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Comment Andrew Levin

Over the past decade or so, researchers at academic institutions and central banks have been active in specifying and estimating dynamic stochastic general equilibrium (DSGE) models that can be used for the analysis of monetary policy.[1] While the first generation models were relatively small and stylized, more recent models typically embed a much more elaborate dynamic structure aimed at capturing key aspects of the aggregate data.[2] Indeed, a number of central banks are now employing DSGE models in the forecasting process and in formulating and communicating policy strategies.

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The views expressed in this comment are solely those of the author, and should not be interpreted as representing the views of the Board of Governors of the Federal Reserve System nor of anyone else associated with the Federal Reserve System.

1. Pioneering early studies include King and Wolman (1996, 1999); Goodfriend and King (1997); Rotemberg and Woodford (1997, 1999); Clarida, Galí, and Gertler (1999); and McCallum and Nelson (1999).

2. See Christiano, Eichenbaum, and Evans (2005); Smets and Wouters (2003); Levin et al. (2006); and Schmitt-Gröhe and Uribe (2006).

However, a crucial ongoing issue in conducting such analysis is to determine the extent to which the policy implications may be sensitive to the particular specification of the behavioral equations, the incidence of the exogenous shocks, and the econometric methodology used to estimate the model.

Harald's chapter follows this approach in addressing an interesting and highly relevant topic: he uses a medium-scale DSGE model to provide an accounting of the differences in monetary policy paths that have been observed in the euro area and the United States over the past decade. While this topic has been considered in two other recent studies—Christiano, Motto, and Rostagno (2008) and Sahuc and Smets (2008), henceforth referred to as CMR and SS, respectively—Harald's analysis involves distinct choices with respect to the model specification and the empirical approach. Thus, the fact that his analysis yields fairly similar results—namely, that the differences in policy paths are largely attributable to the specific shocks that have influenced each economy—provides important confirmation regarding the robustness of that conclusion.

In the remainder of this comment, I will highlight some of the model specification issues and then discuss the estimation results for the parameters related to monetary policy. Finally, I will take a somewhat broader perspective in considering several key factors that have influenced the evolution of the U.S. economy over the past decade and the extent to which further work is needed to incorporate these influences, perhaps in the next generation of DSGE models.

Model Specification

With twenty-three endogenous variables, Harald's model is a bit smaller than the CMR model (which has twenty-nine variables) and substantially larger than the SS model (which has "only" nine variables). Of course, a number of judgmental choices inevitably arise in specifying a model of this scale; here I would like to point out four particularly interesting modeling issues:

1. Harald's analysis follows the classical *q*-theory approach in assuming that *capital accumulation* is subject to adjustment costs that are proportional to the squared level of investment, whereas CMR and SS assumed that these adjustment costs are proportional to the squared growth rate of investment. As emphasized by Christiano, Eichenbaum, and Evans (2005), the latter specification has the advantage of being able to generate a hump-shaped response of aggregate investment in response to a monetary policy shock, consistent with the implications of structural vector autoregressions. Furthermore, while the formal microeconomic foundations of higher-order adjustment costs were initially somewhat opaque, Basu and Kimball (2003) have shown that this mechanism may be viewed as providing a reduced-form representation of an underlying framework with planning delays in investment.

2. In motivating his study, Harald emphasizes the contrasting patterns of *corporate finance* in the euro area and the United States; namely, business investment in Europe is much more likely to be financed by bank loans rather than publicly traded bonds. Nevertheless, credit market frictions are absent from Harald's model, whereas CMR incorporate the debt-contracting framework of Bernanke, Gertler, and Gilchrist (1999), henceforth denoted as BGG. From an empirical standpoint, the BGG framework could provide a means of gauging whether cross-country differences in corporate finance are associated with systematic differences in the steady-state magnitude of the external finance premium. Furthermore, the BGG framework implies endogenous variation in the external finance premium in response to the equity-to-debt ratio—a mechanism that could be particularly important in interpreting the evolution of the U.S. economy over a decade of relatively large swings in equity prices.

3. Harald's study is also motivated by the contrasting structure of *labor markets* in the euro area and the United States; for example, differences in unionization rates, unemployment compensation, and various other aspects of labor market regulation and tax policies. In light of these considerations, Harald's model allows for sluggishness in real wage adjustment, following the formulation of Blanchard and Galí (2006). In contrast to CMR and SS, however, Harald rules out any role for nominal wage inertia in influencing the evolution of the macroeconomy.

4. One other aspect of Harald's model specification is also worth noting; namely, his formulation of the *monetary policy rule*. As in the enormous literature on Taylor-style rules, he assumes that the short-term interest rate responds to the lagged interest rate as well as to deviations of inflation from target; however, he departs from that literature (and from CMR and SS) in assuming that policy responds to movements in real marginal cost instead of movements in the output gap. Because he assumes that nominal wages are completely flexible, this distinction is irrelevant in his model; that is, the output gap is proportional to the deviation of real marginal cost from steady state. In the data, however, there is a much weaker correlation between real marginal cost (as measured by the inverse of the labor share) and the Hodrick-Prescott (HP)-filtered output gap; hence, compared with more conventional specifications, Harald's approach might yield very different empirical implications about the extent to which movements in the stance of monetary policy should be attributed to systematic versus idiosyncratic components.

Specification of Exogenous Disturbances

Harald's empirical approach involves five exogenous disturbances—namely, shocks to the level of total factor productivity (TFP), the level of investment efficiency, the wage markup, the labor tax rate, and the monetary policy rule. The number of disturbances is a bit smaller than in the SS model (seven shocks) and noticeably more parsimonious than the CMR model (fifteen shocks). Of course, the choice of shocks is nontrivial in seeking to provide a meaningful accounting for the evolution of macroeconomic outcomes in the euro area and the United States over the past decade. For example, one could imagine the desirability of including persistent shocks to the *growth rates* of TFP and investment efficiency that might enable the model to match the "new economy" experience of the United States more closely. Similarly, as discussed further following, the model might need to allow for exogenous time variation in government spending and in the public debt target in order to capture the evolution of U.S. fiscal policy. Finally, a number of observers have used the term "opportunistic disinflation" to characterize U.S. monetary policy from the late 1980s through the late 1990s, suggesting that the model might also need to allow for gradual time variation in the implicit inflation goal, as in the CMR and SS models.

Specification of Observed Variables

The number of observed time series in Harald's chapter matches the number of exogenous disturbances (as in SS and CMR), thereby facilitating inference about the actual incidence of shocks hitting each economy during the sample period. Thus, with only five shocks, Harald evidently faced some fairly difficult choices in picking a specific set of five observed variables: the consumption share of gross domestic product (GDP); labor productivity (that is, output per worker); the inflation rate of the GDP price deflator; the short-term nominal interest rate; and the ratio of government debt to GDP. A few comments are worth noting regarding this selection of observed variables:

1. In stark contrast to SS and CMR, Harald's empirical specification does not employ any direct measure of real GDP growth or HP-filtered levels of output or employment. Thus, the interpretation of some key macroeconomic fluctuations (such as the downturn in U.S. economic activity in 2001) is based on inferences from movements in labor productivity and the consumption share.
2. Given Harald's objective of analyzing the role of credit market imperfections in the evolution of the macroeconomy, it might have been ideal if the empirical analysis could have included some measure(s) of domestic credit and/or risk premiums on corporate debt.
3. Harald's analysis follows the bulk of the empirical DSGE literature in measuring inflation in terms of the GDP price deflator, which reflects value added rather than the actual prices charged for goods and services. However, it should be noted that oil import price shocks can have a perverse impact on this measure of inflation, because a value added deflator puts positive weight on output price changes and *negative* weight on input price changes.

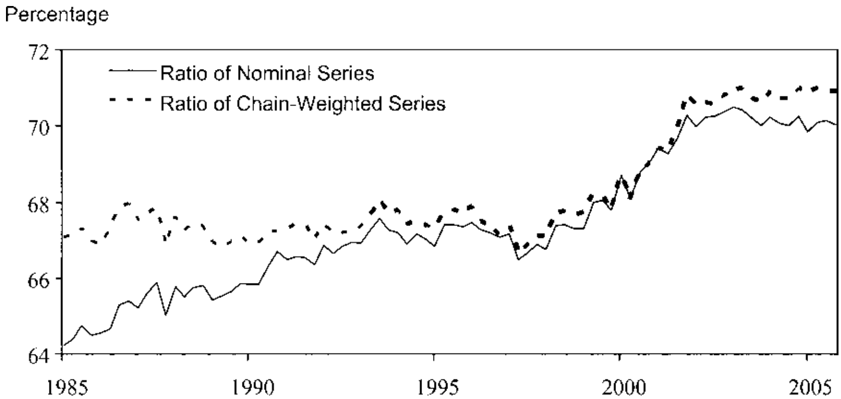

Fig. 9C.1 The evolution of the U.S. consumption share of GDP

4. Finally, while the consumption share of GDP may be reasonably viewed as stationary for the Euro Area, this series is clearly *not* stationary for the United States; that is, the savings rate exhibits a stochastic trend over the two decades of the sample period, and hence the series should presumably be HP-filtered rather than simply demeaned. Moreover, a stochastic trend is present in the relative price of consumption goods versus investment goods; hence, as shown in figure 9C.1 of this comment, the ratio of chain-weighted real consumption to chain-weighted real GDP (the measure used in Harald's analysis) is systematically different from the nominal consumption share of nominal GDP, with potentially important implications for the estimation results and the interpretation of recent macroeconomic developments.[3]

Estimated Parameters

Although it would be interesting to discuss the entire set of parameter estimates, in light of the space constraints I will simply make a few remarks about the inferences regarding the parameters of the monetary policy rule:

$$i_t = \zeta_{iL} i_{t-1} + (1 - \zeta_{iL})[\zeta_\pi \hat{\pi}_t + \zeta_x \widehat{\mathrm{mc}}_t + u_{it}].$$

As previously noted, the policy rate i_t is adjusted in response to its own lagged value as well as to the current inflation rate $\hat{\pi}_t$ and to real marginal cost $\widehat{\mathrm{mc}}_t$, where each variable is expressed in percentage points, and the hat indicates that the variable is measured as a deviation from steady state.

For both the euro area and the United States, the parameter estimates

3. With nonstationary relative prices, the ratio of chain-weighted real consumption to chain-weighted real GDP does not have any clear economic interpretation; for further discussion, see Whelan (2000); Edge, Laubach, and Williams (2004); and Smets and Wouters (2007).

for ζ_π are only slightly larger than unity, implying that monetary policy in each economy has responded only weakly to inflation over the past two decades, and indeed has barely even satisfied the Taylor principle. However, this finding contrasts sharply with conventional wisdom and with most previous empirical studies. For example, Smets and Wouters (2003) employed the following specification of the monetary policy rule in their analysis of euro area data:

$$i_t = \gamma_{iL} i_{t-1} + (1 - \gamma_{iL})[\hat{\pi}_{t-1} + \gamma_\pi(\hat{\pi}_{t-1} - \pi^*_{t-1}) + \gamma_y \hat{y}_{t-1}]$$
$$+ \gamma_{\Delta\pi}\Delta\hat{\pi}_t + \gamma_{\Delta y}\Delta\hat{y}_{t-1} + \varepsilon_{it},$$

and obtained a posterior mean of 1.7 for γ_π, while Levin et al. (2006) used the same policy rule specification in analyzing U.S. data and obtained a posterior mean of 2.7 for ζ_π; using Harald's notation, these estimates would imply that ζ_π has a value of about 3 for the euro area and about 4 for the United States.

Several factors may be relevant in explaining these contrasting results. First, as already noted, Harald's specification assumes that monetary policy responds to movements in real marginal cost, whereas the policy rule specification in most other studies involves some explicit measure of the output gap. Second, Harald's formulation explains any remaining higher-order dynamics of monetary policy in terms of serially correlated disturbances to the policy rule, whereas other recent studies find that policy responds significantly not only to levels but also to *changes* in the inflation rate and the output gap. Finally, Harald's specification assumes a constant inflation target, whereas other recent studies have allowed the central bank's inflation objective to vary over time. This assumption could have significant consequences for characterizing the evolution of monetary policy in each economy, because the average inflation rate for the synthetic euro area exhibited a gradual decline in conjunction with the approach to European Monetary Union, while the U.S. inflation rate exhibited a significant downward shift in the early 1990s that some observers have described as *opportunistic disinflation.*[4]

Interpreting the Evolution of the U.S. Economy

Now I would like to take a somewhat broader perspective in discussing several factors that have had important influences on the evolution of the U.S. economy over the past decade. I hope that these comments will be useful in highlighting some significant issues with respect to the specification of the behavioral equations and the disturbances in empirical DSGE models.

4. Levin and Piger (2004) report evidence of downward shifts in euro area and U.S. inflation rates in the early 1990s, while Orphanides and Wilcox (2002) discuss the characteristics of opportunistic disinflation.

1. The U.S. economy experienced a remarkably large swing in productivity growth over the past decade. The upward part of this swing has often been referred to as the "new economy" era, but fewer commentators seem to have emphasized that this era has apparently now drawn to a close. Thus, while Harald's model—as in a number of other empirical DSGE studies—is specified in terms of shocks to the *level* of productivity, it seems that allowing for persistent shocks to the *growth rate* of productivity would be important in accounting for the recent evolution of the macroeconomy. Furthermore, Harald's analysis—like most other studies—assumes that every shock to the economy can be immediately observed by private agents and policymakers, whereas the reality is that even professional forecasters face a substantial *real-time* challenge in distinguishing persistent swings in productivity growth from the more common variety of transitory fluctuations. For example, Tetlow and Ironside (2007) have recently documented the magnitude of the revisions in FRB/US model-based assessments of the path of U.S. potential GDP growth. For illustrative purposes, figure 9C.2 of this comment depicts five vintages of these FRB/US assessments and underscores the extent to which the characteristics of the initial upward swing in productivity growth were not obvious at its onset in the mid-1990s, while the more recent downturn in potential output growth was not apparent in the real-time assessments that were constructed in early 2001 and mid-2003. Given this pattern of revisions, it seems clear that the next generation of DSGE models needs to incorporate real-time data filtering as well as other forms of learning about the structure and state of the economy.

2. The U.S. fiscal outlook has also been subject to dramatic swings over the past decade. For example, at a Congressional hearing in early 2001, Chairman Greenspan summarized the fiscal outlook at that juncture: "Indeed,

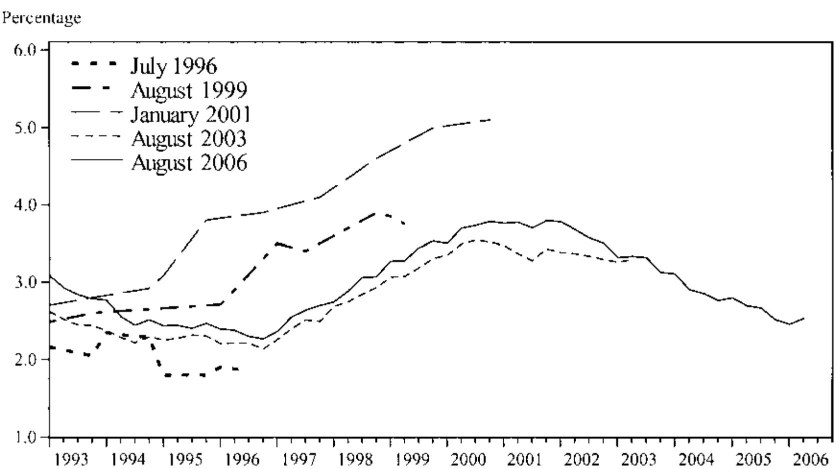

Fig. 9C.2 Real-time assessments of U.S. potential GDP growth

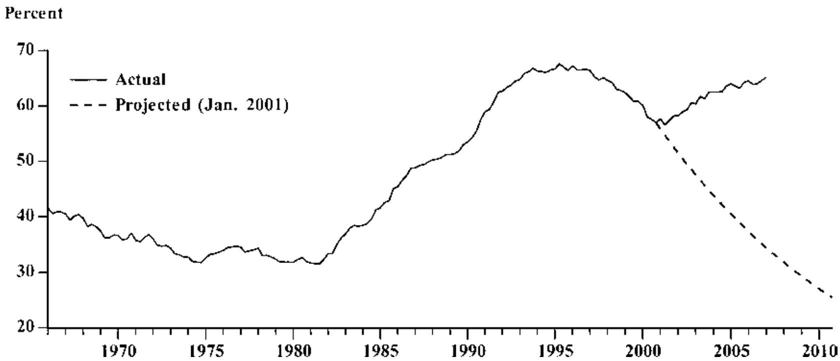

Fig. 9C.3 The evolution of the U.S. government debt/GDP ratio

in almost any credible baseline scenario, short of a major and prolonged economic contraction, the full benefits of debt reduction are now achieved before the end of this decade[. . .]The time has come, in my judgment, to consider a budgetary strategy that is consistent with a preemptive smoothing of the glide path to zero federal debt or, more realistically, to the level of federal debt that is an effective irreducible minimum" (Greenspan 2001).

Nevertheless, as shown in figure 9C.3 of this comment, the ratio of U.S. government debt to GDP has not declined toward zero as projected, but in fact has increased noticeably over the past half-decade or so. This outcome reflects the combined influences of the tax reduction measures that were adopted in early 2001 (partly in response to rosy fiscal projections) and the increased government expenditures that have occurred in the wake of the 9/11 terrorist attacks. The shock to U.S. real government consumption spending is also visible in the left panel of figure 9.3 of Harald's chapter; however, his empirical specification only involves shocks to the tax rate, not to government spending. Figure 9C.3 of this comment also highlights the extent to which the U.S. government debt/GDP ratio does *not* appear to be mean stationary, at least not over the four decades from 1965 to 2005. Thus, to provide a reasonable empirical accounting for the evolution of government debt in a DSGE framework, one might need to incorporate some combination of shocks to the debt target or perhaps some form of nonlinear error correction mechanisms in the determination of government spending and taxes.

3. As noted previously, the BGG framework provides a means of gauging the evolution of credit market frictions over the past decade. In particular, while the wedge between the cost of external and internal finance is not directly observable, the cross-section and time-series behavior of this premium have recently been estimated by Levin, Natalucci, and Zakrajsek (2004), using a novel panel data set that includes balance sheet information,

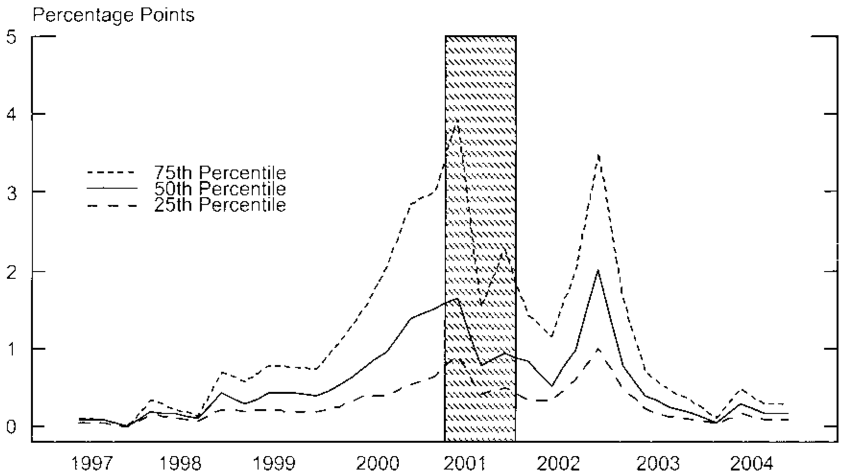

Fig. 9C.4 The evolution of the U.S. external finance premium

measures of expected default risk, and credit spreads on publicly-traded debt for about 800 U.S. firms.

As shown in figure 9C.4 of this comment, the external finance premium for the sales-weighted median firm in this sample was negligible during the expansionary periods of 1997 to 1999 and 2003 to 2004, but increased markedly in mid-2000 (prior to the onset of the 2001 recession) and remained elevated until the end of 2002. Indeed, the cost of external finance rose even more sharply for the upper seventy-fifth percentile of the cross-sectional distribution; that is, for firms in the sample representing one-fourth of total sales. Given that these estimates are based on financial data for relatively large firms with publicly traded equity and debt, one may well presume that smaller firms would tend to face even larger swings in the external finance premium or perhaps face credit rationing due to collateral constraints—a mechanism not incorporated in the BGG framework. Thus, incorporating credit market frictions into empirical DSGE models (such as CMR) should be a priority for further research.

4. Over the past few years, there have also been substantial swings in the U.S. inflation outlook. For example, in early 2004, Chairman Greenspan gave an address to the American Economic Association in which he stated, "A two-decade long decline in inflation . . . eventually brought us to the current state of price stability[. . .]Our goal of price stability was achieved by most analysts' definition by mid-2003. Unstinting and largely preemptive efforts over two decades had finally paid off" (Greenspan 2004).

As shown in figure 9C.5, real-time data at that point in time indicated that core inflation—as measured by the annual average inflation rate for personal consumption expenditures (PCE), excluding food and energy—had fallen

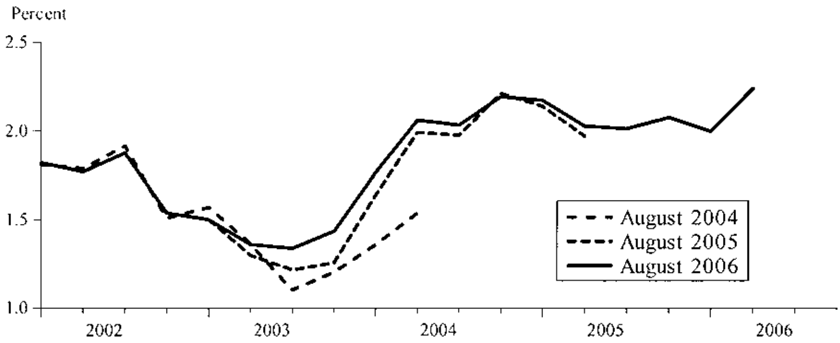

Fig. 9C.5 The real-time evolution of the U.S. core PCE inflation rate

to around 1 percent as of mid-2003. Thus, assuming that this measure of inflation exhibits an upward bias of about 50 basis points or more due to unobserved improvements in the quality of goods and services, it would certainly be reasonable to infer that the true underlying rate of consumer inflation was quite close to zero; that is, "price stability." In contrast, more recent vintages of data have led to a markedly different inflation outlook, partly because the core PCE inflation rates for 2003 and 2004 were subsequently revised upwards by nearly 75 basis points, and partly because the post-2001 decline in core inflation turned out to be largely transitory. These developments highlight the extent to which the implications of real-time data—and the subsequent revision process—need to be incorporated into the next generation of empirical DSGE models.

5. Finally, it should be noted that Harald's analysis (like most other recent studies) assumes that the central bank's inflation goal is completely transparent and credible to the private sector. This assumption might be reasonable in some empirical contexts; for example, from 1976 through 1998, the Deutsche Bundesbank regularly communicated to the public regarding its medium-term inflation objective, and expectations regarding the German inflation outlook appear to have been firmly anchored over this period.[5] However, evidence from financial market data and surveys of professional forecasters suggests that in recent years U.S. long-run inflation expectations have not been as firmly anchored as in other economies—such as the euro area, Sweden, and the United Kingdom—where the central bank has a more explicit inflation objective.[6]

For example, as shown in figure 9C.6 of this comment, the cross-sectional dispersion of professional forecasters' long-run inflation expectations has

5. See Coenen, Levin, and Christoffel (2007).

6. See Levin, Natalucci, and Piger (2004); Gürkaynak, Levin, and Swanson (2007); and Beechey, Johannsen, and Levin (2007).

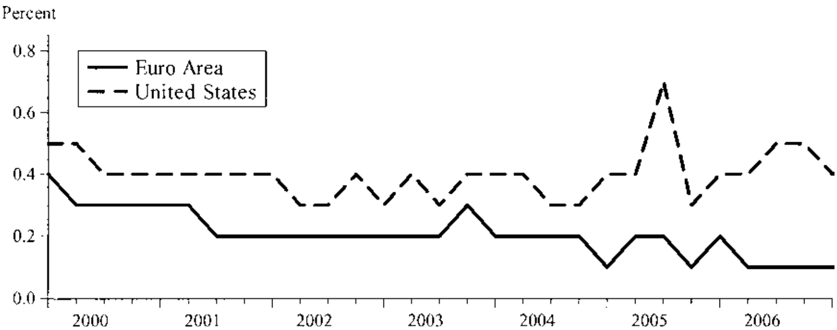

Fig. 9C.6 Dispersion in professional forecasters' long-run inflation expectations

been noticeably greater in the United States than in the euro area; indeed, in late 2006, the standard deviation across forecasters was only 0.1 percent for the Euro Area and 0.4 to 0.5 percent for the United States.[7] In this light, it is worth noting that the Federal Reserve has recently implemented significant enhancements to its communication strategy, including the regular publication of Federal Open Market Committee (FOMC) members' forecasts for consumer inflation three years ahead—a horizon that provides further information about each member's assessment of the inflation rate that best promotes the Federal Reserve's dual mandate of price stability and maximum sustainable employment.[8]

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7. These series are taken from the European Central Bank (ECB) Survey of Professional Forecasters and the Federal Reserve Bank of Philadelphia Survey of Professional Forecasters, respectively. Dispersion is calculated as the cross-sectional standard deviation of responses to the respective survey questions. Forecasts for the Euro Area pertain to five-year-ahead inflation in the euro area harmonized index of consumer prices (HICP). Forecasts for the United States pertain to the inflation rate for the consumer price index (CPI) over the coming ten years.

8. See Bernanke (2007) and Mishkin (2007).

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