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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 describe 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 2015Q1 and conditioning assumptions or "nowcasts" for 2015Q2, where the nowcast assumptions vary slightly across the models depending on their source (EDO, the FRBNY model, and PRISM use forecasts from, respectively, Board staff, FRBNY staff, and Macroeconomic Advisors). Federal funds rate expectations are assumed to be consistent with market expectations through 2015Q2 for FRBNY, through 2015Q3 for PRISM, and throughout the forecast horizon (2017Q4) for EDO. For the sake of comparison, the tables and figures also provide the April Tealbook forecast (the June Tealbook forecast not being yet available to us).

The GDP growth forecasts for 2015 have been revised down, reflecting weaker-than-expected 2015Q1 GDP data. Output growth for 2015 is now projected in a range of 1.1 to 1.5 percent. EDO and FRBNY forecast that output growth will then pick up to between 2 and 3 percent over 2016 and 2017, similar to the March projections. PRISM remains more optimistic, forecasting output to grow between 3 and 4 percent over 2016 and 2017. The DSGE forecasts tend to be more pessimistic than the April Tealbook projections in 2015. For 2016 and 2017 the April Tealbook projections are similar to those of FRBNY and EDO. The median inflation forecast for 2015 has been revised up slightly and the near-term forecasts for core PCE inflation now range from 1.2 to 1.5 percent. EDO and FRBNY raised their 2015 inflation forecasts to reflect stronger-than-expected inflation data in Q1, while the PRISM forecast is unchanged from March. Looking further ahead, EDO and PRISM have inflation accelerating to just below the FOMC target of 2 percent in 2016, and essentially at the target in 2017. FRBNY projects a weaker inflation path: core PCE inflation remains about 0.7 percentage point below the FOMC target in 2017, similar to the March projection. The April Tealbook projections for inflation are in between those of EDO (and PRISM) and the FRBNY forecasts.

The economic interpretation behind all three forecasts is broadly similar: economic activity is projected to remain below potential, which implies that inflation is projected to remain below mandate consistent levels over the medium term. The models also generally agree on the reason why gaps are still open: past shocks to financial conditions – so-called headwinds – have a lasting effect on the economy by continuing to restrain demand and, in particular, investment. More recently, productivity shocks have held down the level of output as well. Where the models differ is in the projected speed at which gaps will close. This difference is reflected in the inflation projections.

The expected speed of the renormalization in the federal funds rate varies across models, consistent with the different assessments regarding the speed of the recovery in economic activity and inflation. In PRISM, the pace of renormalization is more rapid than in the other forecasts, with the federal funds rate projected to be above 3 percent by the end of 2017. This pace is slower in FRBNY and EDO: for these models the 2017Q4 federal funds rate forecast is 2.3 and 1.5 percent, respectively. Note though that EDO constrains federal funds rate expectations for the entire forecast horizon.

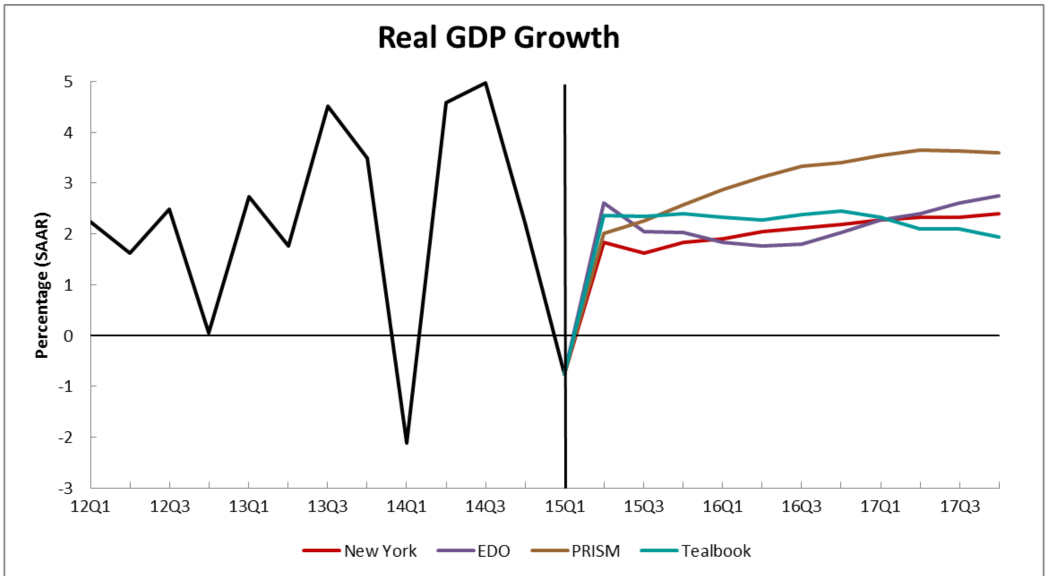
Forecasts

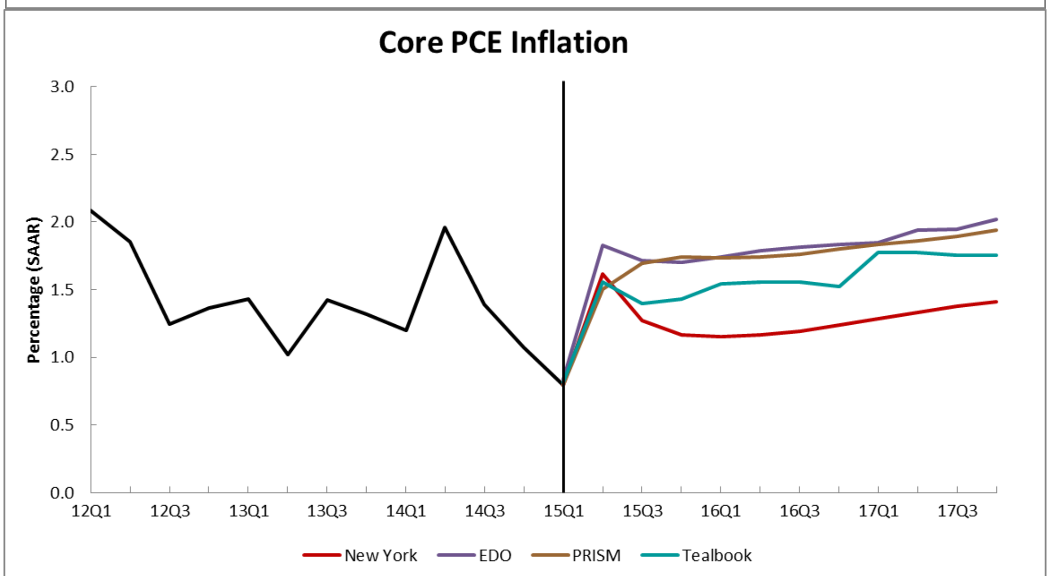
Model	Output Growth (Q4/Q4)					
	2015		2016		2017	
	June	*Mar*	June	*Mar*	June	*Mar*
EDO - Board of Governors	**1.5 (-0.8,3.7)**	*2.9 (0.3,5.5)*	**2.0 (-0.3,3.9)**	*2.2 (0.5,4)*	**2.6 (0.6,4.5)**	*2.4 (0.5,4.4)*
New York Fed	**1.1 (-0.5,2.2)**	*2.4 (-0.1,3.7)*	**2.0 (-0.8,4.2)**	*2.3 (-0.6,4.6)*	**2.3 (-0.4,4.8)**	*2.3 (-0.3,4.9)*
PRISM - Philadelphia Fed	**1.5 (0.1,3.0)**	*3.2 (1.1,5.7)*	**3.2 (-0.1,6.8)**	*3.8 (0.3,7.4)*	**3.7 (0.1,7.4)**	*3.7 (0.1,7.5)*
Median Forecast*	**1.5**	*2.9*	**2.0**	*2.3*	**2.6**	*2.4*
April Tealbook	1.8 (0.1,3.4)		2.4 (-0.2,3.9)		2.1 (-0.8,3.5)	

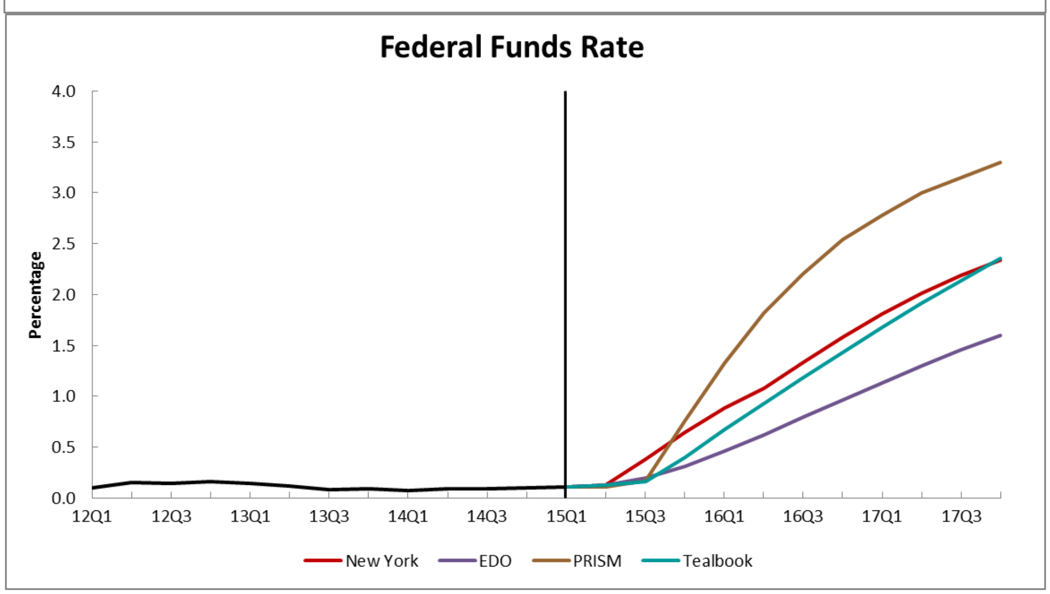
Model	Inflation (Q4/Q4)					
	2015		2016		2017	
	June	*Mar*	June	*Mar*	June	*Mar*
EDO - Board of Governors	**1.5 (1.3,1.8)**	*1.2 (0.8,1.5)*	**1.8 (1.2,2.4)**	*1.5 (0.9,2.2)*	**1.9 (1.3,2.6)**	*1.8 (1.1,2.4)*
New York Fed	**1.2 (0.9,1.6)**	*0.9 (0.4,1.4)*	**1.2 (0.4,1.9)**	*1.1 (0.3,1.9)*	**1.3 (0.5,2.2)**	*1.4 (0.5,2.2)*
PRISM - Philadelphia Fed	**1.4 (0.9,2.0)**	*1.4 (0.4,2.2)*	**1.8 (0.3,3.3)**	*1.7 (0.1,3.3)*	**1.9 (0.2,3.6)**	*1.8 (0.0,3.5)*
Median Forecast*	**1.4**	*1.2*	**1.8**	*1.5*	**1.9**	*1.8*
April Tealbook	1.3 (0.8,1.8)		1.6 (0.8,2.5)		1.8 --	

Model	Federal Funds Rate (Q4)					
	2015		2016		2017	
	June	*Mar*	June	*Mar*	June	*Mar*
EDO - Board of Governors	**0.4 (0.0,1.1)**	*0.6 (0.0,1.6)*	**1.0 (0.0,2.5)**	*1.2 (0.0,3.2)*	**1.5 (0.0,3.5)**	*1.8 (0.3,3.7)*
New York Fed	**0.6 (0.1,1.9)**	*0.8 (0.1,2.3)*	**1.6 (0.3,3.4)**	*1.7 (0.4,3.7)*	**2.3 (0.8,4.4)**	*2.4 (0.8,4.5)*
PRISM - Philadelphia Fed	**0.8 (-0.2,1.6)**	*1.1 (-0.1,2.3)*	**2.5 (0.5,4.5)**	*2.5 (0.4,4.9)*	**3.3 (0.7,6.0)**	*3.2 (0.4,6.0)*
Median Forecast*	**0.6**	*0.8*	**1.6**	*1.7*	**2.3**	*2.4*
April Tealbook	0.4 --		1.4 --		2.3 --	

For each individual forecast, the numbers in parentheses represent 68% confidence bands except for Tealbook which uses 70%. *The median forecast is calculated as the median of the Q4/Q4 projections from the forecasters.


Real GDP Growth
Percentage (SAAR)
5
4
3
2
1
0
-1
-2
-3
12Q1
12Q3
13Q1
13Q3
14Q1
14Q3
15Q1
15Q3
16Q1
16Q3
17Q1
17Q3
New York
EDO
PRISM
Tealbook


Core PCE Inflation
Percentage (SAAR)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12Q1
12Q3
13Q1
13Q3
14Q1
14Q3
15Q1
15Q3
16Q1
16Q3
17Q1
17Q3
New York
EDO
PRISM
Tealbook


Federal Funds Rate
Percentage
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12Q1
12Q3
13Q1
13Q3
14Q1
14Q3
15Q1
15Q3
16Q1
16Q3
17Q1
17Q3
New York
EDO
PRISM
Tealbook

Detailed Descriptions of Individual Model Forecasts

The EDO Model

For 2015, the EDO model projects real GDP growth that is 1¼ percent point lower on average than its trend of 2.7 percent. Subsequently, real GDP growth picks up and averages 2¼ percent through the end of the forecast period. The unemployment rate rises to 5¾ percent by the end of 2015, exceeds 6 percent in the first half of 2016, and reaches 6¼ percent in the first quarter of 2017. Inflation increases gradually over the next two years from the current 1.8 percent, reaching the Committee's 2 percent objective by the end of 2017. The forecast assumes that the funds rate path through 2017:Q4 is consistent with market expectations, which indicate that private agents anticipate the federal funds rate to lift appreciably above its effective lower bound in the fourth quarter of 2015.[2]

Output growth is held down by two factors. First, while the model regards the market-expected federal funds rate path as accommodative relative to the estimated rule, the waning of this unusual accommodation restrains growth. Second, the model attributes the slow-down in economic activity in the first quarter of 2015 to a sharp decline in total factor productivity, whose effects continue to weigh on GDP growth until the beginning of next year. The gradual increase in projected inflation over the forecast horizon is due to the gradual increase in wages, which is driven by the slowly dissipating negative wage markup shock.

The EDO model forecast now conditions on the 2015:Q1 data and a preliminary Tealbook forecast for the second quarter of 2015. Output growth in the first half of 2015 is now estimated to have been much weaker than the model anticipated in March. The model views this weakness as persistent, and output growth is revised down on average by ¼ percent in the second half of 2015 and 2016 since the March round. The model has interpreted the surprising strength of inflation since the March round as driven by the above-mentioned decline in total factor

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

productivity. The inflation rate has been revised up ¼ percentage point on average over the forecast horizon.

The FRBNY Model

The FRBNY model forecasts are obtained using data released through 2015Q1, augmented for 2015Q2 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 2015Q2 observations. Note that we do not constrain the expected federal funds rate to be equal to market expectations, as measured by OIS rates, beyond 2015Q2. The 2015Q2 staff projections and spreads are those that were available on May 26.

The FRBNY DSGE forecast for output growth is weaker in the short run than it was in March, reflecting the weaker than expected 2015Q1 GDP data. The model projects the economy to grow 1.1 percent in 2015, a sharp downward revision from the 2.4 percent projected in March. The growth forecasts for 2016 and 2017 are 2.0 and 2.3 percent, respectively, only slightly weaker than the March projections. Conversely, inflation, as measured both by the GDP and the core PCE deflators, was stronger in Q1 than expected, yielding higher short run forecasts than in March. Inflation projections are 1.2 percent for 2015, up from 0.9 percent in March, while for 2016 and 2017 they are 1.2 and 1.3 percent, respectively. The model attributes the forecast errors for 2015Q1 to largely temporary factors -- transitory technology shocks for GDP growth and mark-up shocks for inflation – which explains why the medium run forecasts are largely unchanged.

The broader story behind the forecasts is unchanged relative to March: The headwinds that slowed down the economy in the aftermath of the financial crisis are finally abating, resulting in an increase of the natural rate of interest toward positive ranges and a gradual closing of the output gap – the difference between output and natural output. The gap is closing only slowly, however, resulting in growth that is barely above potential, and in weak inflation projections. Inflation’s convergence to the FOMC long-run objective is contingent on projected increases in future real wages and marginal costs. In the absence of accelerating wages, inflation projections would be even weaker.

The model projects the federal funds rate to reach 2.4 percent by the end of 2017, well below its steady state value. This relatively shallow path after lift-off is mostly driven by the endogenous response of policy to weak inflation, according to the historical reaction function estimated by the model. However, past forward guidance on interest rates, which is estimated to have provided consistent support to GDP growth and inflation over the last several years, also contributes to maintaining a lower expected future federal funds rates than is implied by the historical reaction function. The estimated natural real rate of interest has been well below the actual real rate during and after the crisis, indicating that the zero lower bound imposed a constraint on interest-rate policy. Currently, the natural rate is close to the actual real rate, suggesting that policy is still not particularly accommodative.

Uncertainty around the forecasts is significant, particularly for GDP growth. The width of the 68 percent probability interval for GDP growth is 2.7 percentage points in 2015, ranging from -0.5 to 2.2 percent, and widens to 5.2 percentage points in 2017 – from -0.4 to 4.8 percent. The 68 percent probability intervals for inflation range from 0.9 to 1.6 percent in 2015 and from 0.5 to 2.2 percent in 2017.

The PRISM Model

The Philadelphia Research Intertemporal Stochastic Model (PRISM) forecast is constructed using data through 2015Q1 that are then supplemented with a 2015Q2 nowcast based on the most recent Macroeconomic Advisors model forecast. In addition, the forecasted path for the federal funds rate is constrained through 2015Q3 using futures market data – implied expectations.

PRISM forecasts that output growth will accelerate from a 1.5 percent pace in 2015 to 3.2 percent in 2016 and 3.7 percent in 2017. Real output growth in 2015Q2 is pinned down at 2 percent by the nowcast, but then rises to 2.3 percent in the third quarter and to 2.6 percent in 2015Q4. Core inflation remains contained at below 2 percent through the end of 2017. The forecast has the funds rate following the financial market expectation through 2015Q3 and then rising to 0.75 percent by the end of 2015 and 3.3 percent by the end of 2017.

According to PRISM, negative shocks to TFP growth are the primary factor holding down real GDP growth in the first half of 2015. As TFP shocks wane, output growth rises above its steady state of 2.7 percent by mid-2016. The model also suggests that the unwinding of government spending shocks and investment shocks will make a positive contribution to output growth over the forecast horizon. Consumption growth (nondurables plus services) remains below its steady state level until the beginning of 2017, held down by the effects of TFP shocks and investment shocks. On balance, PRISM continues to imply a de-trended level of output that is 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 and government spending shocks.

This model is conditioned on a 2015Q2 nowcast for core PCE inflation of 1.5 percent. The model projects a steady but gradual rise in inflation over the next two-and-a-half years, reaching about 1.9 percent at the end of 2017. The principal factor accounting for below-trend core inflation over the forecast horizon is the very slow unwinding of the effects of past financial shocks, and a rising funds rate. The factors are only partially offset by a 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 2015Q3. When that constraint is lifted in 2015Q4, the funds rate begins to rise quickly, jumping by about 55 basis points in 2015Q4. By the end of 2017, the funds rate is projected to be at about 3.3 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.