Modifications to GDPNow Model Effective with the April 30, 2020, Forecast

Prior to April 30, 2020, we removed outliers from the 126 monthly data series used to estimate the GDPNow model's dynamic factor as detailed in equations (2) to (4) below. In particular, we replaced observations that were more than 10 interquartile ranges away from their median values. We derived the replacement values by first preliminarily replacing identified outliers with median values over the entire sample and then replacing them with a three-month-centered moving average of the outlier-adjusted data after padding the starting and ending points of each series with repeats of their first and last observed values. These adjustments generally had a very modest impact on the estimated factor through February 2020. However, given the profound impact of COVID-19 on the macroeconomy, we identified some March 2020 values as "outliers," such as the log-difference of the end-of-month four-week trailing average of initial unemployment insurance claims. Effective with the April 30, 2020, forecast, we no longer replace outliers in the monthly data used to estimate GDPNow's dynamic factor with alternative values. Instead, we now use the (standardized) 126 monthly data series inclusive of any possible outlier values to estimate the model's dynamic factor.

Modifications to GDPNow Model Effective with the April 30, 2018, Forecast

As documented in Higgins (2014), an estimated dynamic factor model is used to forecast the yet-to-be released monthly source data for the GDP subcomponents apart from inventory investment. In particular, the forecasting equations for the monthly growth rates of the source data are of the form[1]

$$(1)\quad \Delta \log(y_t^i) = \alpha_i + \sum_{k=1}^{q} \gamma_k^i \Delta \log(y_{t-k}^i) + \sum_{j=0}^{r} \beta_j^i f_{t-j}$$

In equation (1), y_t^i is the value of a monthly source data series in month *t* such as private nonresidential construction spending put in place from the U.S. Census Bureau's construction spending report adjusted for price changes, $\Delta \log(*)$ is the change in the natural logarithm of the series, which approximately equals its growth rate, f_t is the GDPNow estimate or forecast of the dynamic factor in month *t*, and the remaining terms are coefficient estimates from a regression using ordinary least squares (OLS). As documented on pages 5–6 of Higgins (2014), f_t is estimated, or forecasted, if month *t* data from the Manufacturing ISM Report on Business from the Institute for Supply Management has not been released yet, from the dynamic factor model

$$(2)\quad f_t = \rho_1 f_{t-1} + \rho_2 f_{t-2} + \rho_3 f_{t-3} + u_t$$

$$(3)\quad z_t^i = \gamma_1^i f_t + \varepsilon_t^i$$

where z_t^i is one of 126 standardized observed data series and u_t and ε_t^i are random variables from Gaussian white noise processes. As noted in this February 2018 *macroblog* post, there is autocorrelation for ε_t^i for some of the series including those released in the ISM manufacturing report. This can lead to large and somewhat predictable changes in the GDPNow forecast around the ISM manufacturing release. To mitigate the impact of the ISM report on the GDPNow forecast somewhat, we assume ε_t^i follows the first-order autoregressive process

$$(4)\quad \varepsilon_t^i = \phi_i \varepsilon_{t-1}^i + v_t^i$$

where v_t^i follows a Gaussian white noise process. We then estimate the time series of the dynamic factor using a slightly modified version of the algorithm used in Higgins (2014), which was largely based on the algorithm described in Giannone, Reichlin, and Small (2008).[2] We form an initial estimate of the dynamic factor by taking the first principal component of the standardized data series utilizing the technique described in Appendix A of Stock and Watson (2002)[3] to handle missing, or yet-to-be released, values. We then estimate equations (2) and (3) by OLS. The residuals from equation (3) are used to estimate equation (4) by OLS. Equations (2)–(4) are then recast into a state-space representation with the parameters and error variances taken from the earlier OLS regressions and the dynamic factor is reestimated using the Kalman filter and Kalman smoother. The estimated factor from this modified dynamic factor model is used to forecast the growth rates of the monthly source data in equation (1).

Modifications to GDPNow Model Effective with the October 30, 2017, Forecast

Residential investment

The bridge equation for real residential investment in improvements, which previously used the retail sales of building materials, garden equipment, and supply dealers deflated by the geometric mean of three price series described in Table A5b in Higgins (2014) has been expanded to include the number of seasonally adjusted production and nonsupervisory employees for residential remodelers (NAICS 236118). In particular, the bridge equation is a linear regression using quarterly log growth rates of the form

$$\begin{aligned}(5)\ \Delta\log(RealResInvImprovements_t) \\ = \varphi + \theta_1\,\Delta\log\left(\widehat{RealBuildGardenSupplySales_t}\right) + \theta_2\,\Delta\log\left(\widehat{EmpResRemodelers_t}\right) \\ + e_t\end{aligned}$$

where "hats" on the right-hand side of the equation are used because these values are constructed from both actual and (possibly) forecasted monthly values. See pages 5–8 and equations one to six of Higgins (2014) for further details.

Nonresidential equipment investment

Several changes have been made so some monthly data from the U.S. Census Bureau's advance durable manufacturing report and the U.S. advance international trade in goods report are used soon, or shortly after, their releases. Previously, some of these data had not been used until the full (M3) manufacturing report or the full monthly international trade report were released. Beyond this, no changes have been made. The monthly source data and the structure of the bridge equations are essentially unchanged from the previous version of GDPNow.

GDPNow partitions nonresidential equipment investment into "New autos," "New trucks," "Used autos/light trucks [net purchases]," "Aircraft," "Computers and peripherals," and "Core," where "Core" is the difference between the total and the other five categories. For the last three of the subcomponents—"Aircraft," "Computers and peripherals," and "Core"—the monthly source data for a bridge equation like (5) is “net shipments” or “domestic supply” measured as manufacturing shipments plus imports minus exports.[4] Shipments corresponding to “Computers and peripherals” investment are the sum of shipments of (a) “Electronic computers,” (b) “Computer storage devices,” and (c) “Other computer peripheral equipment.” These three series are not released until the full (M3) manufacturing report and, consequently, data on computer shipments from the advance durable manufacturing report were not used in the previous version of GDPNow. However, the advance durable manufacturing report includes shipments for “Computers & related products” and this series equals the sum of (a–c) in the full M3 report. Consequently, we now map “Computers & related products” shipments from the advance durable manufacturing report to the shipments series for “Computers and peripherals” investment.

In the Higgins (2014) version of GDPNow, month *t* data on exports and imports of capital goods that were mapped into “Aircraft,” “Computers and peripherals,” and “Core” investment were not used until the full international trade report for month *t*. We now forecast these data when the advance international trade in goods report for month *t* is released.[5] That report includes advance estimates of month *t* imports and exports of capital goods excluding autos.[6] In the full international trade report, we can partition imports and exports of capital goods into categories mapping into “Aircraft,” “Computers and peripherals,” “Core,” and a non-core remainder.[7] After making this partition, we construct “Aircraft,” “Computers and peripherals,” and “Core” exports and imports as shares of total capital goods exports and imports through month *t-1*. We include these six time series in a six-lag Bayesian vector autoregression (BVAR) along with five other series: logarithms of manufacturer shipments for the same three categories of imports and exports, and logarithms of total capital goods exports and imports. The latter five series go through month *t* after the month *t* advance durable manufacturing and advance international trade in goods reports. Using the approach of Waggoner and Zha (1999),[8] we make conditional forecasts of the month *t* shares of “Aircraft,” “Computers and peripherals,” and “Core” capital goods exports and imports after these reports. We can then back out total exports and imports for the three categories using total capital goods exports and imports from the advance trade report.

Nonresidential structures investment

One of the seasonally adjusted producer price deflators used to construct the price deflator for monthly private nonresidential construction spending—“Steel mill products: Steel pipe and tube”—was discontinued in December 2013. This index has been replaced by the nonseasonally adjusted version of the deflator; no manual seasonal adjustment is applied to this series. Otherwise, the methodology for forecasting nonresidential structures investment is unchanged from Higgins (2014).

Consumption spending on services

In the previous version of GDPNow, services personal consumption expenditures (PCE) was partitioned into two categories: “Purchased meals and beverages” and “Other.” Now it is partitioned into five categories: “Electricity + natural gas,” “U.S. travel outside the U.S.,” “Foreign travel in the U.S.,” “Purchased meals and beverages,” and “Other.”

When the Federal Reserve’s industrial production report for month *t* is released, we use a linear regression[9] with the month *t* (logarithmic) growth rate of “Electric and gas utilities” industrial production, the month *t-1* growth rate of “Electricity + natural gas” real PCE, and a constant to forecast the month *t* growth rate of “Electricity + natural gas” real PCE. Apart from this wrinkle, monthly “Electricity + natural gas” real PCE growth is forecasted using the same factor-augmented autoregression approach that is used with much of the other monthly source data and described on pages 6–7 of Higgins (2014).

As described in chapter 5 of the *NIPA Handbook*,[10] the U.S. Bureau of Economic Analysis (BEA) uses imports and exports of travel services to estimate net foreign travel PCE. However, month *t* PCE data are published about a week before the monthly international trade report with month *t* estimates of foreign trade in travel services. When month *t* nominal imports of travel services are released, we replace the month *t* (log) growth rate of real PCE "U.S. travel outside the U.S." with the fitted value from a regression using a constant and the month *t* growth rate of nominal imports of travel services.[11] We use the parameter estimates from the regression to forecast revisions to the growth rate of real PCE "U.S. travel outside the U.S."[12] We use a symmetric approach to forecast revisions to real PCE: "Foreign travel in the U.S." after month *t* nominal exports of travel services are released in the same international trade report.

The aggregation of the forecasts for "Electricity + natural gas," "U.S. travel outside the U.S.," "Foreign travel in the U.S.," "Purchased meals and beverages," and "Other" PCE services is handled as in the original version of GDPNow. Equation (15) on page 13 of Higgins (2014) is expanded so that the sum has five terms instead of two.

Change in private inventories

As described on page 13 of Higgins (2014), GDPNow approximates the monthly change in private inventories for each of four industries[13] as the sum of the monthly change in the book value of inventories published by the Census Bureau and an inventory valuation adjustment (IVA). If GDPNow is forecasting growth in quarter *t*, no monthly IVA estimates in quarter *t* are published until the first official GDP estimate for the quarter is released. However, the Underlying Detail Tables for the third estimate of quarter *t-1* GDP include end-of-month estimates of real and nominal manufacturing and trade inventories for the first month of quarter *t*. We use these data to plug in estimates of the IVAs for the first month of quarter *t* after these tables are released. The approximation used is

$$iva_{t,1}^{i} \cong 12\Delta invent_{t,1}^{i,Census-Book} + 12\Delta RealInvent_{t,1}^{i,BEA}\left(\frac{NomInvent_{t,1}^{i,BEA}}{RealInvent_{t,1}^{i,BEA}}\right)$$

where $invent_{t,1}^{i,Census-Book}$ is the Census Bureau's published book value of inventories for industry *i* in the first month of quarter *t*, $RealInvent_{t,1}^{i,BEA}$ is the end-of-month stock of inventories in chained dollars for the same month and industry published by the BEA in Underlying Detail Table 1BU, and $NomInvent_{t,1}^{i,BEA}$ is the end-month nominal stock of inventories for the same month and industry published by the BEA in Underlying Detail Table 1BUC.[14] The updated version of GDPNow treats the estimates of the IVAs in the left-hand side of the above equation as data. The rest of the programs work as before, and unavailable IVAs for months in which Census book value data have been released are still estimated using PPIs and BVAR models as described in Higgins (2014).

Underlying Detail Table 1BUC also contains an estimate of the real stock of inventories for retail motor vehicle and parts dealers. The difference in this stock, multiplied by 12 to annualize, is nearly identical to the published change in real motor vehicle dealer inventories in Underlying Detail Table 5.7.6BM. Therefore, we nowcast the motor vehicle dealer number in Table 5.7.6BM for the first month of quarter

t with 12 times the first difference of the corresponding stock in Table 1BUC after the Underlying Detail Tables for the third estimate of quarter $t-1$ GDP are released.

Government spending

As described on pages 7–9 of Higgins (2014), each of (private) real nonresidential structures investment, equipment investment, intellectual property products investment (IPP), federal government spending, and state+local government spending are disaggregated into finer subcomponents, and each of the real growth rates of these finer subcomponents are forecasted with a "bridge equation" or a four-lag autoregression [AR(4)] model. However, due to an oversight, the disaggregation used for both federal government spending and state+local government spending was not adjusted in July 2013 to account for the introduction of IPP investment. Each of the real growth rates of federal national defense, federal nondefense, and state+local IPP investment are now forecasted with AR(4) models. And these forecasts are now folded into the bridge equation-based forecast of real federal and state+local government spending using equation (7) on page 9 of Higgins (2014). See the tabs **FederalGovt** and **StateLocal** in https://www.frbatlanta.org/-/media/documents/cqer/researchcq/gdpnow/GDPTrackingModelDataAndForecasts.xlsx for these AR(4) forecasts of the real growth rates of government IPP government growth.

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[1] See https://www.frbatlanta.org/research/publications/wp/2014/07.aspx. We have simplified the notation from the Higgins (2014) slightly.

[2] See https://ideas.repec.org/a/eee/moneco/v55y2008i4p665-676.html.

[3] See https://www.princeton.edu/~mwatson/papers/Stock_Watson_JBES_2002.pdf.

[4] For both the "Computers and peripherals" and "Core" categories, the monthly source data on shipments, exports, and imports are independently forecasted and then combined. For "Aircraft," the monthly source data are first combined into "net shipments" and then unavailable values of "net shipments" are forecasted. For the previous version of GDPNow, this had the implication that month t data on manufacturing shipments of (nondefense) aircraft were not used until the full monthly international trade report. The changes made in the current version imply month t aircraft shipments data are used after the advance international trade in goods release.

[5] We simply plug these estimates in and treat them as actual values of month t capital goods imports/exports. No econometrics are used and no forecasted revisions to prior month values are made after the advance international trade report.

[6] Everywhere in this section on equipment investment where capital goods are referred to, we mean "capital goods excluding autos."

[7] For both exports and imports, trade in "Computers" and "Computer accessories" are mapped to "Computers and peripherals" investment, trade in "Civilian aircraft," "Civilian aircraft: parts," and "Civilian aircraft: engines" are mapped to "Aircraft" investment, and trade in "Marine engines," "Semiconductors," "Industrial engines," and "Electrical apparatus" are mapped to the non-core remainder. As of July 2017, non-core remainder exports (imports) have been just over 20 percent of capital goods exports (imports), on average, over the past 12 months.

[8] See https://ideas.repec.org/a/tpr/restat/v81y1999i4p639-651.html.

[9] The sample period for this regression and for the regressions for net foreign travel described below are January 2000 to the latest available month.

[10] See https://bea.gov/national/pdf/all-chapters.pdf.

[11] The regression uses current vintage data.

[12] The predicted revisions are the difference between the current fitted growth rates and fitted growth rates using the previous published values. Typically, only the previous month's value is revised. If a previous monthly PCE value isn't subject to revision in the next PCE or GDP report, then the model does not forecast a revision even if the foreign trade data have been revised.

[13] Durable manufacturing, nondurable manufacturing, merchant wholesalers, and retail trade excluding motor vehicle and parts dealers.

[14] The factor of 12 appears in the above equation because the BEA expresses monthly IVAs at annual rates.