) | (0.973) | (0.004) | (0.102) | (0.180) | |
| Second Rev. | 1.008 | 1.004 | 1.005 | 0.999 | 0.995 | 0.997 | 1.005 | 0.999 | 1.002 | 1.022 | 1.016 | 1.017 | 34 |
| | (0.020) | (0.000) | (0.011) | (0.754) | (0.572) | (0.813) | (0.000) | (0.875) | (0.846) | (0.016) | (0.160) | (0.241) | |
| | (0.006) | (0.000) | (0.003) | (0.725) | (0.524) | (0.791) | (0.000) | (0.859) | (0.827) | (0.005) | (0.109) | (0.183) | |

**Table 3. Forecasting Nonfarm Payroll Employment Growth: 2005 – 2014 (One Quarter Ahead)**

| | GDPg Model 1 | | | GDPg Model 2 | | | GDPg Model 3 | | | GDPg Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **1 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 0.965 | 0.943 | 0.911 | 0.959 | 0.920 | 0.863 | 0.955 | 0.939 | 0.869 | 0.894 | 0.875 | 0.843 | 37 |
| | (0.237) | (0.109) | (0.063) | (0.459) | (0.204) | (0.121) | (0.401) | (0.309) | (0.141) | (0.406) | (0.293) | (0.235) | |
| | (0.223) | (0.096) | (0.052) | (0.448) | (0.190) | (0.108) | (0.389) | (0.296) | (0.127) | (0.394) | (0.280) | (0.221) | |
| First Rev. | 0.969 | 0.946 | 0.911 | 0.968 | 0.926 | 0.862 | 0.961 | 0.944 | 0.868 | 0.915 | 0.891 | 0.856 | 37 |
| | (0.290) | (0.127) | (0.066) | (0.564) | (0.233) | (0.125) | (0.470) | (0.343) | (0.143) | (0.494) | (0.344) | (0.263) | |
| | (0.277) | (0.113) | (0.054) | (0.555) | (0.218) | (0.111) | (0.459) | (0.330) | (0.129) | (0.484) | (0.331) | (0.249) | |
| Second Rev. | 0.969 | 0.947 | 0.913 | 0.968 | 0.927 | 0.867 | 0.961 | 0.944 | 0.872 | 0.914 | 0.892 | 0.859 | 37 |
| | (0.285) | (0.129) | (0.067) | (0.556) | (0.236) | (0.128) | (0.462) | (0.339) | (0.145) | (0.488) | (0.345) | (0.268) | |
| | (0.271) | (0.116) | (0.056) | (0.547) | (0.222) | (0.114) | (0.451) | (0.326) | (0.131) | (0.477) | (0.332) | (0.254) | |

Notes. The tables report the ratio of the root-mean-square error of VAR projections for nonfarm payroll employment growth using model-based GDP growth (models 1 to 4) to the VAR projections using expenditure GDP growth. Ratios less than unity indicate model-based GDP outperforms expenditure GDP in predicting employment. The projections run from one-quarter ahead to four-quarters ahead. A set of two-sided p-values accompanies each statistic. The first is for the Harvey- Leybourne-Newbold (1997) statistic, using a truncation lag equal to the forecast step minus unity. The second is for the Diebold-Mariano (1995) statistic, using a truncation lag twice the size of the one for the HLN statistic. The HLN p-value is recorded as NA when the estimated standard error is negative for the underlying statistic. The projections are generated in real-time at the end of the first, second, and third months of the quarter following the BEA's release of the U.S. national accounts for the previous quarter. Payroll employment growth realizations are the Bureau of Labor Statistics's first, second, and third releases for quarter-over-quarter growth rates (denoted "advance", "first revision", and "second revision"). Quarterly GDP growth rates are for quarter-over-quarter growth, using the formula for continuous compounding. Quarterly employment growth is the quarter-over-quarter growth in the quarterly-average level of employment, using the formula for continuous compounding. The model-based projections are those for the diagonal variance-covariance matrix (model 1), the block-diagonal variance-covariance matrix (model 2), t he GDPplus specification, which imposes a restricted variance-covariance matrix (model 3), and the model that adds the unemployment rate (model 4). The VARs are estimated in long-horizon form, in real time on an expanding window of observations, beginning with that for 1960 Q1. Each VAR includes a constant, two quarterly lags of employment growth, and two quarterly lags of the alternative measures of GDP growth (expenditure or model-based).

**Table 3 (continued). Forecasting Nonfarm Payroll Employment Growth: 2005 – 2014 (Two and Three Quarters Ahead)**

| | GDPg Model 1 | | | GDPg Model 2 | | | GDPg Model 3 | | | GDPg Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **2 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 0.989 | 0.965 | 0.958 | 0.990 | 0.950 | 0.939 | 0.976 | 0.940 | 0.930 | 0.966 | 0.945 | 0.942 | 36 |
| | (0.221) | (0.239) | (0.269) | (0.339) | (0.243) | (0.300) | (0.144) | (0.212) | (0.267) | (0.677) | (0.488) | (0.486) | |
| | (0.194) | (0.211) | (0.241) | (0.311) | (0.215) | (0.272) | (0.119) | (0.185) | (0.239) | (0.662) | (0.465) | (0.463) | |
| First Rev. | 0.987 | 0.962 | 0.955 | 0.987 | 0.946 | 0.934 | 0.974 | 0.936 | 0.925 | 0.953 | 0.936 | 0.932 | 36 |
| | (0.163) | (0.211) | (0.243) | (0.262) | (0.215) | (0.275) | (0.111) | (0.187) | (0.238) | (0.571) | (0.426) | (0.422) | |
| | (0.137) | (0.184) | (0.215) | (0.234) | (0.187) | (0.247) | (0.088) | (0.161) | (0.210) | (0.550) | (0.400) | (0.397) | |
| Second Rev. | 0.987 | 0.962 | 0.955 | 0.987 | 0.945 | 0.934 | 0.974 | 0.935 | 0.925 | 0.956 | 0.938 | 0.934 | 36 |
| | (0.150) | (0.206) | (0.240) | (0.222) | (0.205) | (0.270) | (0.100) | (0.180) | (0.234) | (0.586) | (0.435) | (0.430) | |
| | (0.124) | (0.178) | (0.212) | (0.195) | (0.178) | (0.242) | (0.078) | (0.154) | (0.207) | (0.566) | (0.410) | (0.405) | |
| **3 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 1.004 | 0.972 | 0.977 | 1.013 | 0.979 | 0.988 | 0.995 | 0.952 | 0.964 | 0.957 | 0.946 | 0.952 | 35 |
| | (0.665) | (0.353) | (0.527) | (0.034) | (0.500) | (0.764) | (0.764) | (0.323) | (0.529) | (0.208) | (0.155) | (0.211) | |
| | (0.638) | (0.310) | (0.492) | (0.017) | (0.463) | (0.744) | (0.745) | (0.281) | (0.493) | (0.167) | (0.117) | (0.170) | |
| First Rev. | 1.003 | 0.972 | 0.975 | 1.013 | 0.980 | 0.988 | 0.994 | 0.951 | 0.962 | 0.956 | 0.946 | 0.951 | 35 |
| | (0.751) | (0.352) | (0.502) | (0.021) | (0.512) | (0.741) | (0.717) | (0.330) | (0.509) | (0.179) | (0.152) | (0.202) | |
| | (0.731) | (0.309) | (0.465) | (0.009) | (0.475) | (0.720) | (0.694) | (0.287) | (0.473) | (0.140) | (0.115) | (0.161) | |
| Second Rev. | 1.003 | 0.971 | 0.975 | 1.012 | 0.979 | 0.986 | 0.994 | 0.951 | 0.960 | 0.957 | 0.947 | 0.951 | 35 |
| | (0.781) | (0.345) | (0.487) | (0.008) | (0.497) | (0.715) | (0.703) | (0.324) | (0.495) | (0.178) | (0.153) | (0.200) | |
| | (0.763) | (0.302) | (0.450) | (0.002) | (0.459) | (0.692) | (0.679) | (0.281) | (0.458) | (0.139) | (0.116) | (0.159) | |

**Table 3 (continued). Forecasting Nonfarm Payroll Employment Growth: 2005 – 2014 (Four Quarters Ahead)**

| | GDPg Model 1 | | | GDPg Model 2 | | | GDPg Model 3 | | | GDPg Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **4 Qtr(s) Ahead** | | | | | | | | | | | | | |
| Advance Rel. | 1.007 | 0.986 | 0.983 | 1.021 | 0.999 | 0.995 | 1.009 | 0.980 | 0.980 | 0.993 | 0.976 | 0.976 | 34 |
| | (0.345) | (0.573) | (0.627) | (0.190) | (0.964) | (0.903) | (0.400) | (0.595) | (0.712) | (0.543) | (0.326) | (0.396) | |
| | (0.286) | (0.526) | (0.584) | (0.136) | (0.960) | (0.891) | (0.342) | (0.550) | (0.678) | (0.493) | (0.266) | (0.338) | |
| First Rev. | 1.009 | 0.986 | 0.981 | 1.024 | 0.999 | 0.992 | 1.011 | 0.980 | 0.976 | 0.990 | 0.974 | 0.974 | 34 |
| | (0.297) | (0.585) | (0.587) | (0.173) | (0.979) | (0.851) | (0.357) | (0.605) | (0.669) | (0.353) | (0.290) | (0.352) | |
| | (0.237) | (0.538) | (0.541) | (0.120) | (0.976) | (0.833) | (0.298) | (0.560) | (0.630) | (0.294) | (0.231) | (0.293) | |
| Second Rev. | 1.009 | 0.986 | 0.980 | 1.023 | 0.999 | 0.992 | 1.010 | 0.979 | 0.976 | 0.990 | 0.974 | 0.974 | 34 |
| | (0.304) | (0.579) | (0.582) | (0.176) | (0.968) | (0.841) | (0.367) | (0.601) | (0.664) | (0.341) | (0.286) | (0.347) | |
| | (0.245) | (0.532) | (0.535) | (0.123) | (0.964) | (0.821) | (0.308) | (0.556) | (0.625) | (0.282) | (0.226) | (0.288) | |

**Table 4. Convexity or Complexity? Forecasting Nonfarm Payroll Employment Growth: 2005 – 2014 (One Quarter Ahead)**

| | GDPgMod1 | | | GDPgMod2 | | | GDPgMod3 | | | GDPgMod4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **1 Qtr(s) Ahead** | | | | | | | | | | | | | |
| **GDPe Weight: 25 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 1.003 | 0.991 | 0.982 | 0.996 | 0.967 | 0.930 | 0.991 | 0.987 | 0.937 | 0.929 | 0.919 | 0.909 | 37 |
| | (0.846) | (0.262) | (0.089) | (0.913) | (0.376) | (0.212) | (0.799) | (0.704) | (0.264) | (0.503) | (0.417) | (0.403) | |
| | (0.843) | (0.248) | (0.077) | (0.912) | (0.364) | (0.198) | (0.794) | (0.698) | (0.250) | (0.493) | (0.405) | (0.391) | |
| First Rev. | 1.005 | 0.993 | 0.982 | 1.004 | 0.972 | 0.930 | 0.997 | 0.991 | 0.937 | 0.949 | 0.936 | 0.923 | 37 |
| | (0.699) | (0.426) | (0.097) | (0.901) | (0.448) | (0.218) | (0.929) | (0.794) | (0.267) | (0.627) | (0.499) | (0.467) | |
| | (0.693) | (0.414) | (0.085) | (0.899) | (0.437) | (0.204) | (0.928) | (0.790) | (0.253) | (0.620) | (0.489) | (0.456) | |
| Second Rev. | 1.005 | 0.994 | 0.983 | 1.004 | 0.973 | 0.933 | 0.996 | 0.990 | 0.939 | 0.948 | 0.936 | 0.925 | 37 |
| | (0.733) | (0.423) | (0.099) | (0.917) | (0.452) | (0.224) | (0.911) | (0.776) | (0.269) | (0.615) | (0.498) | (0.471) | |
| | (0.727) | (0.411) | (0.086) | (0.915) | (0.441) | (0.210) | (0.909) | (0.771) | (0.255) | (0.607) | (0.488) | (0.460) | |
| **GDPe Weight: 50 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 0.990 | 0.979 | 0.957 | 0.984 | 0.955 | 0.907 | 0.979 | 0.974 | 0.913 | 0.917 | 0.908 | 0.885 | 37 |
| | (0.503) | (0.213) | (0.091) | (0.696) | (0.328) | (0.177) | (0.606) | (0.557) | (0.212) | (0.472) | (0.388) | (0.334) | |
| | (0.493) | (0.199) | (0.078) | (0.690) | (0.314) | (0.162) | (0.598) | (0.548) | (0.198) | (0.462) | (0.376) | (0.321) | |
| First Rev. | 0.993 | 0.980 | 0.956 | 0.992 | 0.959 | 0.905 | 0.984 | 0.978 | 0.912 | 0.937 | 0.923 | 0.899 | 37 |
| | (0.630) | (0.253) | (0.090) | (0.846) | (0.372) | (0.178) | (0.705) | (0.612) | (0.211) | (0.579) | (0.456) | (0.377) | |
| | (0.622) | (0.239) | (0.077) | (0.843) | (0.359) | (0.164) | (0.699) | (0.603) | (0.197) | (0.571) | (0.445) | (0.365) | |
| Second Rev. | 0.992 | 0.981 | 0.958 | 0.991 | 0.960 | 0.909 | 0.984 | 0.978 | 0.915 | 0.936 | 0.924 | 0.901 | 37 |
| | (0.613) | (0.255) | (0.092) | (0.835) | (0.376) | (0.183) | (0.693) | (0.600) | (0.214) | (0.570) | (0.456) | (0.383) | |
| | (0.604) | (0.241) | (0.080) | (0.832) | (0.363) | (0.169) | (0.687) | (0.591) | (0.200) | (0.561) | (0.445) | (0.370) | |
| **GDPe Weight: 75 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 0.976 | 0.960 | 0.931 | 0.970 | 0.937 | 0.882 | 0.965 | 0.956 | 0.889 | 0.904 | 0.891 | 0.862 | 37 |
| | (0.299) | (0.151) | (0.076) | (0.544) | (0.258) | (0.145) | (0.474) | (0.409) | (0.170) | (0.436) | (0.339) | (0.276) | |
| | (0.285) | (0.137) | (0.064) | (0.534) | (0.244) | (0.130) | (0.463) | (0.397) | (0.155) | (0.424) | (0.326) | (0.262) | |
| First Rev. | 0.979 | 0.963 | 0.930 | 0.978 | 0.942 | 0.881 | 0.971 | 0.960 | 0.887 | 0.924 | 0.907 | 0.875 | 37 |
| | (0.367) | (0.172) | (0.077) | (0.663) | (0.290) | (0.147) | (0.552) | (0.448) | (0.170) | (0.530) | (0.396) | (0.308) | |
| | (0.354) | (0.158) | (0.065) | (0.656) | (0.276) | (0.133) | (0.543) | (0.437) | (0.155) | (0.520) | (0.383) | (0.294) | |
| Second Rev. | 0.979 | 0.963 | 0.933 | 0.978 | 0.943 | 0.885 | 0.971 | 0.960 | 0.891 | 0.924 | 0.907 | 0.877 | 37 |
| | (0.359) | (0.175) | (0.079) | (0.655) | (0.294) | (0.150) | (0.543) | (0.441) | (0.172) | (0.523) | (0.396) | (0.313) | |
| | (0.346) | (0.160) | (0.067) | (0.648) | (0.280) | (0.136) | (0.534) | (0.430) | (0.158) | (0.513) | (0.384) | (0.300) | |

Notes. The table reports the ratio of the root-mean-square error of VAR projections for nonfarm payroll employment growth using model-based GDP growth (models 1 – 4) to the root-mean-square error using GDP growth constructed as a convex combination of expenditure real GDP growth and income real GDP growth. The weights on expenditure GDP in the convex combination run from 0.25 to 0.75. The VARs are estimated in long-horizon form, in real time on an expanding window of observations, beginning with that for 1960 Q1. Each VAR includes a constant, two quarterly lags of employment growth, and two quarterly lags of the alternative measures of GDP growth (expenditure or model-based). Ratios less than unity indicate the projections using model-based GDP are more accurate than those using GDP constructed from the convex combination. Alternative two-sided p-values for the test of equal forecast accuracy accompany each ratio. The notes for table 3 provide additional details.

## Table 4 (continued). Convexity or Complexity? Forecasting Nonfarm Payroll Employment Growth: 2005 – 2014 (Two Quarters Ahead)

| | GDPgMod1 | | | GDPgMod2 | | | GDPgMod3 | | | GDPgMod4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **2 Qtr(s) Ahead** | | | | | | | | | | | | | |
| **GDPe Weight: 25 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 1.001 | 0.995 | 0.993 | 1.002 | 0.979 | 0.973 | 0.988 | 0.969 | 0.965 | 0.978 | 0.974 | 0.976 | 36 |
| | (0.921) | (0.133) | (0.139) | (0.914) | (0.355) | (0.390) | (0.444) | (0.150) | (0.234) | (0.764) | (0.663) | (0.678) | |
| | (0.917) | (0.109) | (0.114) | (0.910) | (0.328) | (0.363) | (0.419) | (0.124) | (0.206) | (0.752) | (0.646) | (0.662) | |
| First Rev. | 1.000 | 0.995 | 0.993 | 1.000 | 0.978 | 0.972 | 0.986 | 0.967 | 0.962 | 0.966 | 0.967 | 0.969 | 36 |
| | (0.998) | (0.135) | (0.150) | (0.991) | (0.329) | (0.373) | (0.372) | (0.134) | (0.209) | (0.642) | (0.585) | (0.593) | |
| | (0.998) | (0.110) | (0.124) | (0.991) | (0.302) | (0.347) | (0.345) | (0.109) | (0.182) | (0.624) | (0.565) | (0.574) | |
| Second Rev. | 1.000 | 0.995 | 0.993 | 1.000 | 0.977 | 0.972 | 0.986 | 0.967 | 0.962 | 0.968 | 0.970 | 0.971 | 36 |
| | (0.986) | (0.124) | (0.145) | (0.997) | (0.320) | (0.368) | (0.355) | (0.124) | (0.204) | (0.663) | (0.607) | (0.614) | |
| | (0.985) | (0.100) | (0.120) | (0.996) | (0.293) | (0.341) | (0.328) | (0.100) | (0.177) | (0.647) | (0.588) | (0.596) | |
| **GDPe Weight: 50 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 0.995 | 0.984 | 0.980 | 0.996 | 0.969 | 0.961 | 0.983 | 0.958 | 0.952 | 0.972 | 0.964 | 0.964 | 36 |
| | (0.563) | (0.165) | (0.218) | (0.791) | (0.259) | (0.326) | (0.232) | (0.173) | (0.247) | (0.719) | (0.580) | (0.584) | |
| | (0.542) | (0.139) | (0.191) | (0.780) | (0.231) | (0.298) | (0.204) | (0.146) | (0.219) | (0.705) | (0.560) | (0.564) | |
| First Rev. | 0.994 | 0.983 | 0.980 | 0.994 | 0.966 | 0.958 | 0.981 | 0.956 | 0.949 | 0.960 | 0.956 | 0.956 | 36 |
| | (0.479) | (0.152) | (0.207) | (0.686) | (0.237) | (0.308) | (0.183) | (0.155) | (0.223) | (0.606) | (0.511) | (0.511) | |
| | (0.455) | (0.126) | (0.179) | (0.670) | (0.210) | (0.280) | (0.156) | (0.130) | (0.195) | (0.587) | (0.488) | (0.488) | |
| Second Rev. | 0.994 | 0.983 | 0.980 | 0.994 | 0.966 | 0.958 | 0.981 | 0.956 | 0.949 | 0.963 | 0.958 | 0.958 | 36 |
| | (0.455) | (0.145) | (0.203) | (0.680) | (0.227) | (0.303) | (0.169) | (0.147) | (0.219) | (0.625) | (0.527) | (0.526) | |
| | (0.431) | (0.120) | (0.176) | (0.664) | (0.199) | (0.275) | (0.143) | (0.122) | (0.191) | (0.607) | (0.505) | (0.504) | |
| **GDPe Weight: 75 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 0.991 | 0.973 | 0.968 | 0.992 | 0.958 | 0.949 | 0.978 | 0.948 | 0.940 | 0.968 | 0.953 | 0.952 | 36 |
| | (0.262) | (0.214) | (0.254) | (0.498) | (0.241) | (0.307) | (0.154) | (0.195) | (0.259) | (0.688) | (0.522) | (0.523) | |
| | (0.234) | (0.186) | (0.226) | (0.475) | (0.213) | (0.279) | (0.128) | (0.168) | (0.231) | (0.673) | (0.500) | (0.501) | |
| First Rev. | 0.990 | 0.972 | 0.966 | 0.989 | 0.955 | 0.945 | 0.976 | 0.945 | 0.936 | 0.956 | 0.945 | 0.943 | 36 |
| | (0.198) | (0.193) | (0.234) | (0.403) | (0.217) | (0.285) | (0.119) | (0.175) | (0.233) | (0.581) | (0.458) | (0.457) | |
| | (0.171) | (0.166) | (0.206) | (0.377) | (0.189) | (0.258) | (0.096) | (0.148) | (0.206) | (0.561) | (0.434) | (0.432) | |
| Second Rev. | 0.989 | 0.972 | 0.966 | 0.990 | 0.955 | 0.945 | 0.976 | 0.945 | 0.936 | 0.958 | 0.947 | 0.945 | 36 |
| | (0.183) | (0.187) | (0.231) | (0.378) | (0.207) | (0.280) | (0.108) | (0.167) | (0.230) | (0.598) | (0.470) | (0.467) | |
| | (0.157) | (0.160) | (0.204) | (0.351) | (0.180) | (0.252) | (0.085) | (0.141) | (0.202) | (0.579) | (0.446) | (0.443) | |

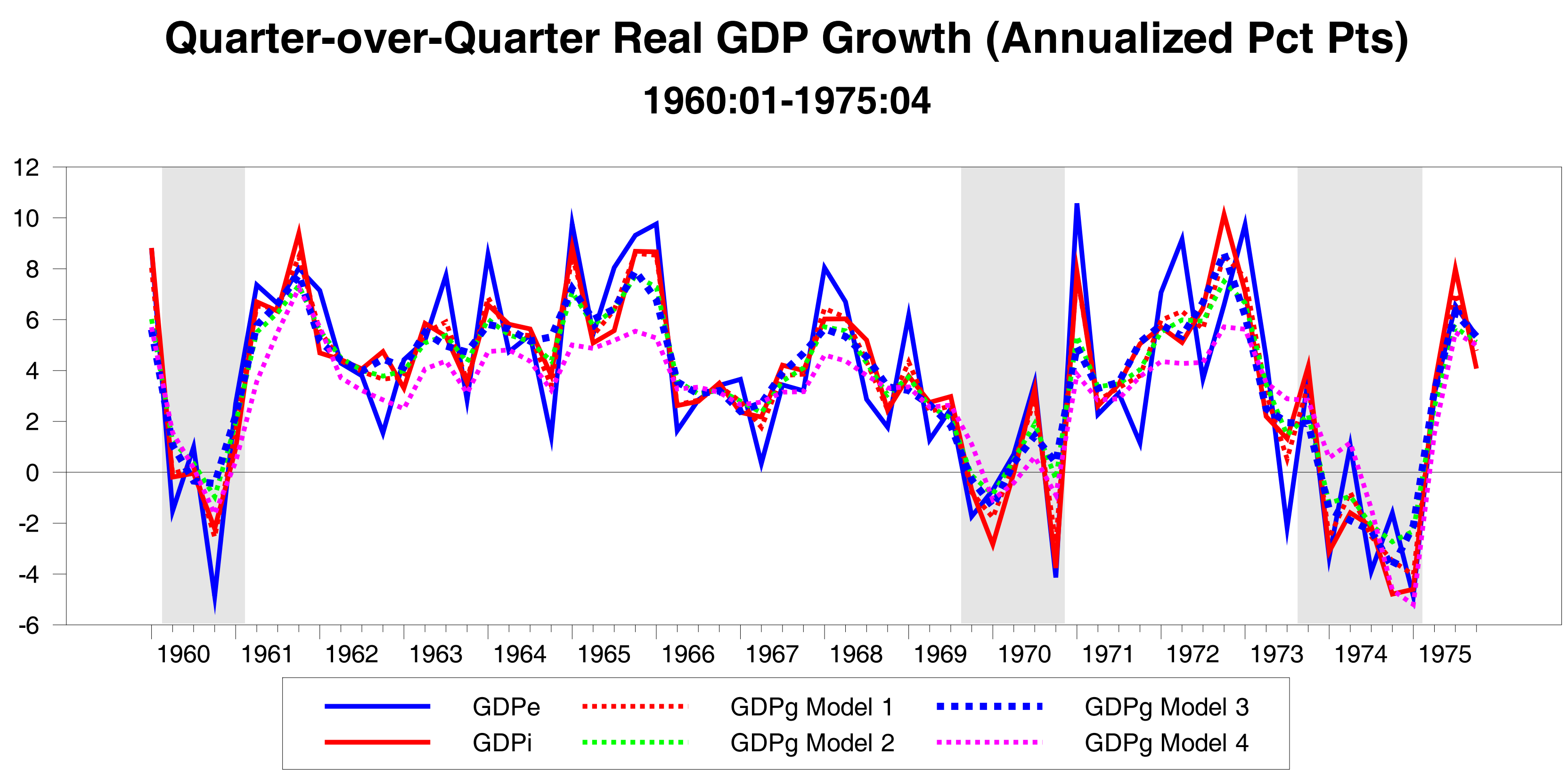
**Table 4 (continued). Convexity or Complexity? Forecasting Nonfarm Payroll Employment Growth: 2005 – 2014 (Three Quarters Ahead)**

| | GDPgMod1 | | | GDPgMod2 | | | GDPgMod3 | | | GDPgMod4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | 1st Mth | 2nd Mth | 3rd Mth | Nobs |
| **3 Qtr(s) Ahead** | | | | | | | | | | | | | |
| **GDPe Weight: 25 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 1.000 | 1.000 | 1.001 | 1.009 | 1.007 | 1.012 | 0.991 | 0.979 | 0.987 | 0.953 | 0.973 | 0.975 | 35 |
| | (NA) | (0.934) | (0.736) | (0.269) | (0.466) | (0.200) | (0.273) | (0.274) | (0.593) | (0.144) | (0.212) | (0.168) | |
| | (0.928) | (0.928) | (0.715) | (0.226) | (0.428) | (0.159) | (0.230) | (0.231) | (0.561) | (0.107) | (0.171) | (0.129) | |
| First Rev. | 1.000 | 1.000 | 1.001 | 1.010 | 1.009 | 1.014 | 0.991 | 0.980 | 0.987 | 0.953 | 0.974 | 0.976 | 35 |
| | (NA) | (0.906) | (0.639) | (0.262) | (0.145) | (0.009) | (0.345) | (0.307) | (0.589) | (0.123) | (0.205) | (0.171) | |
| | (0.944) | (0.898) | (0.610) | (0.220) | (0.109) | (0.003) | (0.302) | (0.264) | (0.557) | (0.088) | (0.164) | (0.132) | |
| Second Rev. | 1.000 | 1.000 | 1.001 | 1.009 | 1.009 | 1.013 | 0.991 | 0.979 | 0.986 | 0.954 | 0.975 | 0.977 | 35 |
| | (NA) | (0.879) | (0.650) | (0.249) | (0.133) | (0.001) | (0.346) | (0.306) | (0.574) | (0.122) | (0.220) | (0.188) | |
| | (0.950) | (0.869) | (0.622) | (0.207) | (0.097) | (0.000) | (0.303) | (0.263) | (0.540) | (0.087) | (0.178) | (0.148) | |
| **GDPe Weight: 50 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 0.999 | 0.989 | 0.992 | 1.009 | 0.996 | 1.003 | 0.991 | 0.968 | 0.978 | 0.953 | 0.963 | 0.966 | 35 |
| | (0.900) | (0.293) | (0.542) | (0.183) | (0.758) | (0.878) | (0.414) | (0.284) | (0.537) | (0.159) | (0.125) | (0.115) | |
| | (0.891) | (0.250) | (0.507) | (0.143) | (0.738) | (0.867) | (0.373) | (0.241) | (0.501) | (0.121) | (0.090) | (0.082) | |
| First Rev. | 0.999 | 0.989 | 0.991 | 1.009 | 0.998 | 1.003 | 0.990 | 0.968 | 0.977 | 0.952 | 0.963 | 0.966 | 35 |
| | (0.875) | (0.311) | (0.525) | (0.194) | (0.838) | (0.840) | (0.436) | (0.302) | (0.525) | (0.136) | (0.118) | (0.108) | |
| | (0.864) | (0.268) | (0.489) | (0.154) | (0.824) | (0.827) | (0.396) | (0.259) | (0.489) | (0.100) | (0.084) | (0.076) | |
| Second Rev. | 0.999 | 0.989 | 0.991 | 1.009 | 0.997 | 1.003 | 0.990 | 0.968 | 0.976 | 0.953 | 0.964 | 0.967 | 35 |
| | (0.869) | (0.311) | (0.512) | (0.176) | (0.816) | (0.870) | (0.437) | (0.300) | (0.511) | (0.134) | (0.122) | (0.112) | |
| | (0.858) | (0.268) | (0.475) | (0.137) | (0.801) | (0.859) | (0.397) | (0.257) | (0.475) | (0.099) | (0.087) | (0.079) | |
| **GDPe Weight: 75 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 1.001 | 0.979 | 0.984 | 1.011 | 0.986 | 0.995 | 0.993 | 0.959 | 0.970 | 0.955 | 0.953 | 0.958 | 35 |
| | (0.865) | (0.327) | (0.525) | (0.096) | (0.545) | (0.856) | (0.588) | (0.304) | (0.528) | (0.182) | (0.131) | (0.162) | |
| | (0.853) | (0.284) | (0.489) | (0.065) | (0.510) | (0.843) | (0.556) | (0.261) | (0.492) | (0.142) | (0.096) | (0.123) | |
| First Rev. | 1.001 | 0.979 | 0.982 | 1.011 | 0.988 | 0.994 | 0.992 | 0.959 | 0.968 | 0.954 | 0.953 | 0.958 | 35 |
| | (0.939) | (0.331) | (0.503) | (0.096) | (0.569) | (0.843) | (0.570) | (0.315) | (0.512) | (0.156) | (0.127) | (0.154) | |
| | (0.934) | (0.288) | (0.466) | (0.065) | (0.535) | (0.830) | (0.537) | (0.272) | (0.475) | (0.118) | (0.092) | (0.116) | |
| Second Rev. | 1.000 | 0.979 | 0.982 | 1.010 | 0.987 | 0.993 | 0.991 | 0.958 | 0.967 | 0.954 | 0.954 | 0.958 | 35 |
| | (0.958) | (0.327) | (0.489) | (0.074) | (0.553) | (0.815) | (0.565) | (0.311) | (0.498) | (0.155) | (0.129) | (0.154) | |
| | (0.954) | (0.284) | (0.451) | (0.047) | (0.518) | (0.799) | (0.531) | (0.268) | (0.461) | (0.117) | (0.094) | (0.117) | |

**Table 4 (continued). Convexity or Complexity? Forecasting Nonfarm Payroll Employment Growth: 2005 – 2014 (Four Quarters Ahead)**

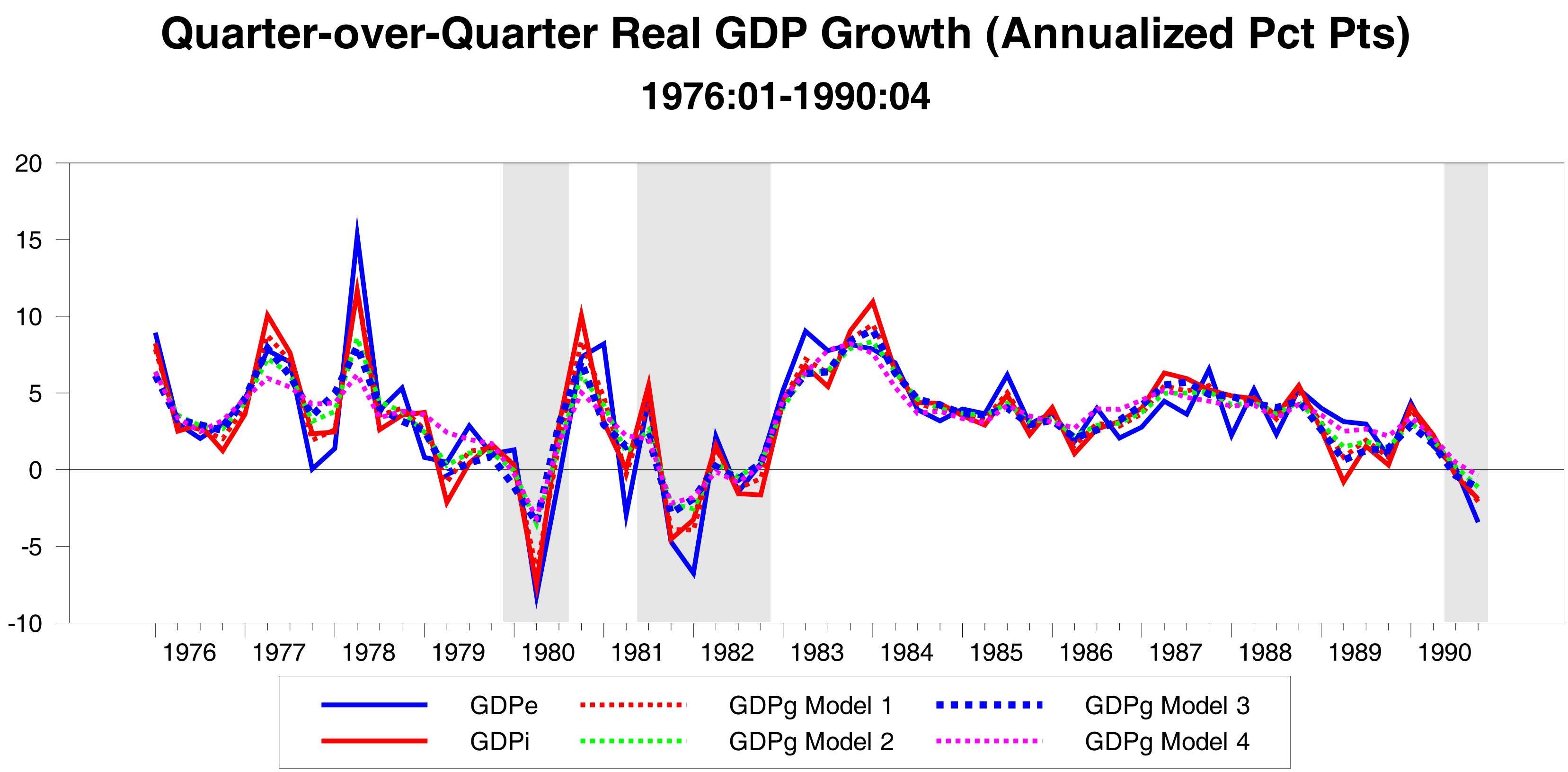
| | GDPgMod1 | | | GDPgMod2 | | | GDPgMod3 | | | GDPgMod4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1st Mth** | **2nd Mth** | **3rd Mth** | **1st Mth** | **2nd Mth** | **3rd Mth** | **1st Mth** | **2nd Mth** | **3rd Mth** | **1st Mth** | **2nd Mth** | **3rd Mth** | **Nobs** |
| **4 Qtr(s) Ahead** | | | | | | | | | | | | | |
| **GDPe Weight: 25 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 1.008 | 1.002 | 1.002 | 1.022 | 1.015 | 1.014 | 1.009 | 0.996 | 0.998 | 0.993 | 0.992 | 0.995 | 34 |
| | (0.378) | (0.469) | (0.413) | (0.113) | (0.019) | (0.157) | (0.402) | (0.744) | (0.944) | (0.730) | (NA) | (NA) | |
| | (0.319) | (0.414) | (0.355) | (0.069) | (0.006) | (0.106) | (0.344) | (0.714) | (0.937) | (0.698) | (0.515) | (0.731) | |
| First Rev. | 1.007 | 1.003 | 1.002 | 1.023 | 1.016 | 1.014 | 1.009 | 0.997 | 0.997 | 0.988 | 0.991 | 0.995 | 34 |
| | (0.394) | (0.285) | (0.407) | (0.105) | (0.011) | (0.137) | (0.411) | (0.801) | (0.894) | (0.562) | (NA) | (NA) | |
| | (0.335) | (0.226) | (0.349) | (0.063) | (0.003) | (0.090) | (0.353) | (0.777) | (0.881) | (0.514) | (0.454) | (0.740) | |
| Second Rev. | 1.007 | 1.003 | 1.002 | 1.022 | 1.016 | 1.013 | 1.009 | 0.996 | 0.997 | 0.988 | 0.991 | 0.995 | 34 |
| | (0.414) | (0.283) | (0.416) | (0.107) | (0.008) | (0.136) | (0.429) | (0.796) | (0.886) | (0.555) | (NA) | (NA) | |
| | (0.357) | (0.224) | (0.358) | (0.064) | (0.002) | (0.089) | (0.372) | (0.771) | (0.872) | (0.507) | (0.442) | (0.731) | |
| **GDPe Weight: 50 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 1.008 | 0.997 | 0.996 | 1.022 | 1.009 | 1.008 | 1.010 | 0.990 | 0.992 | 0.993 | 0.986 | 0.989 | 34 |
| | (0.207) | (0.608) | (0.724) | (0.100) | (0.280) | (0.668) | (0.304) | (0.626) | (0.816) | (0.666) | (NA) | (NA) | |
| | (0.151) | (0.563) | (0.691) | (0.059) | (0.221) | (0.629) | (0.245) | (0.584) | (0.794) | (0.628) | (0.295) | (0.377) | |
| First Rev. | 1.008 | 0.997 | 0.995 | 1.023 | 1.010 | 1.007 | 1.010 | 0.990 | 0.990 | 0.989 | 0.985 | 0.988 | 34 |
| | (0.215) | (0.683) | (0.673) | (0.099) | (0.255) | (0.720) | (0.313) | (0.654) | (0.766) | (0.466) | (NA) | (NA) | |
| | (0.159) | (0.646) | (0.635) | (0.059) | (0.197) | (0.687) | (0.254) | (0.614) | (0.738) | (0.411) | (0.228) | (0.315) | |
| Second Rev. | 1.008 | 0.997 | 0.994 | 1.023 | 1.010 | 1.006 | 1.010 | 0.990 | 0.990 | 0.989 | 0.985 | 0.988 | 34 |
| | (0.227) | (0.676) | (0.666) | (0.101) | (0.251) | (0.734) | (0.325) | (0.652) | (0.760) | (0.459) | (NA) | (NA) | |
| | (0.169) | (0.638) | (0.627) | (0.060) | (0.193) | (0.702) | (0.266) | (0.611) | (0.731) | (0.404) | (0.217) | (0.302) | |
| **GDPe Weight: 75 Percent** | | | | | | | | | | | | | |
| Advance Rel. | 1.008 | 0.991 | 0.989 | 1.022 | 1.004 | 1.001 | 1.010 | 0.984 | 0.986 | 0.993 | 0.981 | 0.983 | 34 |
| | (0.188) | (0.567) | (0.657) | (0.131) | (0.827) | (0.962) | (0.306) | (0.599) | (0.752) | (0.570) | (0.181) | (0.248) | |
| | (0.134) | (0.520) | (0.617) | (0.084) | (0.806) | (0.957) | (0.246) | (0.554) | (0.722) | (0.523) | (0.128) | (0.190) | |
| First Rev. | 1.009 | 0.991 | 0.987 | 1.024 | 1.004 | 0.999 | 1.010 | 0.985 | 0.983 | 0.990 | 0.979 | 0.981 | 34 |
| | (0.188) | (0.590) | (0.612) | (0.128) | (0.805) | (0.980) | (0.301) | (0.614) | (0.704) | (0.350) | (0.127) | (0.185) | |
| | (0.134) | (0.545) | (0.568) | (0.082) | (0.781) | (0.977) | (0.241) | (0.570) | (0.670) | (0.291) | (0.081) | (0.131) | |
| Second Rev. | 1.008 | 0.991 | 0.987 | 1.023 | 1.004 | 0.999 | 1.010 | 0.984 | 0.982 | 0.989 | 0.979 | 0.981 | 34 |
| | (0.193) | (0.585) | (0.606) | (0.130) | (0.815) | (0.968) | (0.309) | (0.611) | (0.699) | (0.341) | (0.124) | (0.182) | |
| | (0.139) | (0.539) | (0.562) | (0.083) | (0.792) | (0.964) | (0.250) | (0.567) | (0.664) | (0.282) | (0.078) | (0.128) | |

**Figure 1.**



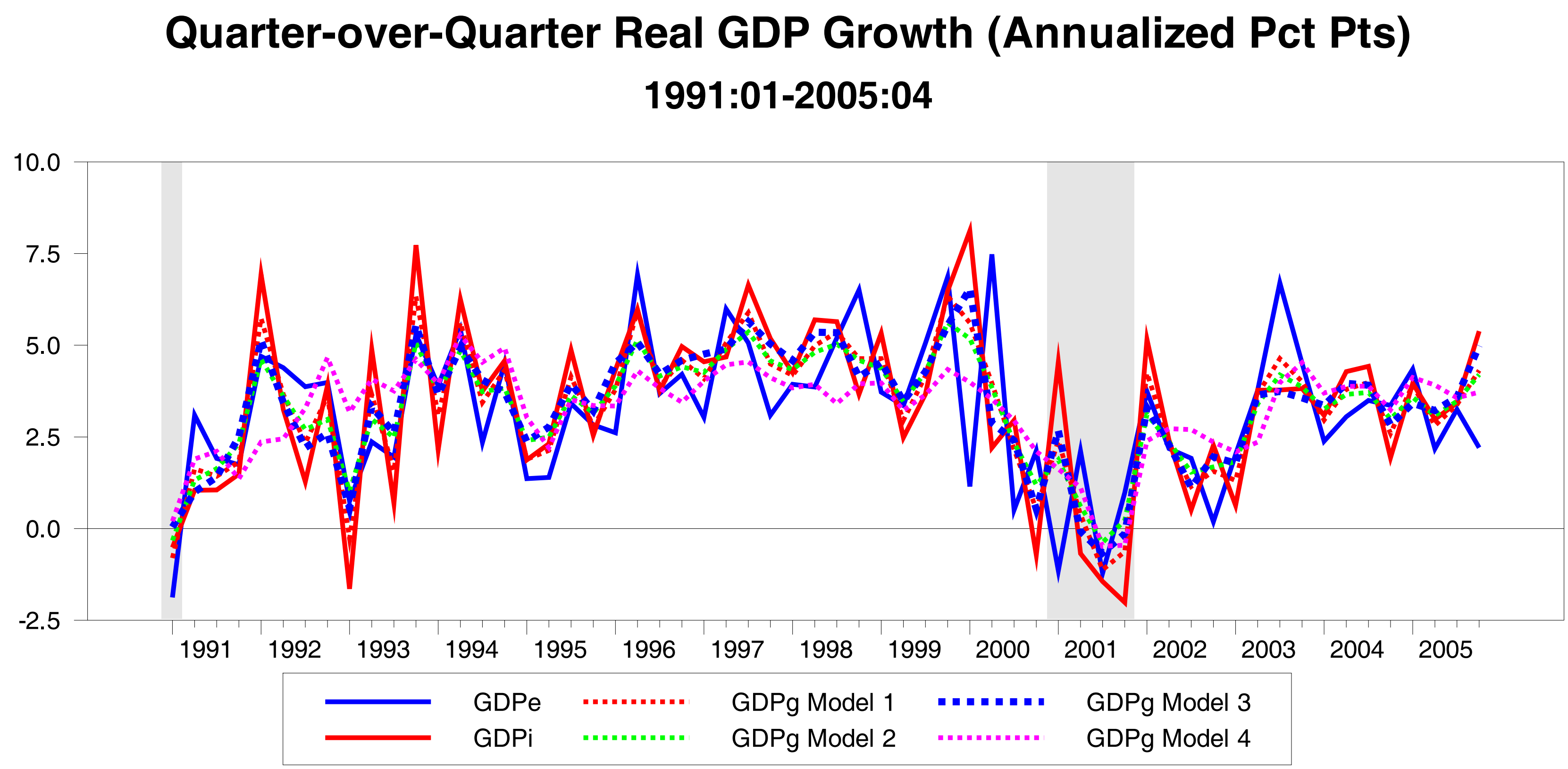

The plot shows real GDP (measured as expenditure and income) and four model-based Kalman smoothed estimates. Shading shows recessions.

**Figure 2.**



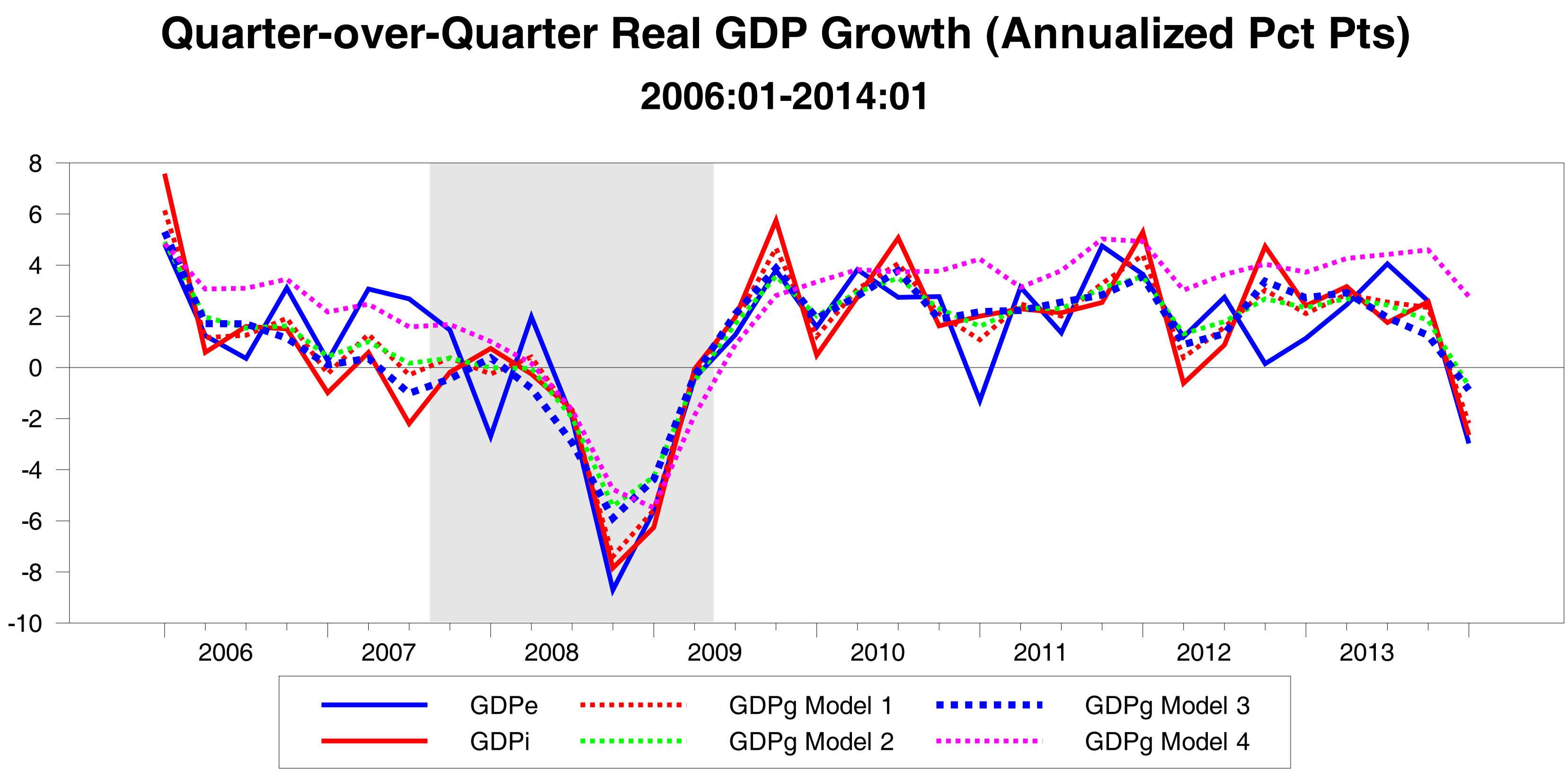

The plot shows real GDP (measured as expenditure and income) and four model-based Kalman smoothed estimates. Shading shows recessions.

**Figure 3.**



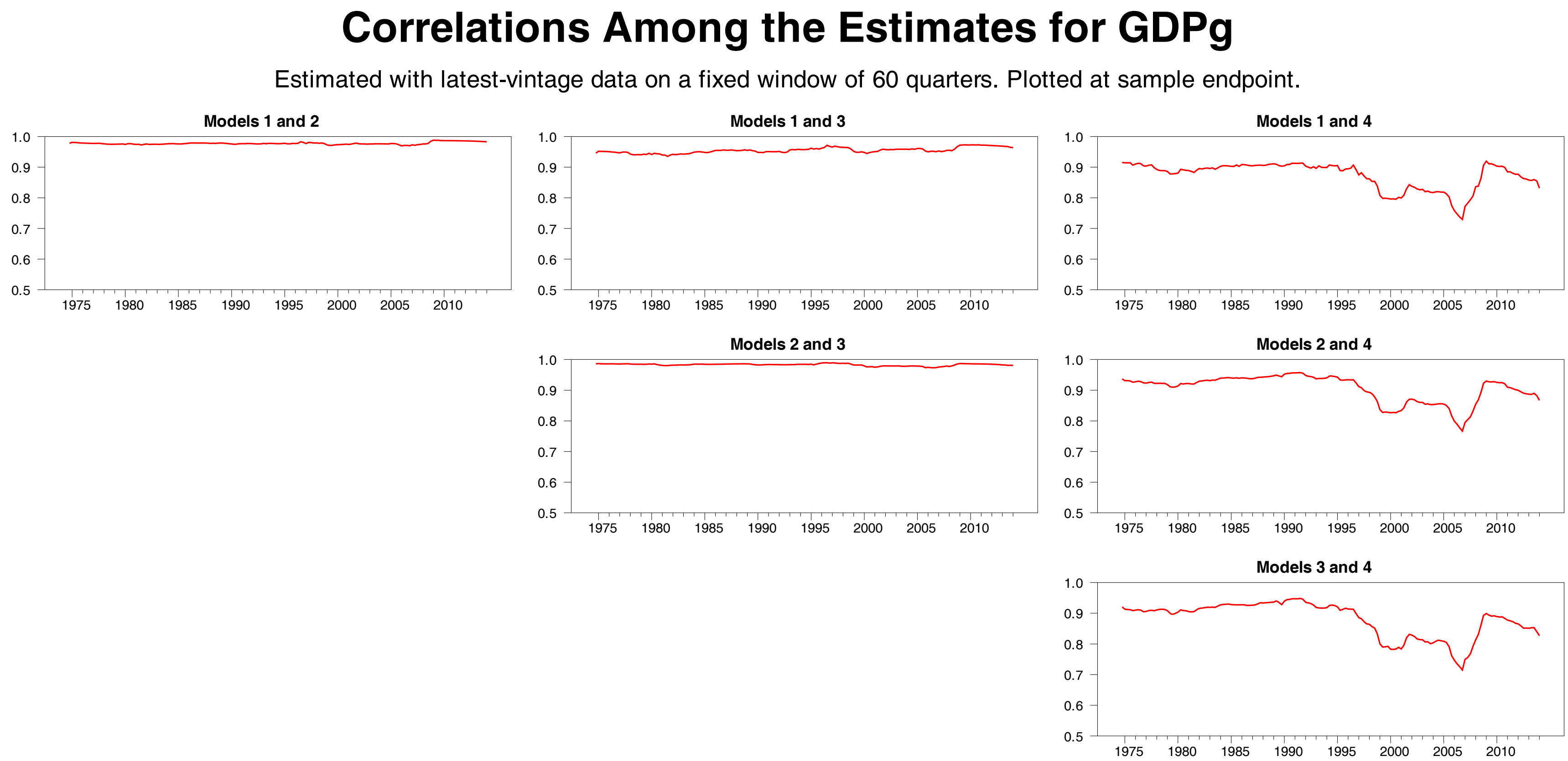

The plot shows real GDP (measured as expenditure and income) and four model-based Kalman smoothed estimates. Shading shows recessions.

**Figure 4.**



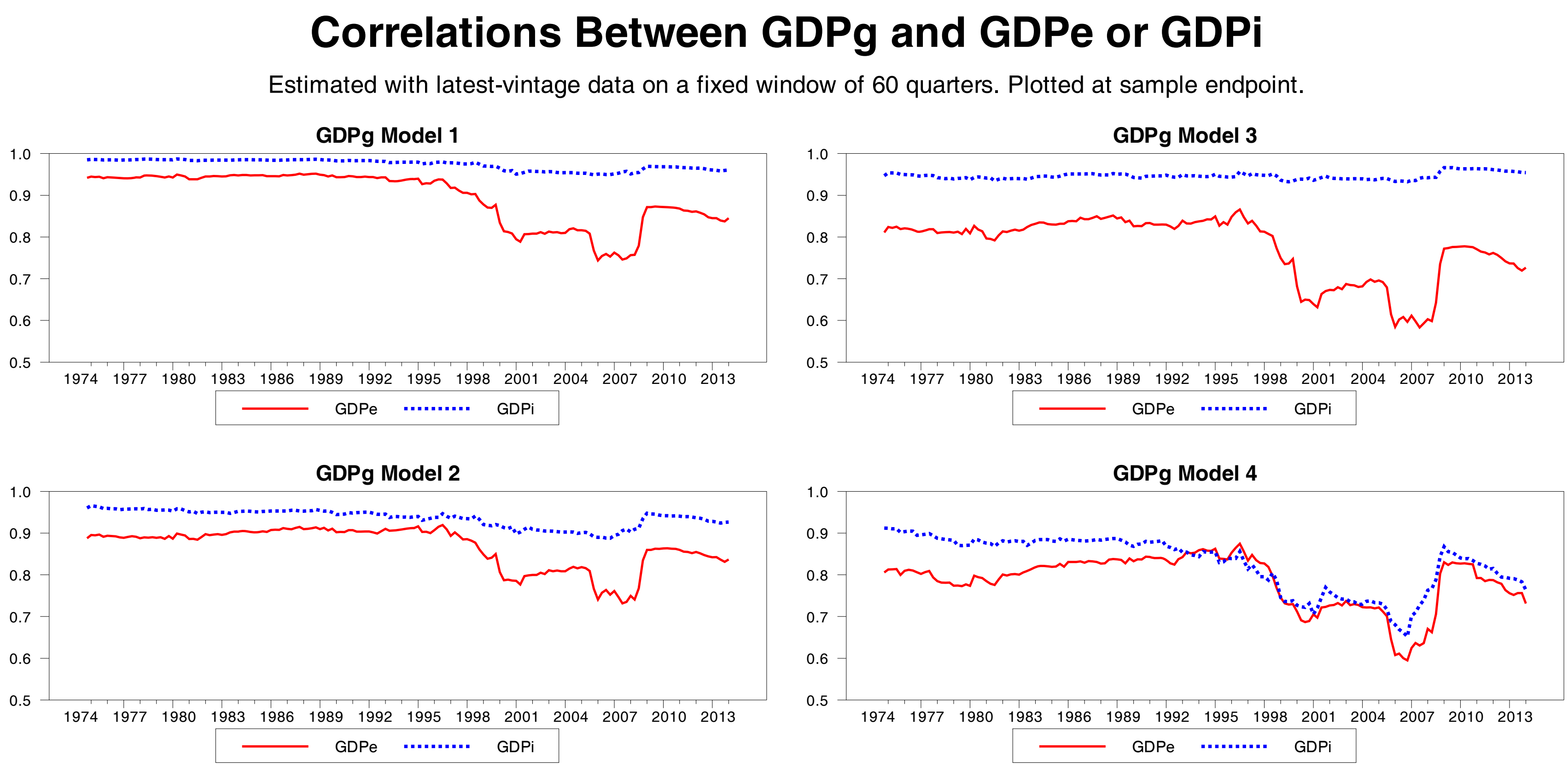

The plot shows real GDP (measured as expenditure and income) and four model-based Kalman smoothed estimates. Shading shows recessions.

**Figure 5.**



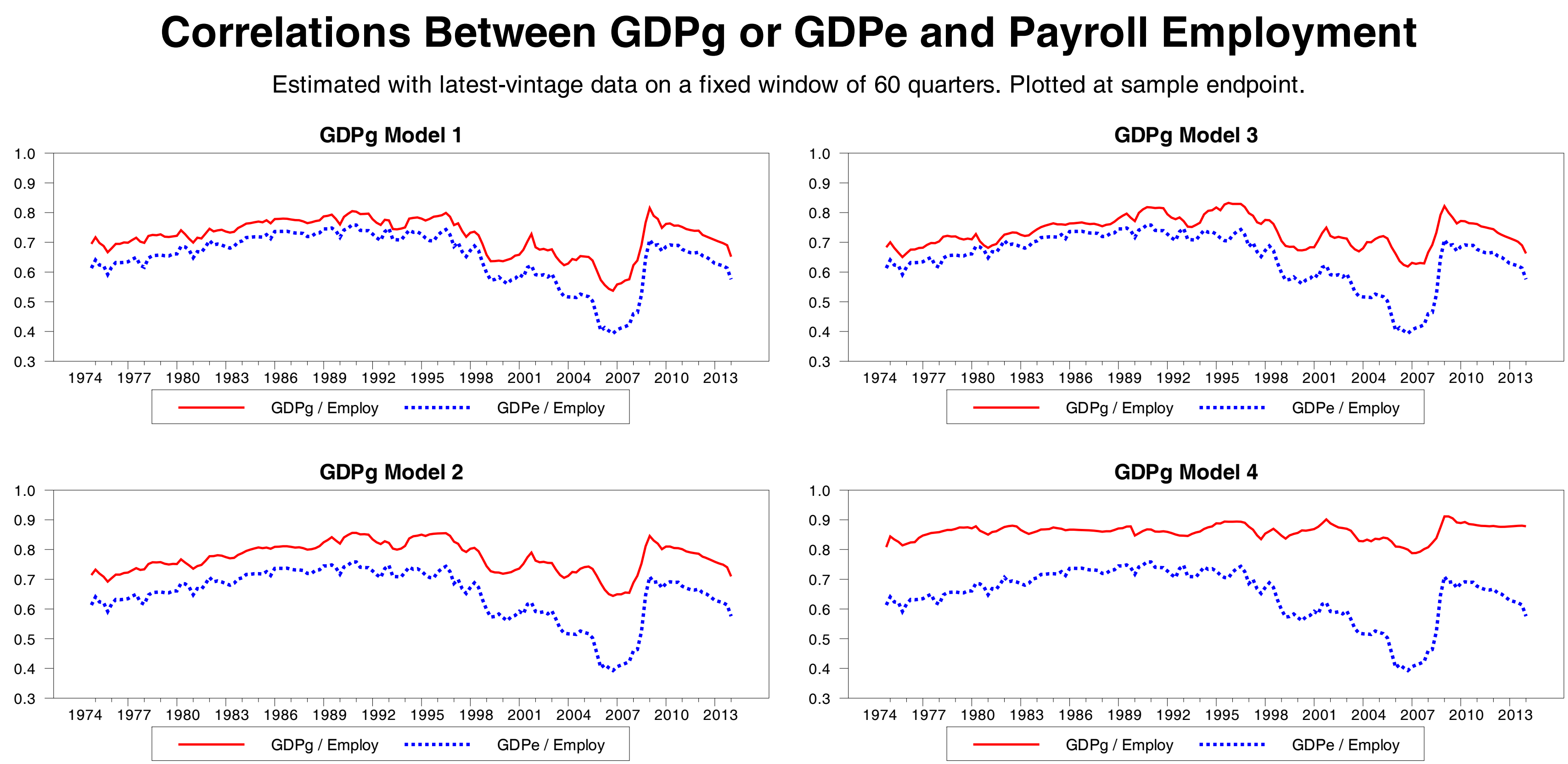

The panels show rolling contemporaneous correlations between model estimates for real GDP growth.

**Figure 6.**



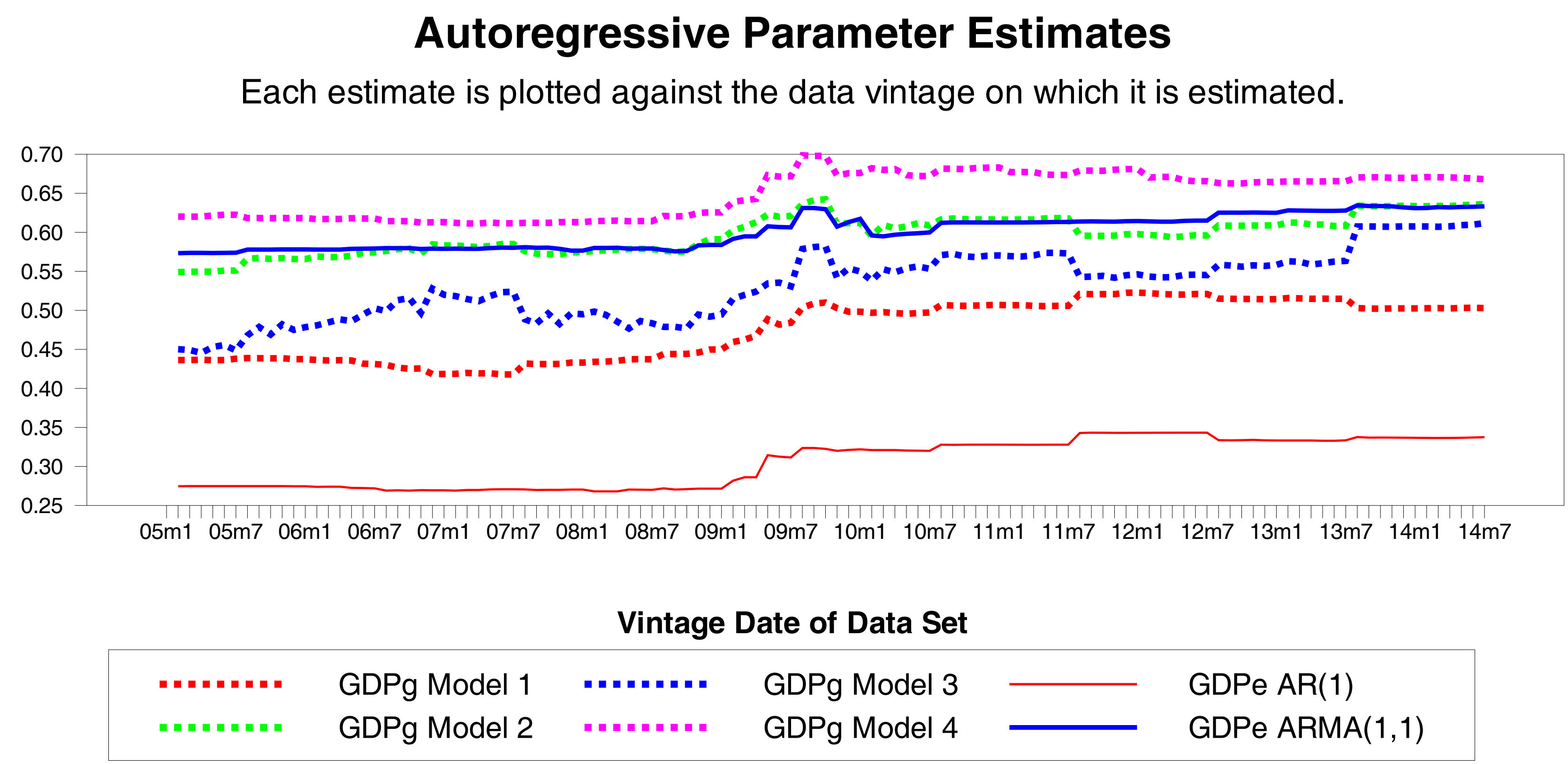

The panels show rolling contemporaneous correlations between model-estimated GDP growth and expenditure or income GDP growth.

**Figure 7.**



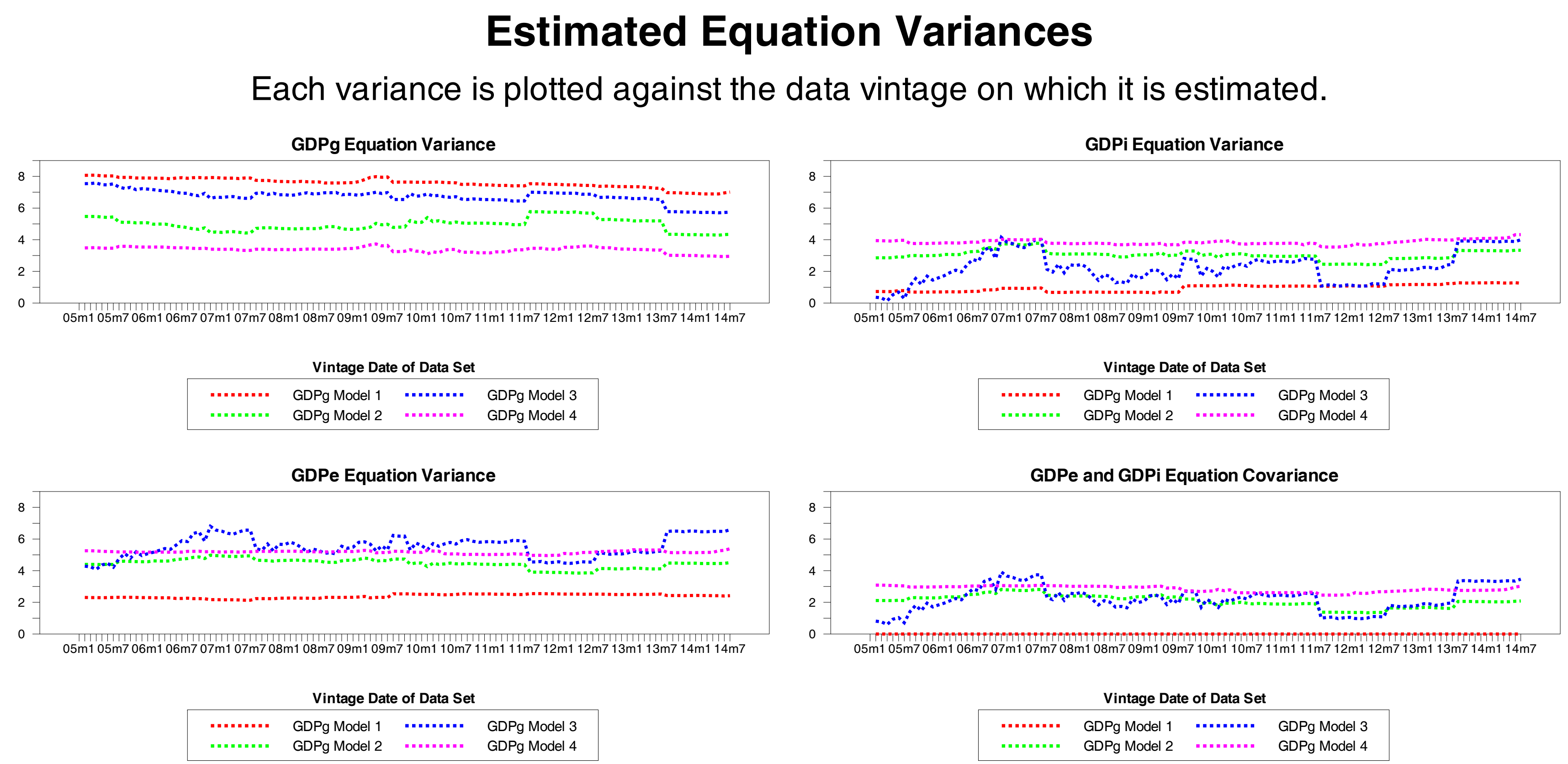

The panels show rolling contemporaneous correlations between model-estimated or expenditure GDP growth and employment growth.

**Figure 8.**



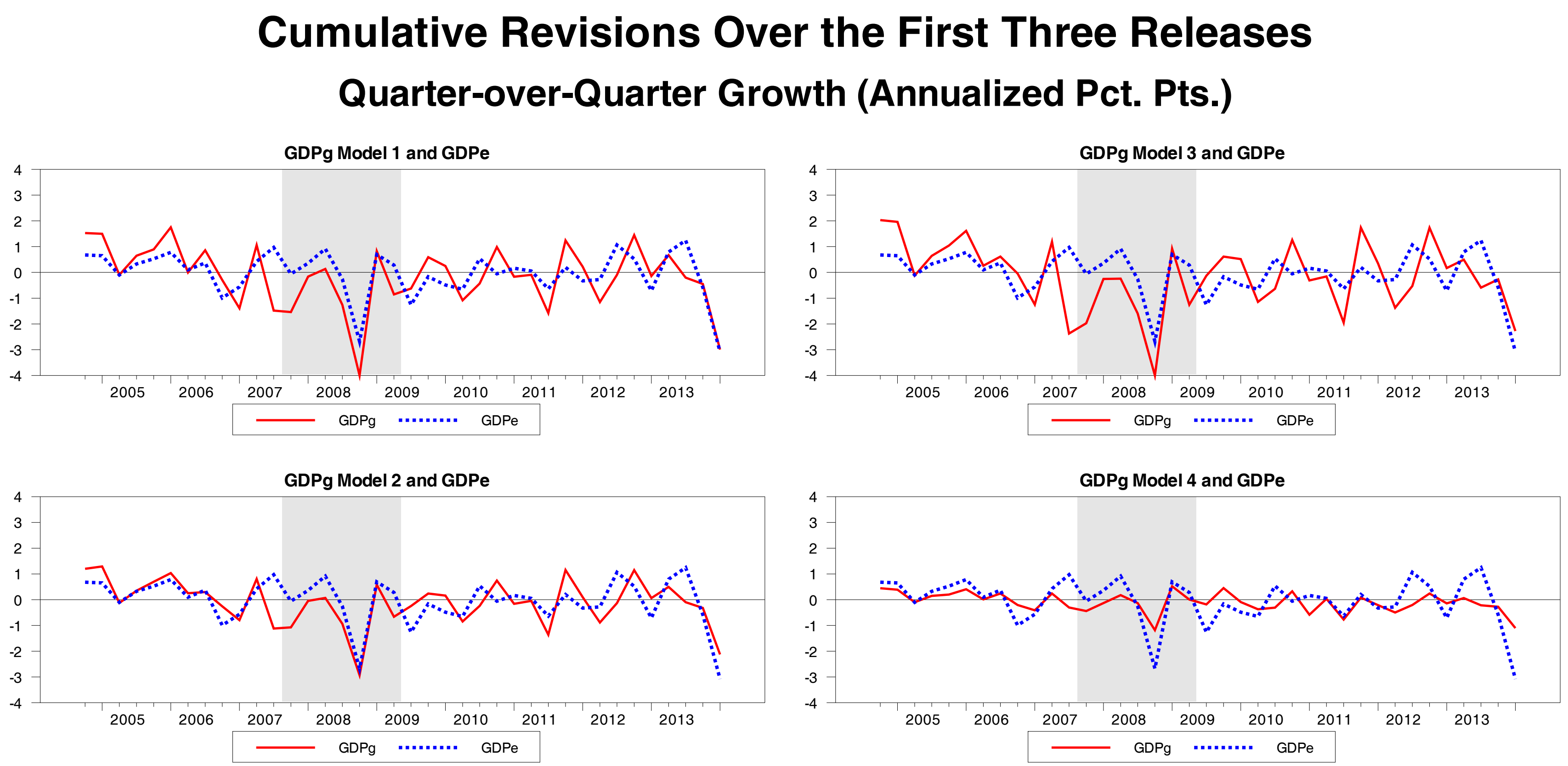

The graph shows the AR coefficients for GDPg and GDPe estimated on an expanding window of real-time observations.

**Figure 9.**




The graph shows equation variances for GDPg, GDPe, and GDPi, estimated monthly on an expanding window of real-time quarterly observations.

**Figure 10.**




The panels show cumulative revisions (first release to the third) for model-estimated GDP and expenditure GDP. Shading shows recessions.