Adapting the Laubach and Williams and Holston, Laubach, and Williams Models

to the COVID-19 Pandemic

Kathryn Holston, Thomas Laubach, and John C. Williams[1]

May 27, 2020

The COVID-19 pandemic and the necessary public health response have caused dramatic declines in economic activity around the world. The Laubach and Williams (LW, 2003) and Holston, Laubach, and Williams (HLW, 2017) models are reduced-form models of the natural rate of interest (r*) that are not suited for the study of the direct effects of the pandemic.[2] In particular, estimates of r* during the pandemic period should be interpreted with caution due to the extraordinary nature of the COVID-19 pandemic, the economic shutdown, and the policy responses. That said, during the economic recovery and post-pandemic period, these models may provide a useful empirical tool to parse the aftereffects from the pandemic and the associated policy responses between transitory and highly persistent or permanent components, as well as between demand and supply components. In addition, we recognize that the natural rate of interest is likely to remain low for the foreseeable future and these models provide useful benchmarks for measuring r*.

---

[1] The views expressed here are those of the authors and do not necessarily reflect those of the Federal Open Market Committee, the Board of Governors of the Federal Reserve System, or anyone else in the Federal Reserve System. Contact information: Holston: Harvard University, kathrynholston@g.harvard.edu; Laubach: Board of Governors of the Federal Reserve System, Thomas.Laubach@frb.gov; Williams: Federal Reserve Bank of New York, John.C.Williams@ny.frb.org. We thank Emily Martell for outstanding research assistance.

[2] Thomas Laubach and John C. Williams, "Measuring the Natural Rate of Interest," *Review of Economics and Statistics*, 85(4), November 2003, 1063–1070. Kathryn Holston, Thomas Laubach, and John C. Williams, "Measuring the Natural Rate of Interest: International Trends and Determinants," *Journal of International Economics*, 108, May 2017, S59-S75.

For these reasons, we put forth an approach to modifying the models that is consistent with their basic structures. This note describes the modifications to the LW and HLW models that we incorporated to allow continued estimation and publication of results during and after the COVID-19 pandemic.

Although the LW and HLW models incorporate transitory and permanent shocks to supply and demand, the model specification is restrictive in two ways that are at odds with the COVID-19 shock. First, in keeping with the standard Kalman filter method, stochastic innovations are assumed to follow a Gaussian distribution. Relative to historical experience, the COVID shock represents an extreme tail event. This is a violation of the Gaussian assumption that would significantly distort the estimation results. Second, the models incorporate transitory shocks to supply as innovations in the equation for the inflation rate (the Phillips curve equation). These shocks are assumed to be serially uncorrelated, which is inconsistent with implications of a sequence of shutdowns and re-openings associated with COVID. We modify the LW and HLW models to incorporate a persistent, but temporary, supply shock, in addition to the transitory and permanent shocks already present in the models, in order to capture the direct effects of restrictions related to the pandemic.

Note that these modifications are neither designed to provide a counterfactual prediction of how the economy would have behaved absent the COVID pandemic, nor do they attempt to capture the full set of indirect effects of the pandemic on the economy. Instead, the aim is to adapt the model structure to the COVID shock in a way that allows the model mechanisms to be operative once the pandemic period has passed.

COVID-adjusted LW and HLW Models

In the COVID-adjusted LW and HLW models, one new variable, denoted d(t), is introduced as a proxy for the direct effects of the shutdowns related to the pandemic. This COVID indicator is set equal to the quarterly average of the COVID-19 Government Response Stringency Index for each country or region.[3] The stringency index, which ranges between 0 and 100 with larger numbers indicating stricter restrictions, aggregates measures of government containment and closure policies such as school and workplace closures, travel restrictions, bans or limits on public gatherings, and shutdowns of public transportation.

We choose this indicator because it is comprehensive and publicly available for all of the economies in our sample. We recognize that such an index of government responses cannot capture the full set of behavioral responses or compliance; nonetheless, it should provide a reasonable first-order approximation to the time-series properties of the direct effects of the pandemic and associated public health actions on economies. For the Euro Area, a GDP-weighted stringency index, using 2019 GDP weights, is used. The COVID indicator is set equal to zero through 2019q4 in all countries. It is assumed to be an exogenous variable in the model.

[3] See Hale, Thomas, Sam Webster, Anna Petherick, Toby Phillips, and Beatriz Kira (2020). Oxford COVID-19 Government Response Tracker, Blavatnik School of Government. https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker.

The direct effects of COVID on the economy are incorporated in the models as an adjustment to the natural rate of output. In particular, the adjusted natural rate of output is given by $y^*(t) + \phi \cdot d(t)/100$, where ϕ is an estimated parameter that translates the COVID indicator into effects on output, and $y^*(t)$ is the standard natural rate of output. The output gap is correspondingly modified with the adjusted natural rate of output replacing the standard natural rate of output. That is, the modified output gap equals $100 \cdot (y(t) - y^*(t)) - \phi \cdot d(t)$, where $y(t)$ is log real GDP. The adjusted output gap replaces the standard output gap in the measurement equations (the IS and Phillips curve equations). No other changes are made to the model specification.

This specification can accommodate large and persistent movements in GDP resulting from changes in COVID-related restrictions on economic activity. It also allows the model to parse other influences on the economy into transitory and permanent components, and to distinguish between effects on supply and demand.

Technical note:

To implement this approach, we modify the estimation procedure and code to incorporate the inclusion of the COVID indicator in the model measurement equations.[4] In addition, the code that generates the initial parameter estimates for the MLE routines has been modified. In the standard LW and HLW models, we make use of a log-linear trend in real GDP to obtain initial guesses for parameter values, which are inputs in the MLE routines. The large declines in real

[4] See our public replication materials and code guide for details found on the New York Fed webpage: https://www.newyorkfed.org/research/policy/rstar.

GDP in 2020q1 distort the initial estimation of this trend in real GDP. The code to obtain initial guesses for parameter values has been modified as follows:

- First, run a log-linear trend of real GDP through 2019q4; extend this trend through the current estimation quarter;
- Construct initial estimate of the output gap as usual;
- Estimate by OLS the IS and Phillips curve equations, augmented to include the COVID indicator, to obtain initial parameter values, including ϕ, the coefficient on the COVID indicator variable;
- Estimate the COVID-adjusted model by MLE.

Special note on estimation through 2020q1:

The estimation results using data through the first quarter of 2020 will be released on May 29th. This represents a special case of including the COVID indicator in the model in that there is only one observation of the COVID indicator in each country/region and one free parameter. Given the specification of the model, in this case, the COVID indicator only appears in the IS curve equation (the lagged output gap appears in the inflation equation). Therefore, the COVID indicator can essentially absorb the entire movement in GDP in the first quarter of 2020. As such, these initial estimation results should be discounted in terms of being informative about movements in latent variables such as r*. Given the lack of degrees of freedom, we do not report estimated standard errors for ϕ in 2020q1. As more data become available in the future, the cross-equation restrictions placed on the model allow for estimation of standard errors for ϕ and imply that model estimates of latent variables will evolve according to data on GDP, inflation, interest rates, and the COVID indicator.