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To: Federal Open Market Committee

From: Matthew M. Luecke

Subject: DSGE Models Update

The attached memo provides an update on the projections of the DSGE models.

System DSGE Project Forecasts

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This memo describes the economic forecasts for three of the four models that are currently part of the System project on dynamic stochastic general equilibrium (DSGE) models. These are the EDO (Board), PRISM (FRB Philadelphia), and FRBNY models. We first give a summary of the model forecasts and then provide each model's forecasts in greater detail.

Summary of Model Forecasts

The current forecasts for real GDP growth, core PCE inflation, and the federal funds rate, as well as those presented at the March FOMC meeting, are displayed in the table and figures at the end of this summary section. These forecasts were obtained using actual data through 2014Q1 and conditioning assumptions or "nowcasts" for 2014Q2. The nowcast assumptions for 2014Q2 vary across the models. For example, PRISM assumes a current quarter growth rate of 3.7 percent, FRBNY anticipates 4.0 percent, and EDO projects current quarter growth of 4.2 percent. Further, each model assumes that near-term expectations of the future federal funds rate are implied by market prices of interest rate swaps, with predicted funds rate behavior becoming model driven after 2015Q2. The relatively robust nowcasts have meaningful effects on the forecasts.

Compared with the March forecast, both EDO and PRISM have slightly revised down their forecasts for Q4/Q4 output growth this year and in 2016, while FRBNY has made a fairly small upward revision to its projections for real GDP growth in 2014 and 2015 (Q4/Q4). Absent the strong Q2 nowcast, the models would have predicted slower near-term growth. In EDO, the assumed accommodative monetary policy path results in the model inferring relatively adverse financial conditions over the forecast horizon. These adverse shocks contribute to the downward revision in the forecast. For PRISM, the relatively robust forecast is driven largely by the model's internal dynamics and the waning of both negative financial shocks and negative shocks to investment. Output is currently well below potential in PRISM, and absent any large negative economic shocks output returns to steady state fairly quickly. In FRBNY, the slower and declining pace of activity from the 2014Q2 nowcast peak is accounted for by the persistent effects of financial headwinds, which as in PRISM are primarily due to negative shocks to the efficiency of investment. In FRBNY, these shocks, as well as the waning effects of forward

guidance, keep output growth below trend and result in the weaker tenor of its forecast. Thus, the three models paint different outlooks for economic growth over the forecast horizon, with FRBNY expecting less-than-trend growth, EDO anticipating about trend growth, and PRISM forecasting above trend growth. The median forecast across models is for growth of 2.2 percent in 2014 (barely changed from 2.1 percent in March) rising to 2.7 percent in 2015 (up from 2.5 percent in March), and 2.7 percent in 2016 (down from 3.0 percent in March).

Regarding inflation, all the models have fairly similar predictions with inflation rates remaining below the FOMC's long-run target for the entire forecast horizon. Financial shocks, which persistently and adversely affect inflation in both PRISM and FRBNY models, are largely responsible for the muted view of inflation going forward. In EDO, the gradual rise in inflation is attributed to a rebound in wages, which were depressed as a result of negative markup shocks, and a slow return to more normal labor supply conditions. In summary, the median forecasts of inflation from the four models is 1.4 percent in 2014 (slightly down from 1.2 percent in March), 1.4 percent in 2015 (the same as in March), and 1.7 percent in 2016 (the same as in March).

To varying degrees, EDO, PRISM, and FRBNY all interpret the federal funds rate path implied by market expectations as providing greater accommodation than would be implied by each model's interest rate rule. The relatively more subdued economic forecasts in EDO and FRBNY imply less policy tightening than is anticipated in PRISM. All the models expect the funds rate to lift-off from the zero lower bound in 2015Q3, but EDO and FRBNY expect a rather gradual increase in the funds rate, once policy tightening commences. In those models, the funds rate reaches 1.6 percent and 1.9 percent respectively by the end of 2016. By contrast, with inflation returning to near-targeted values at the end of the forecast horizon, PRISM anticipates a faster pace of tightening with the funds rate hitting 2.7 percent by the end of 2016.

Forecasts

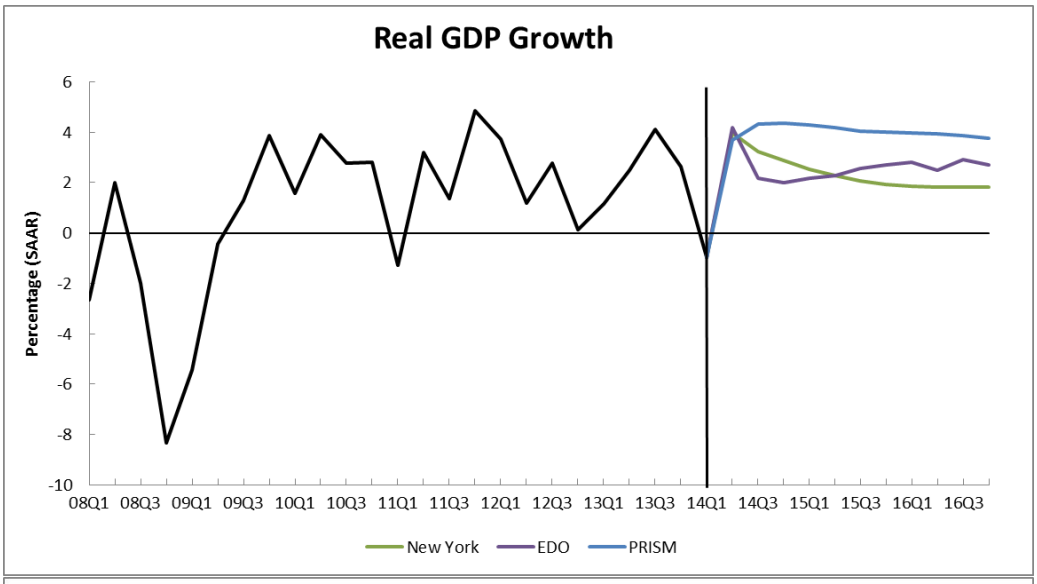
Model	Output Growth (Q4/Q4)					
	2014		2015		2016	
	Jun	*Mar*	Jun	*Mar*	Jun	*Mar*
EDO - Board of Governors	**1.8 (-0.6,4.1)**	*2.1 (-1.0,4.9)*	**2.7 (0.1,4.8)**	*2.5 (0.5,4.3)*	**2.7 (0.8,5.2)**	*3.0 (1.0,5.0)*
New York Fed	**2.2 (0.9,3.2)**	*2.0 (-0.1,3.4)*	**2.2 (-1.0,4.7)**	*1.9 (-1.3,4.6)*	**1.8 (-1.3,4.9)**	*1.9 (-1.2,5.0)*
PRISM - Philadelphia Fed	**2.9 (1.4,4.3)**	*3.4 (1.2,5.9)*	**4.2 (0.7,7.7)**	*4.2 (0.8,8.0)*	**3.9 (0.3,7.6)**	*4.1 (0.6,7.9)*
Median Forecast*	**2.2**	*2.1*	**2.7**	*2.5*	**2.7**	*3.0*

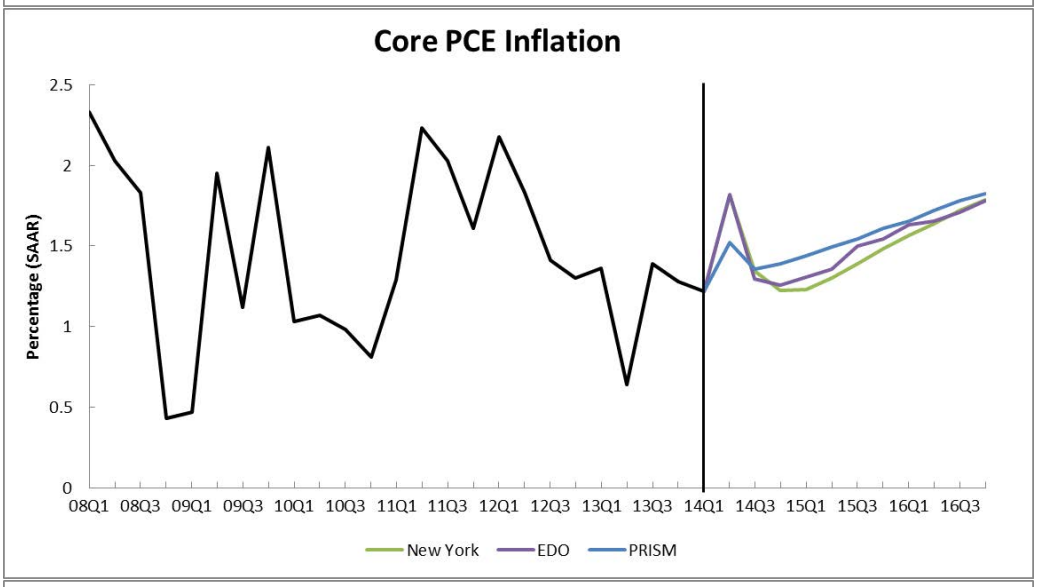
Model	Inflation (Q4/Q4)					
	2014		2015		2016	
	Jun	*Mar*	Jun	*Mar*	Jun	*Mar*
EDO - Board of Governors	**1.4 (1.2,1.6)**	*1.2 (0.5,1.6)*	**1.4 (0.9,2.0)**	*1.4 (0.7,2.1)*	**1.6 (1.2,2.3)**	*1.7 (0.9,2.5)*
New York Fed	**1.4 (1.0,1.7)**	*1.0 (0.5,1.4)*	**1.3 (0.6,2.0)**	*1.2 (0.4,1.9)*	**1.7 (0.8,2.4)**	*1.6 (0.8,2.4)*
PRISM - Philadelphia Fed	**1.4 (0.8,2.0)**	*1.2 (0.3,2.1)*	**1.5 (0.0,3.0)**	*1.5 (0.0,3.1)*	**1.8 (0.1,3.5)**	*1.7 (0.0,3.5)*
Median Forecast*	**1.4**	*1.2*	**1.4**	*1.4*	**1.7**	*1.7*

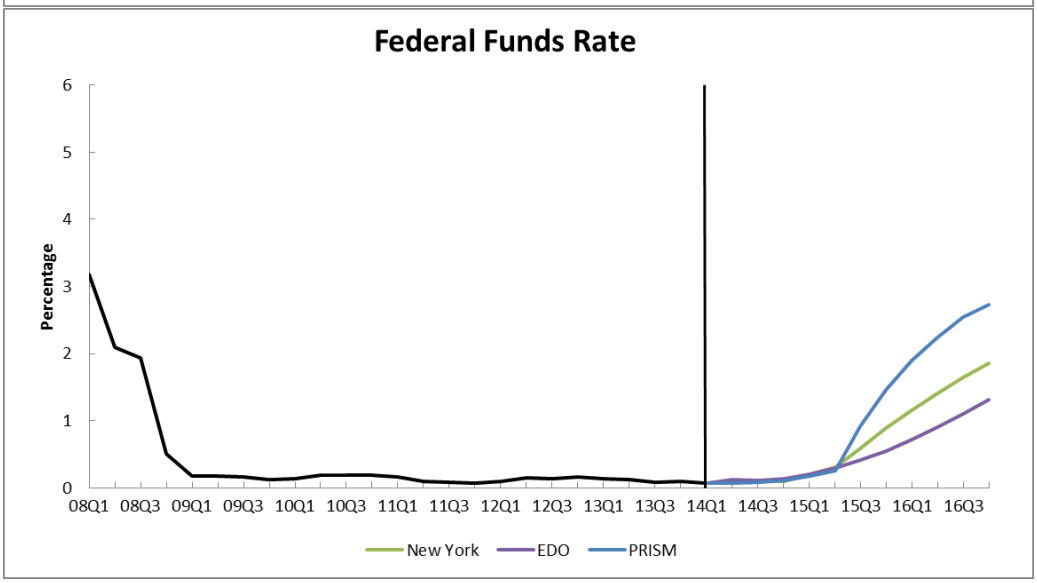
Model	Federal Funds Rate (Q4)					
	2014		2015		2016	
	Jun	*Mar*	Jun	*Mar*	Jun	*Mar*
EDO - Board of Governors	**0.3 (0.0,0.9)**	*0.3 (0.0,1.2)*	**0.7 (0.0,2.2)**	*0.8 (0.0,2.3)*	**1.5 (0.1,3.4)**	*1.5 (0.2,3.1)*
New York Fed	**0.1 (0.1,0.8)**	*0.1 (0.1,1.0)*	**0.9 (0.2,2.0)**	*0.9 (0.2,2.1)*	**1.9 (0.7,3.2)**	*1.8 (0.6,3.2)*
PRISM - Philadelphia Fed	**0.1 (-0.8,1.0)**	*0.1 (-1.1,1.3)*	**1.5 (-0.4,3.6)**	*1.5 (-0.7,3.7)*	**2.7 (0.2,5.6)**	*2.7 (-0.1,5.4)*
Median Forecast*	**0.1**	*0.1*	**0.9**	*0.9*	**1.9**	*1.8*

For each individual forecast, the numbers in parentheses represent 68% confidence bands.

* The median forecast is calculated as the median of the Q4/Q4 projections from the forecasters.







Detailed Descriptions of Individual Model Forecasts

The EDO Model

On average, the EDO model projects real GDP growth slightly below its trend of 2.7 percent until the end of 2015. The unemployment rate gradually rises to 6.9 percent by early 2015 and stays at that level through 2016, while inflation runs below the Committee's 2 percent objective, averaging around 1.5 percent over the next three years. In this forecast, the funds rate path through 2016:Q4 is consistent with market expectations, which indicate that private agents do not expect the federal funds rate to lift appreciably above its effective lower bound until the second quarter of 2015.[2]

The weak activity forecast is heavily shaped by the model's interpretation of the anticipated path of the federal funds rate inferred from interest rate swaps, which is considerably lower than the model would have anticipated in the absence of data on market expectations. To a considerable extent, in recent quarters, the model accounts for this lower path by attributing to private agents the expectation of relatively adverse financial conditions over the forecast horizon. In the forecast, the aggregate risk premium returns to its early 2012 levels, lowering GDP growth and boosting unemployment above its steady state. The negative impact of expected adverse financial conditions is partly offset by expectations of unusually accommodative monetary policy in 2014. The gradual increase in projected inflation over the forecast horizon is driven by the rebound of wages following negative markup shocks and a slow return of household labor supply preferences to long-run levels.

As the EDO model forecast now conditions on the Tealbook forecast for 2014:Q2, real GDP growth, employment, and inflation for that quarter have been revised up sharply, while the medium-term projection were revised only modestly. In particular, real GDP growth was revised down by ¼ percentage points on average in 2015 and 2016. This downward revision is driven by a large downward revision in potential output in 2014, which implies that the expected federal funds rate path at 2014:Q1 was more accommodative than the model would have inferred last

[2] Observations of the market-expected funds rate path through 11 quarters into the future are provided to the model starting in 2008:Q4.

March. The positive effects of more accommodative monetary policy on output in 2014 gradually wane, leading a slower acceleration in real GDP growth in 2015 and 2016 relative to the March forecast.

The FRBNY Model

The FRBNY model forecasts are obtained using data released through 2014Q1, augmented for 2014Q2 with the FRBNY staff forecasts for real GDP growth, core PCE inflation, and growth in total hours, and with values of the federal funds rate and the spread between Baa corporate bonds and 10-year Treasury yields based on 2014Q2 observations. The expected federal funds rate is constrained to equal market expectations, as measured by OIS rates, through 2015Q2. This constraint is implemented via anticipated policy shocks, whose standard deviations are estimated using federal funds rate (FFR) expectations since 2008Q4, when the zero bound became binding. The 2014Q1 staff projections and OIS rates are those that were available on May 30, 2014.

Despite the unexpectedly large drop in real GDP in 2014Q1, the FRBNY DSGE forecasts were revised up slightly compared to March. The short and medium run DSGE forecasts remained fairly upbeat because the staff nowcasts for 2014Q2 GDP growth and inflation are quite sanguine. However, the FRBNY DSGE model does not cope well with very large high frequency fluctuations in output such as those experienced in 2014Q1, as it tends to interpret at least part of these movements as due to more permanent factors. The outlook would thus have been less upbeat were the forecasts only based on 2014Q1 data.

Relative to March, the GDP growth forecasts increased to 2.2 percent for both 2014 and 2015 (Q4/Q4) from 2.0 and 1.9 percent, respectively, while the forecast for 2016 (Q4/Q4) remained virtually unchanged at 1.8 percent. For inflation, the mean core PCE inflation for 2014 is projected to be 1.4 percent, higher than the 1.0 percent projected in March. Inflation tends to return closer to the long term objective of 2 percent over the forecast horizon. The point forecasts are 1.3 and 1.7 percent for 2015 and 2016, slightly above the March point forecasts. Uncertainty around real GDP growth and inflation forecasts has diminished for 2014 (partly because we treat the 2014Q2 nowcasts as data) but is broadly unchanged otherwise. For GDP growth, the 68 percent bands cover the intervals 0.9 to 3.2 percent in 2014, -1.0 to 4.7 percent in 2015, and -1.3

to 4.9 in 2016. For inflation, the 68 percent probability bands range from 0.6 to 2.4 percent throughout 2016.

The low frequency dynamics behind the FRBNY DSGE forecast can be described as follows. The headwinds from the financial crisis are dissipating over time, but at a very slow pace, implying only a small effect on growth. At the same time the fact that output is still below trend implies that inflation is below the long term objective. In addition, in the past few years the economy has been buffeted by mostly negative shocks, which have further slowed down the return to trend. Many of these negative shocks have been compensated by expansionary monetary policy. However, the positive effect of this policy accommodation on the level of output begins to wane from the end of 2014 onward, implying a negative effect on growth.

The FRBNY model projects the FFR to be roughly 2 percent by the end of 2016, about 2 percentage points below its steady state value. The slow return of the FFR to steady state is mostly driven by the endogenous response of policy to the relatively weak economy, rather than by policy shocks.

The PRISM Model

The Philadelphia Research Intertemporal Stochastic Model (PRISM) forecast is constructed using data through 2014Q1 that are then supplemented with a 2014Q2 nowcast based on the most recent Macroeconomic Advisors model forecast. In addition, the forecasted path for the federal funds rate is constrained through 2015Q2 using futures market data – implied expectations.

PRISM continues to forecast an acceleration in growth from the 2.7 percent pace seen in 2013. While 2014Q2 real output growth is pinned down at 3.7 percent by the nowcast, the forecast calls for output growth to rise to 4.3 percent in the third quarter of 2014 and a 4.4 percent pace in 2014Q4. Real GDP growth then maintains a near 4 percent pace though 2016. While output growth is projected to be fairly robust, inflation remains contained at below 2 percent through the forecast horizon. The forecast has the funds rate following the financial

market expectation through 2015Q2 and then rising to 1.5 percent by the end of 2015 and 2.7 percent by the end of 2016.

According to PRISM, negative shocks to TFP, investment, and government spending/net exports were the primary factors holding down real output growth during 2014Q1. The model continues to imply a de-trended level of output that is well below its steady state and an important factor in accounting for this output gap is the low level of aggregate hours worked, which the model generates through a combination of labor supply shocks, investment shocks, and government spending shocks. Looking ahead, the model anticipates that above-trend real GDP growth will be driven by a rebound in hours worked and a waning of investment and financial shocks.

The 2014Q2 nowcast for core PCE inflation is 1.5 percent. The model then predicts a steady but gradual acceleration in core inflation over the next 3 years to a peak of 1.8 percent in 2016Q4. The principal factor accounting for below-trend core inflation over the forecast horizon is the very slow unwinding of the effects financial shocks, that are being only partially offset by the rebound in hours worked and aggregate demand (which put upward pressure on inflation).

The forecast is implemented with a path for the federal funds rate that is constrained by financial market expectations through 2015Q2. When that constraint is lifted in 2015Q3 the funds rate begins to rise quickly, jumping about 65 basis points in 2015Q3. By the end of 2016, the funds rate is projected to be at about 2.7 percent. The model puts relatively little weight on the output gap in the estimated policy rule. Consequently, the shocks that account for the dynamics of the federal funds rate are largely the same as those that account for the dynamics of inflation.