

**BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM**  
**DIVISION OF MONETARY AFFAIRS**  
**FOMC SECRETARIAT**

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**Date:** December 5, 2014  
**To:** Federal Open Market Committee  
**From:** Matthew M. Luecke  
**Subject:** DSGE Models Update

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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 September FOMC meeting, are displayed in the table and figures at the end of this summary section. These forecasts were obtained using actual data through 2014Q3 and conditioning assumptions or “nowcasts” for 2014Q4, where the nowcast assumptions for 2014Q4 vary slightly across the models depending on their source (Board staff, FRBNY staff, and Macroadvisers forecasts for EDO, the FRBNY model, and PRISM, respectively). The models differ somewhat in their assumptions on federal funds rate expectations. FRBNY and PRISM assume funds rate expectations that are consistent with market expectations through 2015Q2. EDO assumes funds rate expectations that are consistent with market expectations through 2017Q2.

The three forecasts share a similar underlying story: gaps in economic activity have not yet closed, which implies that inflation is projected to remain below mandate consistent levels throughout the forecast horizon. 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. Where the models differ is in the projected speed at which gaps will close, with PRISM forecasting a relatively robust growth of the economy while EDO and especially FRBNY foresee a much slower pace of the recovery.

Compared to September, PRISM and FRBNY show little change in their projections for output growth over the next three years, with PRISM forecasting annual growth of about 4 percent and FRBNY forecasting annual growth of about 2 percent. The EDO forecast is marked

up a bit to 3 percent in 2015 and down to 2.6 percent in 2016 and 2017. Averaging across the models, output growth is 3 percent in 2015 and 2.8 percent in 2016 and 2017. The inflation forecasts are, on average, slightly lower than they were in September and reflect the lower-than-expected realization on core inflation for 2014Q3. Core inflation is projected to remain below mandate consistent levels over the next 3 years, rising from 1.6 percent in 2014 to 2 percent at the end of 2017.

The forecasts for the federal funds rate are little changed from September. EDO's path remains constrained at market expectation through mid-2017, while PRISM and FRBNY constrain the path of the funds rate only through 2015Q2. To the extent they bind, market expectations hold the funds rate below the level implied by the models' estimated rules. Beginning in 2015Q3, PRISM's strong growth and rising inflation lead to a rapid pace of renormalization, with the funds rate rising to 3.3 percent by the end of 2017. Consistent with its weaker fundamentals, FRBNY shows instead a more gradual re-normalization as the funds rate reaches 2.3 at the end of 2017.

## Forecasts

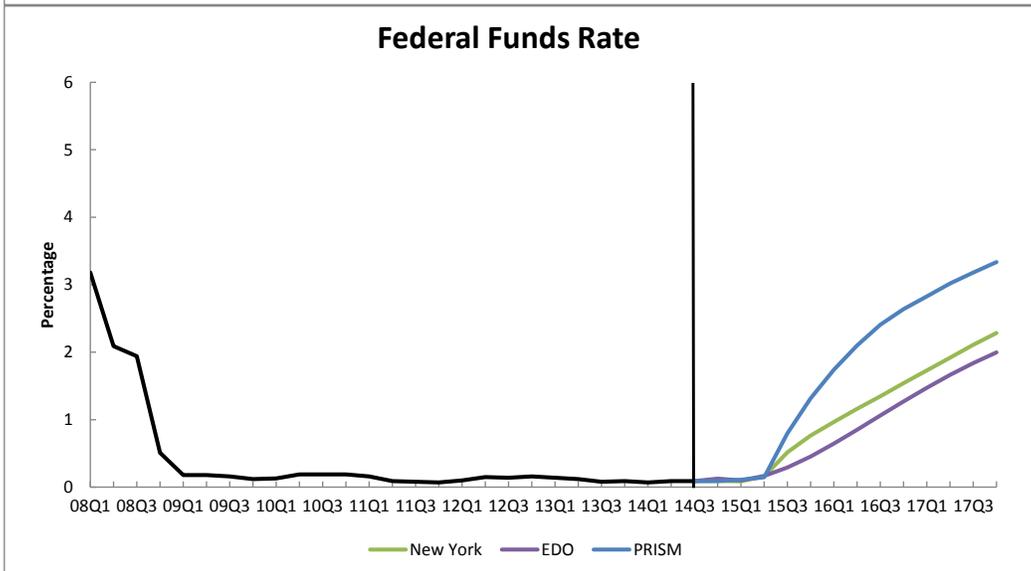
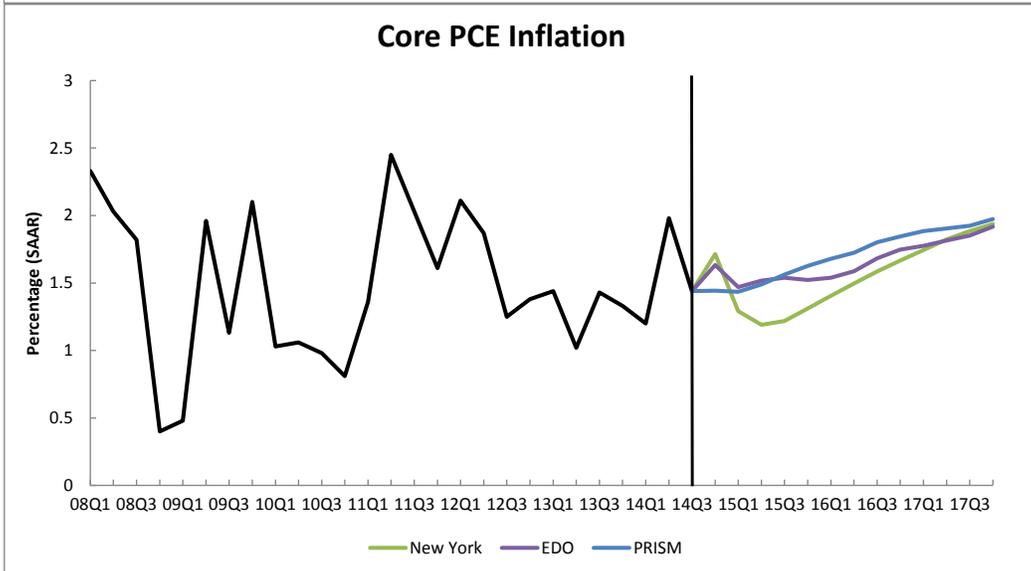
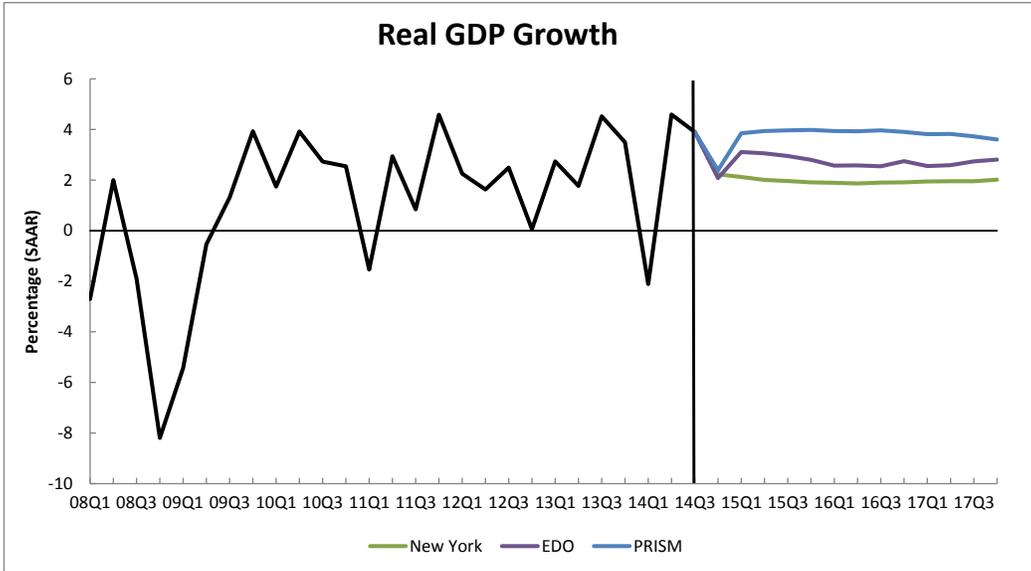
Model	Output Growth (Q4/Q4)							
	2014		2015		2016		2017	
	Dec	Sep	Dec	Sep	Dec	Sep	Dec	Sep
EDO - Board of Governors	<b>2.1</b> (2.1,2.1)	2.0 (0.2,3.5)	<b>3.0</b> (-0.3,6.4)	2.5 (0.2,5.2)	<b>2.6</b> (1.0,4.3)	3.1 (1.1,4.8)	<b>2.6</b> (0.8,4.6)	3.2 (1.0,5.1)
New York Fed	<b>2.1</b> (2.1,2.1)	1.9 (1.2,2.4)	<b>2.0</b> (-0.9,4.1)	2.0 (-1.1,4.5)	<b>1.9</b> (-1.4,4.9)	1.7 (-1.5,4.9)	<b>1.9</b> (-1.4,5.2)	1.8 (-1.3,5.1)
PRISM - Philadelphia Fed	<b>2.2</b> (2.2,2.2)	2.2 (1.6,2.9)	<b>4.0</b> (0.8,7.2)	3.8 (0.6,7.3)	<b>4.0</b> (0.5,7.7)	3.8 (0.5,7.7)	<b>3.8</b> (0.1,7.6)	3.7 (-0.5,7.3)
Median Forecast*	<b>2.1</b>	2.2	<b>3.0</b>	2.5	<b>2.6</b>	3.1	<b>2.6</b>	3.2

Model	Inflation (Q4/Q4)							
	2014		2015		2016		2017	
	Dec	Sep	Dec	Sep	Dec	Sep	Dec	Sep
EDO - Board of Governors	<b>1.6</b> (1.6,1.6)	1.6 (1.5,1.7)	<b>1.5</b> (1.0,2.0)	1.6 (1.0,2.1)	<b>1.6</b> (1.0,2.3)	1.7 (1.0,2.4)	<b>1.8</b> (1.2,2.5)	1.8 (1.1,2.6)
New York Fed	<b>1.6</b> (1.6,1.6)	1.6 (1.4,1.7)	<b>1.2</b> (0.6,1.8)	1.4 (0.7,2.0)	<b>1.5</b> (0.8,2.2)	1.7 (0.9,2.4)	<b>1.8</b> (1.0,2.6)	1.9 (1.1,2.7)
PRISM - Philadelphia Fed	<b>1.5</b> (1.5,1.5)	1.7 (1.5,2.0)	<b>1.5</b> (0.2,2.8)	1.7 (0.3,3.1)	<b>1.8</b> (0.2,3.5)	1.9 (0.2,3.6)	<b>1.9</b> (0.2,3.7)	1.9 (0.2,3.7)
Median Forecast*	<b>1.6</b>	1.6	<b>1.5</b>	1.6	<b>1.6</b>	1.7	<b>1.8</b>	1.9

Model	Federal Funds Rate (Q4)							
	2014		2015		2016		2017	
	Dec	Sep	Dec	Sep	Dec	Sep	Dec	Sep
EDO - Board of Governors	<b>0.1</b> (0.1,0.1)	0.1 (0.0,0.6)	<b>0.7</b> (0.0,1.9)	0.7 (0.0,2.4)	<b>1.5</b> (0.1,3.2)	1.5 (0.0,3.6)	<b>2.0</b> (0.4,3.9)	2.3 (0.4,4.0)
New York Fed	<b>0.1</b> (0.1,0.1)	0.1 (0.1,0.6)	<b>0.8</b> (0.2,1.7)	1.0 (0.3,2.0)	<b>1.5</b> (0.5,2.8)	1.8 (0.7,3.1)	<b>2.3</b> (0.9,3.7)	2.6 (1.1,4.0)
PRISM - Philadelphia Fed	<b>0.1</b> (0.1,0.1)	0.1 (-0.4,0.6)	<b>1.3</b> (-0.2,2.8)	1.6 (0.0,3.4)	<b>2.6</b> (0.3,5.0)	2.9 (0.2,5.4)	<b>3.3</b> (0.4,6.1)	3.4 (0.4,6.2)
Median Forecast*	<b>0.1</b>	0.1	<b>0.8</b>	1.0	<b>1.5</b>	1.8	<b>2.3</b>	2.6

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 moderately higher than its trend of 2.7 percent in 2015. Thereafter, real GDP growth hovers around its trend. The unemployment rate rises to 6.1 percent by the end of 2015 and stays at that level through the end of 2017. Inflation runs below the Committee's 2 percent objective, averaging around 1.6 percent over the next three years. In this forecast, the funds rate path through 2017:Q2 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.<sup>2</sup>

The lackluster growth of GDP over the forecast is the product of two offsetting forces. First, the combination of weak growth in consumption along with relatively high real short-term interest rates has led the model to estimate a relatively elevated aggregate risk premium, the model's main cyclical driver. All else equal, GDP growth would rise above trend as this risk premium converges to its historical average. However, the model also interprets the market-expected path of the federal funds rate as unusually accommodative, given the expected state of the economy and the estimated monetary policy reaction function. Although these lower-than-expected interest rates boost the current level of real GDP, these effects vanish over the medium term, lowering GDP growth. In the current forecast, these two forces are balanced, leading to roughly trend GDP growth. 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.

The EDO model forecast now conditions on the 2014:Q3 data and a preliminary Tealbook forecast for the fourth quarter. Although growth early in 2015 is initially stronger, the medium-term projection was revised down compared to September with real GDP growth averaging 2¾ percent in 2016-2017. Inflation gradually increases to 1.9 percent in 2017.

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

## **The FRBNY Model**

The FRBNY model forecasts are obtained using data released through 2014Q3, augmented for 2014Q4 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 2014Q4 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 FFR expectations since 2008Q4, when the zero bound became binding. The 2014Q4 staff projections, OIS rates and spreads are those that were available on November 26.

The FRBNY DSGE forecast did not change much compared to September, with the trajectory of output somewhat stronger in 2016 and 2017, but inflation a bit weaker throughout the forecast horizon. Over the short term, this modest change reflects to a large extent the moderating influence of the staff GDP now-cast for Q4, which is weaker than the model's own forecast for that quarter. Given the staff projection of a Q4/Q4 growth rate of 2.1% for 2014, GDP growth is seen leveling off close to 2% throughout the forecast horizon, while inflation dips to 1.2% in 2015 and only very gradually recovers towards mandate consistent levels, reaching 1.8% in 2017.

Uncertainty around the real GDP growth and inflation forecasts has diminished for 2015, reflecting the addition of one more data point to the conditioning set, but it is broadly unchanged otherwise. Notably, the 68% percent probability intervals for inflation remain quite tight, with the probability of negative inflation assessed at roughly 10% in 2015, and at less than 5% thereafter. Similarly, the probability of core PCE inflation above 3% is less than 5% in 2015 and about 15% in 2017. In contrast, the width of the 68% probability interval for GDP growth is almost 5 percentage points already in 2015, and 6.5 percentage points in 2017, in both cases with about one third of the probability mass at negative values.

The dynamics behind medium-to-long-term FRBNY DSGE forecasts can be described as follows. The headwinds from the financial crisis, which the model identifies as responsible for holding growth below average over the recovery, continue to dissipate. In fact, spread shocks,

which were the main driver of the Great Recession and continued to exercise a negative pull on the economy during the first phase of the recovery, provide a positive contribution to GDP growth and inflation starting in 2014. This contribution builds over the forecast horizon and reaches about 1 percentage point of GDP in 2017. In contrast, a low marginal efficiency of investment, which has persisted throughout the recovery, continues to hamper GDP growth and to exert a negative drag on inflation. However, this effect is now smaller than in the recent past, and it is forecast to shrink further. On the other side of the ledger, monetary policy has provided consistent support to GDP growth over the last several years, but this support must be paid back over time, since monetary policy is neutral in the long-run. This payback from past stimulus implies a negative effect on growth over the foreseeable future, which reaches a peak of about 1 percentage point in 2016 and declines slowly afterwards.

Finally, the FRBNY model projects the FFR to reach 2% by the end of 2017, well below its steady state value. This very shallow path after lift-off is mostly driven by the endogenous response of policy to the relatively weak fundamentals, according to the historical reaction function estimated by the model, rather than by the consequences of policy shocks.

### **The PRISM Model**

The Philadelphia Research Intertemporal Stochastic Model (PRISM) forecast is constructed using data through 2014Q3 that are then supplemented with a 2014Q4 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 forecasts that growth will accelerate from a 2.2 percent pace in 2014 to about 4 percent in 2015 and 2016, and then taper down to about 3.8 percent in 2017. While 2014Q4 real output growth is pinned down at 2.4 percent by the nowcast, the forecast calls for output growth to rise to 3.8 percent in the first quarter of 2014, and then run at about that pace through the end of 2016. Growth then gradually edges down to about a 3.6 percent pace by the end of 2017. 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 1.3 percent by the end of 2015 and 3.3 percent by the end of 2017.

According to PRISM, an ongoing rebound in the labor market and investment demand will drive above-trend growth over the next 3 years. The model 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, 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 the largely negative investment and financial shocks that have accumulated since 2010.

The 2014Q4 nowcast for core PCE inflation is 1.4 percent. The model predicts a steady but gradual rise in inflation over the next 3 years, reaching about 2 percent at the end of 2017. The principal factor accounting for slightly below-trend core inflation over the forecast horizon is the very slow unwinding of the effects of 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 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.