<div align="center">

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

</div>

Date: December 6, 2013

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

December 6, 2013

Argia Sbordone and Andrea Tambalotti[1]

Federal Reserve Bank of New York

This memo describes the economic forecasts of the four models that are currently part of the System dynamic stochastic general equilibrium (DSGE) project. These are the Chicago, EDO (Board), PRISM (FRB Philadelphia) and FRBNY models. We start with an overall summary of the forecasts and then provide more detail on each model.

Summary

The current forecasts for real GDP growth, core PCE inflation, and the federal funds rate (FFR), along with those distributed before the September FOMC meeting, are displayed in the table and figure at the end of this summary section. The forecasts cover the years 2013-2016 and were obtained using released data through 2013Q3 and conditioning assumptions or "nowcasts" for 2013Q4. The conditioning assumptions for 2013Q4 vary across models: the growth nowcast, for example, is 1.5% in EDO and the FRBNY model, and a lower 1.2% in PRISM and the Chicago model. All models match near-term expectations of the FFR to those derived from interest rate swaps, with the funds rate behavior becoming model-driven at somewhat different dates. Both Philadelphia and New York pin down the funds rate with market expectations until 2015Q2, while Chicago and the Board staff match it with swaps data through 2016Q2 and 2016Q3, respectively.

Relative to the September forecast, current projections for real growth are moderately lower. The median forecast for growth across the four models is of 2 percent in 2013 (unchanged from September), but it is down to 2.4 percent in 2014 (from 2.6 percent), and to 2.8 and 3.2 percent in 2015 and 2016 (from 3.4 percent in September for both years). The FRBNY model is the most pessimistic, projecting growth at or below 2 percent throughout the forecast horizon. The long-lasting effects of the financial shocks that hit the economy during the Great Recession and in its aftermath play a major role in this subdued forecast; in addition, the waning of the stimulative effect of past policy accommodation on the level of output results in a drag on GDP growth of up to 1 percentage point in 2015. The EDO model also forecasts growth below its trend of 2.7 percent through 2015, with unemployment above 7 percent through 2017. This weak outlook is heavily shaped by agents' perceptions of adverse financial conditions, with aggregate risk premia back to levels observed in early 2012. For the Chicago model and PRISM, negative shocks to total factor productivity and transitory aggregate demand shocks are the primary contributors to

the weaker near-term forecasts. Starting in 2014, PRISM projects a robust recovery, due to a rebound in hours worked and to the unwinding of financial shocks, with GDP growth reaching almost 4 percent in 2015 and 2016. The Chicago model projects a more moderate acceleration of growth from 2014 through 2016, to around 3 percent, driven by forward guidance, with a very low policy rate extending to the end of 2015, as priced in by market expectations.

Regarding inflation, all the models predict it to remain below the FOMC's long-run target over the entire forecast horizon. As in the case of GDP growth, the median forecasts of inflation across the four models are slightly lower than in September: 1.2 percent in 2013 (down from 1.3 percent), 1.1 percent in 2014 (down from 1.2 percent), and 1.3 and 1.6 percent in 2015 and 2016 (down from 1.5 and 1.7 percent).This subdued inflation outlook results from the persistent effects of financial shocks in PRISM and the FRBNY model, and from high risk premia and a persistent shift in labor supply in EDO. The Chicago model remains a bit of an outlier on this front, projecting inflation rates below one percent through 2016, with aggregate demand acting as a major drag, only marginally offset by positive innovations in price and wage markups, and well-anchored expectations.

Market-based measures of the future path of the FFR have moved down substantially since September, impacting the interest rate projections of all models. EDO, PRISM and the FRBNY model interpret the decline in these projections as mostly reflecting weaker economic conditions rather than unusual policy actions. After liftoff, the interest rate increase is very gradual in EDO and the Chicago models, which follow market expectations, and a bit more pronounced in the FRBNY model, while it is quite decisive in PRISM, due to its more optimistic outlook for growth and especially inflation. AS a result, the funds rate is 1.4 percent in EDO and the Chicago model, 1.9 percent in the FRBNY model and 2.9 percent in PRISM at the end of 2016.

Summary Tables

Model	Output Growth (Q4/Q4)							
	2013		**2014**		**2015**		**2016**	
	Dec	Sep	**Dec**	Sep	**Dec**	Sep	**Dec**	Sep
EDO	**2.1**	1.8	**1.9**	2.5	**2.7**	3.5	**3.3**	3.3
Board of Governors	--	(0.2,3.5)	**(-1.6,5.1)**	(-0.1,4.8)	**(0.9,4.5)**	(1.6,5.2)	**(1.3,5.3)**	(1.4,5.2)
New York Fed	**2.0**	2.0	**2.0**	2.0	**1.7**	1.7	**1.7**	1.8
	--	(1.3,2.4)	**(-0.9,3.9)**	(-1.1,4.2)	**(-1.8,4.5)**	(-1.5,4.5)	**(-1.5,5.0)**	(-1.2,5.0)
PRISM	**2.0**	2.6	**3.6**	4.4	**3.9**	3.9	**3.9**	3.7
Philadelphia Fed	--	(2.0,3.4)	**(0.4,6.7)**	(1.1,8.0)	**(0.3,7.6)**	(0.3,7.6)	**(0.3,7.7)**	(0.2,7.6)
Chicago Fed	**1.9**	2.0	**2.7**	2.7	**3.0**	3.2	**3.1**	3.5
Median Forecast*	**2.0**	2.0	**2.4**	2.6	**2.8**	3.4	**3.2**	3.4

Model	Inflation (Q4/Q4)							
	2013		**2014**		**2015**		**2016**	
	Dec	Sep	**Dec**	Sep	**Dec**	Sep	**Dec**	Sep
EDO	**1.1**	1.2	**1.1**	1.3	**1.4**	1.5	**1.6**	1.7
Board of Governors	--	(1.1,1.4)	**(0.5,1.7)**	(0.7,1.9)	**(0.7,2.1)**	(0.8,2.2)	**(0.8,2.5)**	(0.9,2.4)
New York Fed	**1.2**	1.3	**0.9**	1.2	**1.3**	1.5	**1.7**	1.7
	--	(1.1,1.5)	**(0.3,1.5)**	(0.4,1.8)	**(0.4,2.0)**	(0.6,2.2)	**(0.8,2.4)**	(0.8,2.5)
PRISM	**1.3**	1.3	**1.4**	1.5	**1.6**	1.7	**1.8**	1.8
Philadelphia Fed	--	(1.1,1.6)	**(0.2,2.7)**	(0.2,2.9)	**(-0.1,3.2)**	(0.1,3.3)	**(0.1,3.6)**	(0.0,3.5)
Chicago Fed	**1.2**	1.1	**0.5**	0.4	**0.5**	0.4	**0.9**	0.8
Median Forecast*	**1.2**	1.3	**1.0**	1.3	**1.3**	1.5	**1.6**	1.7

Model	Federal Funds Rate (Q4)							
	2013		**2014**		**2015**		**2016**	
	Dec	Sep	**Dec**	Sep	**Dec**	Sep	**Dec**	Sep
EDO	**0.1**	0.1	**0.3**	0.6	**0.8**	1.5	**1.4**	2.3
Board of Governors	--	(0.0,0.6)	**(0.0,1.5)**	(0.0,2.1)	**(0.0,2.4)**	(0.1,3.4)	**(0.2,3.1)**	(0.6,4.1)
New York Fed	**0.1**	0.1	**0.1**	0.4	**0.9**	1.3	**1.9**	2.1
	--	(0.3,0.6)	**(0.3,1.1)**	(0.3,1.5)	**(0.3,2.2)**	(0.4,2.6)	**(0.7,3.3)**	(0.8,3.6)
PRISM	**0.1**	0.1	**0.1**	0.4	**1.6**	2.0	**2.9**	3.1
Philadelphia Fed	--	(-0.5,0.6)	**(-1.3,1.6)**	(-1.4,2.1)	**(-0.7,4.1)**	(-0.5,4.5)	**(0.1,5.9)**	(0.3,6.0)
Chicago Fed	**0.1**	0.1	**0.1**	0.4	**0.5**	1.1	**1.4**	1.7
Median Forecast*	**0.1**	0.1	**0.1**	0.4	**0.9**	1.4	**1.7**	2.2

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.

Figures

Real GDP Growth

Core PCE Inflation

Federal Funds Rate

EDO — New York — PRISM — Chicago
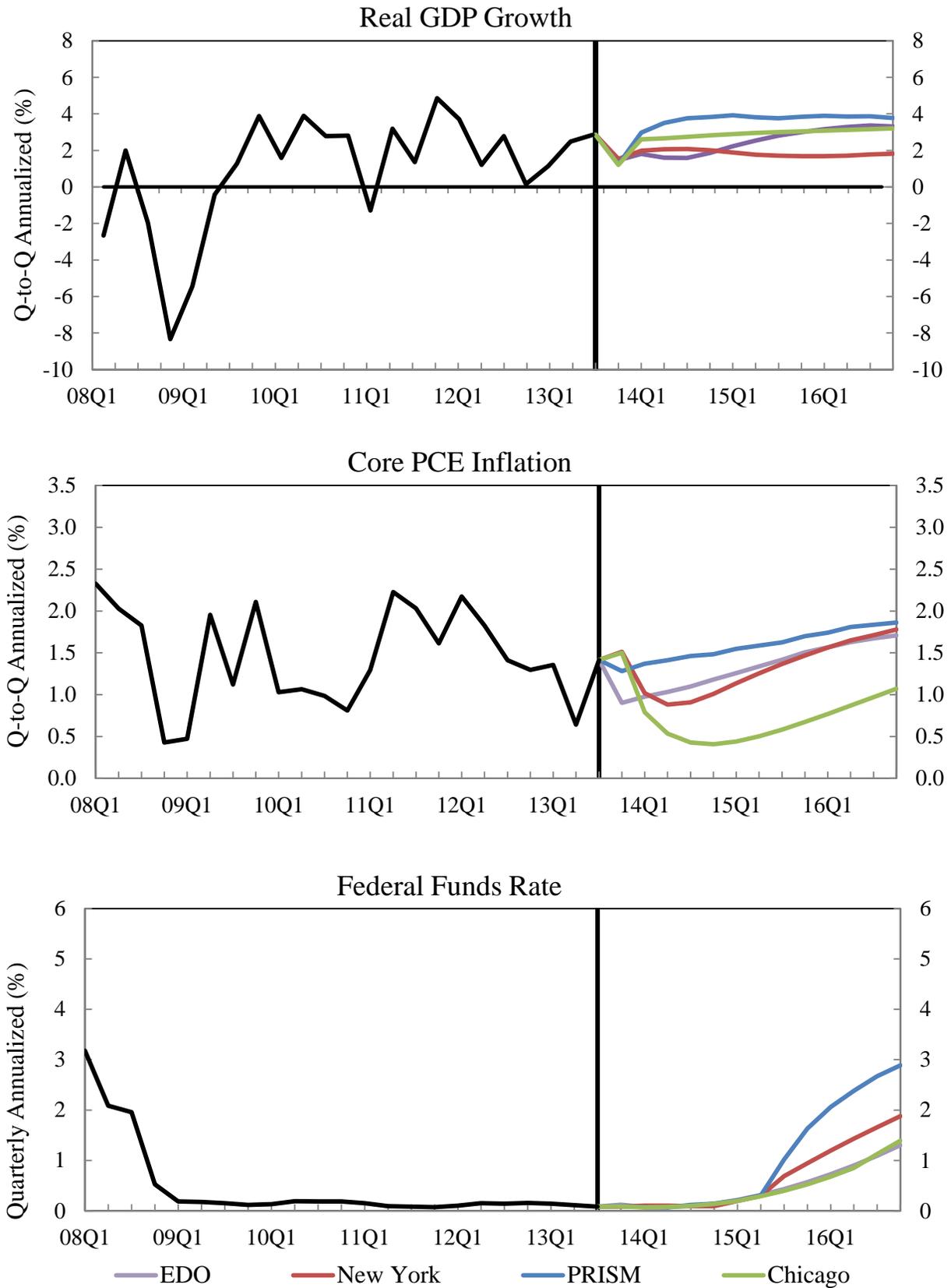
Detailed Descriptions of Individual Model Forecasts

The Chicago model

The Chicago model forecast incorporates data through 2013Q3 and uses staff projections to plug the necessary inputs for 2013Q4. The staff projections for Q4 are for real GDP growth to rise 1.2 percent as real consumption and real investment growth both decline from their Q3 values.

Additionally, we use forward guidance shocks to shape the model's expected federal funds rates through the second quarter of 2016 based on their implied values from futures market prices. The model also includes a slowly drifting inflation anchor (currently 2.3 percent) which dominates changes in long-run expected inflation and is identified by equating the 10-year average of model-based expected goods price inflation with the long-term annual average CPI inflation projection from the Survey of Professional Forecasters.

The Chicago forecasts for real GDP growth are only moderately lower than they were in September. Real GDP growth in 2013 and 2014 on a Q4/Q4 basis is now projected to be 1.9 and 2.7 percent, respectively. The growth forecast then rebounds, rising to 3 percent in 2015 and 3.1 percent in 2016, down from 3.2 and 3.5 percent, respectively, in September. With growth near or slightly above steady state (2.7 percent in our model) for the next three years, the measure of the output gap that enters our Taylor-type policy rule closes slowly over the forecast horizon, ending the fourth quarter of 2016 at -0.2 percent.

Transitory adverse demand shocks explain much of the near-term weakness in economic activity. In particular, a residual shock to the national income and product accounting identity—embodying a change in expenditures on inventories, net exports, and government purchases in the model—accounts for the majority of the weakness in GDP growth in the fourth quarter. This shock has a highly persistent negative effect on the level of GDP, but a relatively transitory impact on its growth rate.

In contrast, a neutral technology shock largely explains the persistence of weaker activity. The model interprets the weakening of consumption and investment concomitant with increasing

hours worked in the fourth quarter as an adverse innovation to neutral technology. Pushing back against this is a favorable forward guidance shock. Market expectations now hold the path of the funds rate near or below 0.5 percent through the fourth quarter of 2015, implying lift-off three quarters later than in September.

Our forecasts for inflation are essentially unchanged from September. The forecasted path for Q4/Q4 core PCE inflation declines from the 1.7 percent observed in 2012 to 1.2 percent in 2013 and 0.5 percent in 2014 (1.1 and 0.4 percent in September) before gradually increasing to 0.9 percent in 2016 (0.8 percent in September). Several large shocks to aggregate demand during the recession, particularly those to households' rate of time preference, continue to drag down our forecasts for inflation. Counteracting the deflationary effect of these shocks are contemporaneous innovations to price and wage mark-ups and the model's highly persistent inflation anchor, reflecting the stability of inflation expectations.

After the projected lift-off of the funds rate in the fourth quarter of 2015, the interest rate forecasts increase less than 25 bps per quarter. Our forecasted interest rate ends 2016 at 1.4 percent. This is 30 bps lower than the corresponding forecast in September. The decrease in our interest rate forecasts primarily reflects a later projected lift-off date.

The EDO Model

The EDO model projects average real GDP growth below its trend of 2.7 percent until mid-2015 and unemployment above 7 percent until the end of 2017. This subdued pace of real activity is accompanied by inflation gradually accelerating from a low of 0.9 percent in 2013:Q4 to about 1¾ percent by the end of 2016. In this forecast, the funds rate path through 2016:Q3 is consistent with market expectations, which indicate that private agents do not expect the federal funds rate (FFR) to lift appreciably above its effective lower bound until the second quarter of 2015.[2]

---

[2] Starting in 2008:Q4, the model is estimated using observations of the market-expected funds rate path for 11 quarters into the future.

The weak activity forecast is heavily shaped by the model's interpretation of the anticipated path of the FFR inferred from interest rate swaps, which the model attributes to a considerable extent to private agents' expectations of relatively adverse financial conditions over the forecast horizon. The aggregate risk premium returns to its early 2012 levels, lowering GDP growth and boosting unemployment well above their steady-state. However, the negative impact of adverse financial conditions is expected to be partly offset by unusually accommodative monetary policy in 2014. In addition, surprisingly low labor productivity and high inflation since the beginning of 2011 have led the model to infer a steady deterioration of aggregate supply conditions.

Thus restrained, GDP growth decelerates from 1.8 percent in 2014:Q1 to 1.6 percent in the middle of 2014, returning to trend only in 2015. Chiefly as a result of the elevated risk premiums mentioned previously, the unemployment rate rises slowly through the end of 2014, reaching a peak of 8 percent, before declining to 7.3 percent by the end of 2016. High risk premiums, along with a very persistent shift in labor supply, also account for the low trajectory of inflation in the forecast.

Since September, market-based measures of the path of the federal funds rate have come down substantially, with the exit from the zero lower bound now expected to happen 3 quarters later. Although some of this downward revision is accounted for in the model by more accommodative monetary policy, it mostly reflects weak expected demand conditions rather than unusual policy actions. Accordingly, the lower path for the funds rate has largely been translated into a signal of more pessimistic private sector expectations, leading to a downward revision of the forecasts for both activity and inflation.

PRISM

The Philadelphia Research Intertemporal Stochastic Model (PRISM) forecast is constructed using data through 2013Q3 that are then supplemented with a 2013Q4 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 expectations implied by futures market data.

PRISM forecasts acceleration in growth from the modest pace seen in 2013. While 2013Q4 real output growth is pinned down at 1.2 percent by the nowcast, the forecast calls for output growth to rise to 3 percent in the first quarter of 2014 and then to gradually rise to a 3.9 percent pace by 2015Q1. Real GDP growth then maintains a near 4 percent pace through 2016. While output growth is projected to be fairly robust, inflation remains contained below 2 percent through the forecast horizon. The forecast has the funds rate following the financial market expectation through 2015Q2 and then rising to 1.6 percent by the end of 2015 and 2.9 percent by the end of 2016.

According to PRISM, negative shocks to TFP and investment have been the primary factors holding down real output growth over the course of 2013. The model continues to see the de-trended level of output well below its steady state. 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 2013Q4 nowcast for core PCE inflation is 1.3 percent. The model then predicts a steady but gradual acceleration in core inflation over the next 3 years to a peak of 1.9 percent in 2016Q4. The principal factor accounting for below-trend core inflation over the forecast horizon is the very slow unwinding of the effects of financial shocks, which are only partially offset by the upward pressure on inflation associated with the rebound in hours worked and aggregate demand).

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 70 basis points in 2015Q3. By the end of 2016, the funds rate is projected to be at about 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.

The FRBNY Model

The FRBNY model forecasts are obtained using data released through 2013Q3, augmented for 2013Q4 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 2013Q4 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 2013Q4 staff projections and OIS rates are those that were available on November 22, 2013.

Relative to September, GDP growth forecasts for 2013, 2014 and 2015 (Q4/Q4) are unchanged at 2.0, 2.0 and 1.7 percent, respectively, while the forecast for 2016 (Q4/Q4) is marginally lower (1.7 versus 1.8 percent). In general, the model continues to project a lackluster recovery in economic activity throughout the forecast horizon. Inflation projections are overall weaker than those reported in September: mean core PCE inflation for 2013 (Q4/Q4) is projected to be 1.2 percent, below the September forecast of 1.3 percent, and the 2014 and 2015 (Q4/Q4) projections have declined relative to September to 0.9 and 1.3 percent, respectively, from 1.2 and 1.5 percent. Despite a projected increase in 2016 (to 1.7 percent, unchanged relative to September), inflation remains below the FOMC long-run goal of 2 percent throughout the whole forecast horizon.

Uncertainty around real GDP growth forecasts shifted somewhat relative to September, but remains large. The 68 percent bands cover the intervals -0.9 to 3.9 percent in 2014, -1.8 to 4.5 percent in 2015 and -1.5 to 5.0 in 2016. The forecast distribution for inflation also shifted marginally relative to September, with the 68 percent probability bands within the 0.3 to 2.4 percent interval throughout 2016.

The FRBNY forecast is driven by two main factors. On the one hand, the headwinds from the financial crisis, as captured by the effect of shocks to credit spreads and to the marginal efficiency of investment (MEI), result in low real activity, low real marginal costs, and consequently low inflation. The economy experienced large spread shocks during the Great Recession and a sequence of adverse MEI shocks afterwards. Given that these shocks have

persistent effects on output growth and inflation, financial headwinds continue to negatively affect the forecasts for these variables through the end of the forecast horizon. On the other hand, accommodative monetary policy, particularly forward-guidance, has played an important role in counteracting these headwinds, lifting output and inflation. However, the impact of past forward guidance announcements on the *level* of output, which must eventually converge to zero since monetary policy is neutral in the model, has now begun to wane. This implies a negative effect of policy on *growth*, particularly toward the end of the forecasting horizon, which largely explains why output growth is still below trend at the end of 2016.

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. This forecast is mostly driven by the endogenous response of policy to the weak economy, rather than by policy shocks. In fact, about two thirds of the FFR deviation from steady state (close to 1.5 percentage points) is accounted for by the negative contribution of MEI shocks, while anticipated policy shocks add about 70 basis points of accommodation. In this respect, the DSGE forecast is quite consistent with the September Summary of Economic Projections (SEP), which showed a cluster of FOMC participants expecting the FFR to be at or below 2% in 2016, but inflation and unemployment close to target. The FOMC minutes attributed this particular constellation of forecasts to the slow abatement of economic headwinds, implying that "the achievement of the Committee's employment and price stability objectives would likely require keeping the federal funds rate below its longer-run equilibrium value for some time even as economic conditions improved." Unlike in the SEP, however, the large and persistent undershooting of the longer-run level of the FFR in the model is not sufficient to achieve the Committee's objectives even by the end of 2016. On the contrary, the model sees GDP growth about one percentage point below steady state, inflation about half a percentage point below target, and hours worked still 4 percentage points below their long-run level in 2016. This forecasted underperformance of the economy reminds us that the level of the FFR is not by itself an indicator of policy accommodation, even if this level remains below steady state for an extended period of time. Quantitatively, our model suggests that the drag from 'financial headwinds' is large enough to depress the FFR into 2016, but that this low rate has in itself no beneficial effect on activity, since it is simply a reflection of the economy's weakness.