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Abstract

The paper discusses monetary policy stance assessment in times of both conventional and unconventional monetary policy. Prior to the financial crisis, many central banks had one primary target and one instrument, the short-term rate. Over the years there was a consensus that the rule-of-thumb characterization known as the Taylor rule could broadly outline the policy and supplement discretionary policy. In the post-crisis period, one instrument was no longer sufficient and unconventional measures, such as large-scale asset purchases and forward guidance, were put in the policy makers' agendas. Therefore, assessing the impact of the implemented unconventional measures and understanding the overall monetary policy stance in traditional ways no longer suffices, while finding new suitable ways is not an easy task. The shadow rate literature is able to circumvent the lower bound constraint and incorporate the monetary policy accommodation provided by the asset purchase programmes. However, application of the shadow rate estimates, in order to assess monetary policy stance, has to be done with caution since the estimates lack robustness.

Keywords: monetary policy stance, Taylor rule, equilibrium real rate of interest, unconventional monetary policy, shadow rates

1 Introduction

A conventional economic textbook explains that monetary policy can boost economic activity and inflation by lowering short-term interest rates, or depress economic activity and inflation by raising interest rates. The simplest way to define monetary policy stance is to say that the central bank sets the short-term interest rate higher than the equilibrium real rate of interest (ERRI) when actual inflation exceeds the target (monetary policy is then considered contractionary) or vice versa, in case of accommodative monetary policy.[1] Thus, monetary policy stance is assessed based not on levels of, for example, short-term interest rates, but on their divergences from some benchmark level, which is driven by economic conditions and not monetary policy actions.

The quest to describe the stance of monetary policy always goes in line with monetary policy formation. In seeking their goals, central banks set their policy instruments, such as the main interest rate, at the level which guarantees that the policy is either contractionary (meant to slow the economy and prevent overheating) or accommodative (meant to stimulate economic growth). Still, characterization of the monetary policy stance is not an easy task. First, policy makers need to identify an appropriate indicator for monetary policy. In times of standard monetary policy, the short term interest rate set by central banks is considered a good indicator. Second, once the indicator is identified, a benchmark level has to be devised, against which the policy indicator is compared. The benchmark, such as the ERRI, is not a perfect measure and comes with its own caveats. Nevertheless, the monetary policy stance can be assessed using the policy rate and the ERRI.

In order to make decisions on the short-term interest rate more effective, it is important for the central bank to have an idea of the underlying level of real interest rates that correspond to a neutral monetary policy stance and of the factors that drive this underlying rate. A benchmark rate is essentially a function of factors like productivity and population growth, fiscal policy and risk premia, institutional structure of financial markets (Giammarioli and Valla, 2003). Therefore, central banks set their policy rate by taking into account at the same time a benchmark rate (such as the ERRI) and the real rate gap to determine the policy stance.

Before the financial crisis, there was a consensus that the gap between a short-rate policy rate and the ERRI is a good measure to proxy the monetary policy stance. Monetary policy was primarily conducted in terms of the target interest rate and academic research applied the central bank policy rate as a proxy for monetary policy, exploiting its correlations in dynamic regressions with other macroeconomics variables. In the post-crisis period, academics and policy makers find themselves in the environment where the traditional monetary policy instrument (i.e., short-term interest rate) is at the lower bound and non-standard measures, such as large-scale asset purchase programmes and forward guidance, are used to implement monetary policy.[2]

[1] Sometimes the equilibrium real rate of interest (ERRI) is called the natural or the neutral real rate of interest. In this work, we use the term ERRI.

[2] For example, from December 2008 to December 2015, the Fed effective federal funds rate was in the 0 to 1/4% range, the ECB's rate for the main refinancing operations is below 1% since mid-2012 and was set to 0 in March 2016, and the deposit facility rate has been below 0 since mid-2014, while the Bank of England's official

Therefore, assessing the impact of implemented unconventional measures and understanding (describing) the overall monetary policy stance in traditional ways (such as using the Taylor rule) no longer suffice. Finding new suitable ways is not an easy task – as it happens, it is quite a challenging one.

Over the years – until the major economies started living in the low interest rates environment – there was a consensus that the rule-of-thumb characterization known as the Taylor rule (Taylor, 1993), which prescribes the central bank interest rate as a function of inflation and a measure of economic activity, could broadly outline the policy and if not substitute, then supplement the discretionary policy. The policy-rule prescriptions, such as the Taylor-rule, are also subject to the following caveats. First, Taylor-rule type policy prescriptions are based on past relationships that do not take into account measures currently employed by unconventional policy. Second, the intercept for the rule (a measure of the ERRI) is set to its pre-crisis level and is assumed to stay constant. However, as discussed in Section 3, the estimates of the ERRI, though always surrounded by great uncertainty, have been declining. Debates on model-based ERRI are not only concentrated on the validity of estimates, but also include discussions on whether the Taylor-type rules should include time-varying estimates of the ERRI.

In the pre-crisis period, the Taylor-type rules were appealing because of the focus on the short-term interest rate as the main monetary policy instrument, its simplicity and intuitiveness. However, the question is whether in the post-crisis period the Taylor-type rules are still applicable when the policy instruments employed by the central banks in many countries became more complex and the measures that are now called "unconventional" are likely to become the new normal. J. Taylor did not advocate for the proposed rule to be used mechanically without an ounce of discretion (Taylor, 1993). He claimed that in some episodes of policy making there might be a need to take into account other than the proposed factors. However, whether it is appropriate to deviate from rule-based policy making, is still a topic under debate. What is more, given the unconventional central bank policies, no single indicator is seen as a consistent representation of the policy, especially if considered in both the pre- and post-crisis periods.

The challenges that policy makers have to deal with when facing the lower bound are the following: the rate that typically summarizes monetary policy stance, short-term interest rate, is bounded and no longer informative, while research is still in pursuit of finding a good alternative rate. The challenge lies not only in finding a new measure or new way to describe central banks' policies in the post-crisis period, but also to "merge" the new measures with historical ones in a coherent way, in order to describe the full set of historical data along with the recent one. Consequently, traditional VAR models – a workhorse in monetary policy analysis – cannot be used on a full period sample because of regime changes in policy rate (policy rate provides basis for empirical analysis of interaction between policy and the economy). What is more, non-standard monetary policy measures primarily work through signalling and portfolio rebalancing channels, this way affecting long term interest rates.

rate has been below 1% since March 2009.

The shadow rate literature is able to circumvent the lower bound constraint, incorporate the monetary policy accommodation provided by the asset purchase programmes, therefore suggesting that the shadow short-term rate is potentially a good measure for assessing the monetary policy stance. Shadow rates are an appealing construct to answer the question of "what policy rate would be in line with the observed yield curve if a policy rate were unbounded". Despite the described appeal of the shadow rates, their use in monetary policy stance assessment has to be done with caution, since the shadow rate estimates lack robustness.

The paper is structured as follows. Section 2 gives a brief description of the Taylor rule and its developments. Section 3 describes the concept of the equilibrium real rate of interest and overviews recent model-based findings on its trends in the post-crisis period and possible implications for the policy rule prescriptions. Section 4 overviews recent studies on the shadow rates estimation and application in monetary policy analysis. Section 5 discusses other measures such as various indices in the assessment of the monetary policy stance. Section 6 concludes.

2 Taylor rule

The Taylor rule, introduced by John B. Taylor in 1993 and based on the U.S. monetary policy experience in the late 1980s and early 1990s, numerically relates the central bank policy rate to the state of the economy (Taylor, 1993). Back in the 1990s, Taylor argued for the rule-based behavior of central banks as an important part in commitment for transparency and time-consistency. The rule was derived using observations of U.S. policy actions and the economy during the period in which the Fed monetary policy is widely considered to have been unusually successful. Therefore, Taylor argued that the rule based on such behavior could have normative significance.

According to Taylor, the nominal interest rate, given some level of ERRI, should respond to differences between actual inflation rates and target inflation (desired level of inflation) rates and between actual and potential GDP (full capital and labor employment level) in the following way (Taylor, 1999):

$$i_t = r_t^* + \pi_t + \alpha(\pi_t - \pi_t^*) + \beta(y_t - \bar{y}_t), \tag{1}$$

where i_t is the nominal short-term interest rate (policy rate), π_t^* is inflation target, r_t^* is the ERRI, y_t is the logarithm of real GDP, $\bar{y}_t$ is the logarithm of potential GDP, and $\alpha > 0$, $\beta > 0$ are coefficients.[3] The Taylor rule prescription indicates the monetary policy stance: for example, in case of contractionary monetary policy, the rule prescribes a higher nominal interest rate, when inflation is above its target or GDP is above its full-employment level, and lower in the opposite case, when there is a need to stimulate the economy. The coefficients α, β provide relative weights between the two deviations. The Taylor rule clearly illustrates the role of the ERRI as a benchmark for describing monetary policy stance: the real interest rate $(i_t - \pi_t)$ exceeds

[3] John B. Taylor assumed that the target inflation rate, and equilibrium real interest rate were equal to 2%, and the coefficients, α, β were equal to a 0.5 and 0.5 respectively.

the equilibrium interest rate, i.e., monetary policy is contractionary, when inflation exceeds the target rate and vice versa for the case of accommodative monetary policy.

Since the publication of Taylor's paper there have been many cases of estimating the rule, fitting it to other central bank policy decisions (such as the ECB). In general, this stream of literature produced many applications using Taylor-type rules with approaches such as different forward-looking specifications or using different variables and estimation methods. The number and the range of estimates is vast.[4]

The Taylor rule (or rules, since there are multiple rules of this type) provides monetary policy makers with a simple rule that prescribes how a policy maker should adjust its policy instrument – interest rate – systematically when responding to developments in inflation and economic conditions. Since the beginning of the 1990s, central banks have incorporated various Taylor-type rules into macroeconomic models that are used to understand and forecast the economy. However, there is a distinction between a simple rule and optimal monetary policy, which should take into account future developments in the economic outlook, possible macroeconomic shocks and the fact that it takes some time for monetary policy to have an effect on the real economy. Woodford (2001) concludes that the Taylor rule incorporates several features of an optimal monetary policy, because it prescribes the response to fluctuations in inflation or the output gap, which tends to stabilize those variables. However, Woodford (2001) also notes that the Taylor-rule, at least the original version, could be improved by, for example, allowing the intercept (the ERRI) to vary if disturbances occur. The author also states that an optimal rule should incorporate inertia in interest rate adjustment, in order to have a more gradual adjustment of the level of interest rates.

The Taylor rule embodies several important underlying assumptions (Bernanke, 2015). First, the Taylor rule assumes that the policy makers agree on the size of the output gap, while the amount of slack in the labor markets is still an ongoing debate. Second, the assumption of a fixed equilibrium real rate of interest is currently being questioned, since there is a debate whether the level of this rate is lower than the assumed level in the Taylor rule. Third, the policy prescriptions made by the Taylor rule are very sensitive to the choice of data sources and coefficient weights (Labonte, 2012). For example, the output gap is a constructed series that can be estimated using a number of different methods; also, various inflation measures created from different data series can diverge for short periods of time. Kozicki (1999) shows that different data sources can change the Taylor rule's recommended interest rate. Comparing a series of Taylor rules using many of these different measures can give a more robust benchmark for the stance of monetary policy than using just one set of variables. Lastly, no guidance exists on what to do with the prescribed rate in a negative territory, while major central banks have lived with the lower bound problem for a few years already. The standard rules prescribe negative rates way below of what actual policy rates can move to.

[4] For the summary of estimation results for studies attempting to determine the Taylor-type rule of the ECB, see, for example, Gori (2016).

Despite the above-mentioned caveats, the appeal of Taylor rule lies in the fact that when referring to this rule, policy makers only need to consider the two key data points that describe what state the economy is in. However, this appeal is shadowed by the fact that the natural level of the economy is not observed. In order to know what this level is, one needs to estimate measures such as the level of GDP, employment, and interest rates, when the economy works at its potential. Such measurements provide estimates (which are also time-varying) with an amount of uncertainty. While the Taylor rule assumes that the ERRI is fixed, various recent studies question this assumption and provide evidence that the ERRI has reached levels that are lower than what is assumed amongst policy makers. Therefore, the assumption about the natural state of the economy may cause false policy prescriptions during the time – such as the post-crisis period – when it seems to fail to hold.

3 Equilibrium real rate of interest

The ERRI is consistent with the economy operating at its full potential with a stable rate of inflation. The concept was coined by the Swedish economist Knut Wicksell, who argued that the general price level would rise or fall indefinitely as long as the real interest rate deviates from the neutral (equilibrium or natural) real interest rate.

The concept of the equilibrium real rate of interest is based on the idea that there are real economic forces that lead the economy to a long-term equilibrium at full employment with a stable inflation. According to this, monetary policy should steer its rates to that equilibrium rate, which provides a sort of anchor. This way, central banks can meet the price stability mandate. If the real equilibrium rate is decreasing, then failure to accompany the new levels of the ERRI would leave the economy with too-high borrowing costs compared to the return on investment. This would discourage investment and consumption and generate recessionary and deflationary pressures. The rate is an important concept for assessing the stance of monetary policy. When major central banks target inflation, the central bank's decisions depend on whether the actual rates lie below or above this benchmark rate. Therefore, a guidepost such as the ERRI allows to do just that.

3.1 A model based real rate of interest: methods and recent findings

Since the rate is a hypothetical construct and cannot be observed directly, but is estimated instead, different models yield different estimates, which are also not very precise. Despite this, policy makers may use this measure as a guidepost in deciding whether policy is too tight or too loose (Lubik and Matthes, 2015). The methods used to estimate this measure vary, including semi-structural time series models with Kalman filtering and dynamic stochastic general equilibrium (DSGE) models.

Laubach and Williams (2003) introduced a semi-structural model, where the equilibrium rate of interest depends on the trend growth of potential output and on a time-varying unobserved component that represents all the other factors. The authors rely on an empirical model, where they link interest rates to measures of economic activity by specifying a simple theoretical relationship that consumption and investment are affected by changes in the real interest rate. The model is estimated using the Kalman filter.[5] The method in Laubach and Williams (2003) is popular because it provides a compromise between the DSGE approach and ad hoc statistical approaches.[6]

Laubach and Williams (2016), building on Laubach and Williams (2003), apply a multivariate model that incorporates movements in inflation, output and interest rates. The ERRI is defined implicitly by assuming the absence of inflationary or deflationary pressures. The rate is assumed to depend on the estimated contemporaneous trend growth rate of potential output and a time-varying unobserved component (assumed to follow a random walk process) that captures the effects of other unspecified influences on the natural rate. The estimates of the ERRI display two periods of significant declines: a moderate secular decline over the two decades preceding the Great Recession, and a second, more substantial decline during the Great Recession.

Holston et al. (2016) estimate the ERRI, output gaps and the trend growth rates in four economies – Canada, the euro area, the U.K., and the U.S.. The authors find that estimates exhibit significant variation over time and have declined over the past years (although estimates tend to be highly imprecise). They also show that movements in the trend growth rate are an important determinant of changes in the ERRI estimates. Fig. 1 shows estimates in Holston et al. (2016). On the eve of the global financial crisis the estimates were between 2 and 2.5%, but by 2015, all four estimates had dropped sharply, to 1.5% for Canada and the United Kingdom, below 1% for the United States, and below zero for the euro area. The estimates of the ERRI differ, but they all exhibit a downward trend that is especially observed since the beginning of the financial crisis. The rate of interest is mainly explained by a significant decline in the estimated trend growth rates found in all four economies, together with other highly-persistent factors, including some global ones. These findings suggest that declining ERRI estimates are an international phenomenon and, therefore, stem in large part from developments common to a number of countries.

[5]The Kalman filter works in such a way that the estimate of the unobserved rate is adjusted based on how far away the model's prediction of GDP is from actual GDP given the behavior of other variables. If, for example, actual GDP is lower than what the model predicts, then the policy rate is likely to be less stimulative than the model had predicted and, hence, that the real rate gap was more positive than previously thought. The filter then adjusts the estimate of ERRI accordingly.

[6]For applications for the euro area, see also Garnier and Wilhelmsen (2005); Fries et al. (2016).

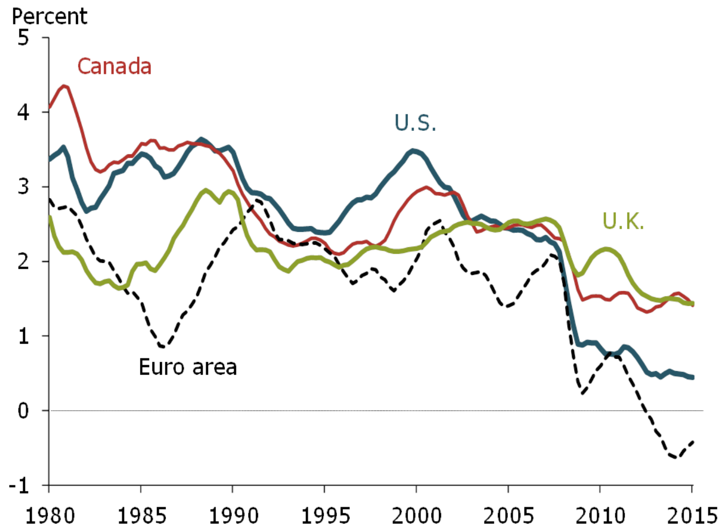

Fig. 1. Estimated inflation-adjusted natural rates of interest. Source: Holston, Laubach, and Williams (2016); data are four-quarter moving averages. Reprinted from John C. Williams, 'Monetary Policy in a Low R-star World', *FRBSF Economic Letter* 2016-23 (2016), Federal Reserve Bank of San Francisco.

Cukierman (2016) questions the view that the ERRI is substantially lower than it used to be. The author points out that existing literature on the ERRI mainly focuses on estimation of riskless rates, even though investment activity depends mainly on risky rates. The author refers to the findings that during crisis times riskless and risky rates tend to move in opposite directions. He conceptualizes and estimates a risky equilibrium rate. Cukierman (2016) argues that this rate better reflects the impact of the financial system on economic activity and is practically always bounded away from the lower bound. The author argues that the recent post-crisis estimates of the riskless equilibrium rate experienced a downward trend because of upward shifts in the propensity to save, downward shifts in the propensity to invest and an increase in the relative demand for safe assets. However, the author also argues that the estimates are likely to be biased downward due to changes in credit rationing (lower credit due to the decrease in the value of financial assets in the wake of the financial crisis) and the financial stability motive, which are both not considered in the monetary rule during the crisis when modelling and estimating the ERRI. Because of this reason, the decrease in aggregate demand in the model is interpreted as a decrease in the ERRI. Cukierman (2016) argues that during periods of financial distress monetary policy should be aimed at the equilibrium risky rate rather than the riskless rate.

When discussing the possible causes for the observed low levels of the ERRI estimates, for example, Constâncio (2016) argues that the estimates suggest that the components, such as long-term inflation expectations, the nominal term premium, the expected path of the short-term real rate over the life of the asset have all contributed to the decline in equilibrium interest rates. Pedersen (2015) also lists possible drivers that put a downward pressure on the ERRI: productivity slow-down, quality of labor input (the quality of the labor force grows slower and hence the economy is not able to implement new technology fast enough), demographics (the population is stagnant and life expectancy is increasing rapidly, leading to lower potential growth and higher savings), savings-glut (IMF, 2014), low demand for investments from advanced economies, and fiscal austerity leading to extra savings from governments.

The findings of declining and abnormally low levels of the equilibrium real rate of interest supports the secular stagnation hypothesis. Summers (2013, 2014) invoked the concept of "secular stagnation" and argued that due to secular stagnation there would be a reduced growth trend and it would be hard to achieve adequate growth in industrialized countries and the decline in the equilibrium real rate of interest would follow.[7] The interpretation of this hypothesis varies, but the underlying idea is, that given the low levels of the ERRI, equilibrium state of the economy can only be achieved if the real interest rate is negative (and, thus, cannot be achieved through conventional central-bank policies when inflation is low) and until then demand remains insufficient, desired levels of saving exceed desired levels of investment, and the unemployment rate remains high. If the secular stagnation hypothesis is true with low inflation it is hard to achieve negative real interest rates and the economy is stuck below the natural level with insufficient demand and excessive saving. Therefore, traditional monetary policy tools are inadequate and unconventional monetary policy tools are likely to become regular (the new normal) (Yellen, 2016).

3.2 The equilibrium real rate of interest inside the Taylor rule

Taylor and Wieland (2016) discuss the ERRI and increasing model-based research on the decline of estimated time-varying rates (as discussed, for example, in Lubik and Matthes (2015) and Holston et al. (2016)). Increasing research on the equilibrium rates lead to suggestions to modify monetary policy rule accordingly or to quit using it altogether. However, there is no straightforward answer on how to adjust the Taylor rule, taking into account recent observations in the ERRI. The authors examine the underlying methodology used to estimate the ERRI. They discuss omitted variable/equation bias and show that alternative simulation techniques (based on the framework in, for example, Smets and Wouters (2007)) can radically change the results. The authors conclude that the time-varying ERRI estimates are not yet useful for application to current monetary policy. Important variables relating to structural and monetary policies are omitted and the observed decline in the estimated rates might be due to shifts in policies and regulations.

Taylor and Wieland (2016) also discuss Janet Yellen's suggestion (Yellen, 2015) to use the time-varying ERRI estimates in the Taylor rule (see Fig. 2). Yellen in her speech in 2015, argued that in order to continue following the policy prescriptions by the Taylor rule, policy makers need to change the assumption that the ERRI is fixed at 2%, since empirical evidence suggests that it has been lower for quite some time. Fig. 2 shows policy prescriptions for the U.S. by the standard Taylor rule together with the Taylor rule adjusted by Yellen's assumptions. The line

[7] The concept of "secular stagnation" was first put forward by the economist Alvin Hansen in the 1930s.

"Yellen Taylor rule" shows the results when the constant 2% equilibrium real rate of interest is substituted by the estimates from Laubach and Williams (2016).

Taylor and Wieland (2016) dismiss such "discretion", arguing that changes in the ERRI assumed in the policy rule must be backed by comprehensive research. They also suggest that changes in the ERRI must be accompanied by changes in other variables, such as potential GDP. The line "Consistent Yellen Taylor rule" in Fig. 2 shows the results when the ERRI and the output gap are substituted with the estimates of Laubach and Williams (2016). Once all changes are included, the policy recommendation by the Taylor rule might be a higher policy rate than the rate suggested by the rule after changing only the equilibrium rate.

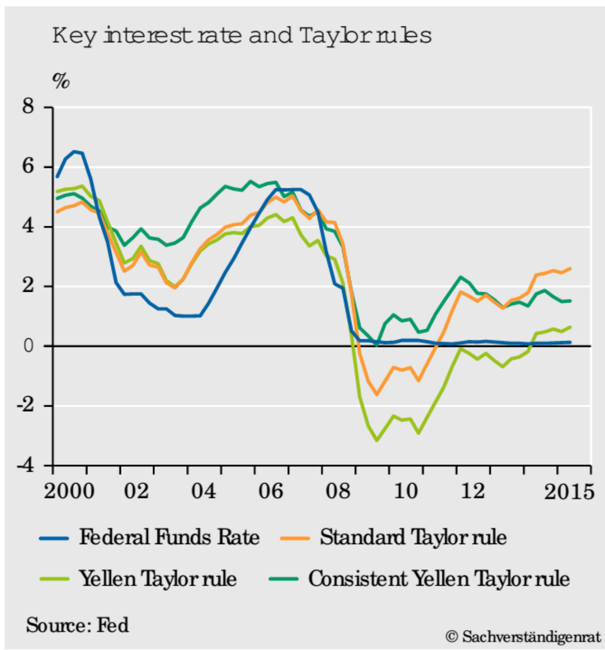

Fig. 2. Modified Taylor rule. Reprinted from *Annual Report, the German Council of Economic Experts, November 2015.*

4 At the lower bound: shadow rates

4.1 The concept

Central banks can no longer afford to use one instrument to achieve their inflation target, because soon after the crisis the policy makers in advanced economies started working in the lower bound environment. The central banks started using other measures, such as forward guidance, asset purchases, targeted long-term lending operations, which were soon labeled as unconventional policy measures. Therefore, the standard ways of assessing the monetary policy stance were no longer as informative as they used to be, since the actual interest was no longer informative as to what was going on in the agendas of policy makers. Furthermore, when the central banks engage in unconventional policies, there is the need for a single indicator that could describe the monetary policy stance in both the pre- as well as post-crisis periods.

Unconventional policy measures, such as asset purchases and forward guidance, influence the economy by (directly) affecting the whole yield curve – not only the short end of the curve, but also long-term interest rates and future policy rate expectations. The models that estimate term premia dynamics can be used to analyse unconventional monetary policy. One can employ the Gaussian affine term structure models, which are designed to extract term premia and future expectation from the yield curve by imposing linear structure on the yield curve factors, cross-sectional dependence and linear short rate dynamics. However, when the economy is in the lower bound environment, Gaussian affine term structure models fit the data poorly. Therefore, recent literature on term structure of interest rates focuses on the so called shadow rate term structure models (SRTMs).[8]

The shadow rate model of the dynamics of the interest rates when the short end of the yield curve (short maturities) is near zero (or slightly below) was pioneered by Black (1995). Research on shadow rates assumes that the short-term interest rate is the maximum of the shadow rate and a lower bound (since there is always an option to hold currency at no cost):

$$i_t = \max(\underline{i}, s_t) \tag{2}$$

where i_t is a short-term interest rate, $\underline{i}$ is a lower bound, and s_t is the shadow rate. The maximum function means that if the shadow rate is greater than the lower bound, then the short-rate is equal to the shadow rate, and if the shadow rate is lower than the lower bound, the lower bound is binding. Therefore, the shadow rate can be negative, while the observed short-term interest rate will be the truncated version due to the binding lower bound. This way, the shadow rate literature is able to circumvent the lower bound constraint and incorporate the monetary policy accommodation provided by the asset purchase programmes. Therefore, this literature suggests that the shadow short-term rate is a relevant measure for assessing the monetary policy stance.

Shadow rates are an appealing construct to answer the question "what policy rate would be in line with the observed yield curve if a policy rate were unbounded". Nevertheless, these estimated rates are exposed to the following critique. A construct, such as a shadow rate, is not directly observed and is estimated using asset pricing models and the term structure of interest rates. This makes the estimated shadow rate model-specific: different models (may) generate different estimates due to different estimation techniques, different maturities used in constructing the yield curves, or different values for the lower bound parameter. While the standard monetary policy rate is directly observable and all lenders and borrowers are exposed to it, this is not the case with the shadow rates. Nevertheless, shadow rates have the advantage of not being bound and also allow analysis of the heterogeneity of the monetary policy stance across countries of a monetary union, provided there is yield curve data at a country level

[8]SRTMs with many factors and with no closed-form solution for bond pricing equations can be estimated (at the same time estimating shadow rates) using numerical methods.

(Damjanović and Masten, 2016).

Despite the fact, that shadow rates are not directly observable and are empirical constructs which depend on model specification, these rates are increasingly used in monetary policy research. Literature on the usefulness of shadow short rate estimates for modelling monetary policy is mainly centered around U.S. data, but the discussion on the usage in the Eurosystem's monetary policy is increasing. It seems that currently shadow short rates are the main measure consistently used to summarize unconventional monetary policy stance. It can be combined with estimated policy Taylor-type rules to discuss the degree of accommodation as in Hakkio and Kahn (2014) or used within a VAR framework to study monetary policy shocks as in Huber and Punzi (2016), Damjanović and Masten (2016).

4.2 Estimation methods and results

Literature has developed several methodologies for constructing shadow rates using information from the term structure of interest rates (see, for example, Bauer and Rudebusch, 2015; Wu and Xia, 2016; Krippner, 2013b,a; Lemke and Vladu, 2015). Wu and Xia (2016) applied a nonlinear shadow rate term structure model (SRTSM) for analysis of an economy operating near the lower bound. They showed that such a model describes the data well and can be used to summarize the macroeconomic effects of unconventional monetary policy. They demonstrate that the shadow rate correlates with the macroeconomic variables in the lower bound environment in a similar way as the policy short-term interest rate does when it is not bounded.[9] Wu and Xia (2016) show that it is possible to view the interaction between monetary policy and macroeconomic variables with the historic and current time series as a continuum, using a hybrid of the policy rate and the shadow rate. This can be done by substituting the policy rate for the shadow rate during periods when the policy rate is at the lower bound and continue using monetary economic models. Wu and Xia (2016) argue that their shadow rate can be used to summarize the impact of Fed actions including quantitative easing.[10] Krippner (2013b,a) also applies a shadow rate term structure model, but use the model in continuous time and estimate the shadow rates using OIS (overnight index swap) rates, not yield curves as in Wu and Xia (2016). The shadow rate estimates in Krippner (2013a) differ from the ones in Wu and Xia (2016): the estimated levels are much lower in Krippner (2013a) for the period of 2010–2014; however, the direction of change through time in the estimates is comparable in the two studies.

Bauer and Rudebusch (2015) apply a dynamic term structure model (DTSM) and focus on the estimation of monetary policy expectations at the lower bound. To measure monetary policy expectations the authors use two metrics, namely, the time until lift-off (when the interest rates

[9]The authors did so using two exercises. In a structural break test, they substituted the shadow rate estimates for the federal funds rate in some macroeconomic models for the lower bound period, and showed that the model behaved similarly before and during the lower bound period. In another exercise, they plotted how variables, such as industrial production, consumer prices, and unemployment, dynamically responded to monetary-policy shocks before and during the lower bound period. They showed that the shadow rate moves in the lower bound the way the federal funds rate would if negative rates were possible.

[10]By continuing their work, they provided the shadow rate estimates for the euro area and the U.K..

are expected to leave the lower bounds) and the subsequent pace of tightening (the expected increase in interest rates following lift-off). They show that shadow-rate DTSMs can produce good forecasts for the distribution of future short interest rates. They find that the shadow-rate DTSMs with macroeconomic variables provide a statistically significant and economically relevant improvement in fit and forecasting performance compared to standard Gaussian affine DTSMs.

Comunale and Striaukas (2017) replicate the results of Bauer and Rudebusch (2015) and Wu and Xia (2016) for the euro area using different values of the lower bound parameter, see Fig. 3.[11] The estimated shadow rate for the euro area is not robust with respect to the choice of the lower bound parameter ($\underline{i}$ in (2)). Following Wu and Xia (2016) the time varying lower bound parameter for the euro area is set using changing levels of the deposit facility rate. As a result, the shadow rate's level changes dramatically (see the right-hand-side panel of Fig. 3). The shadow rate estimates using the Bauer and Rudebusch (2015) framework are more robust with respect to the setting of the lower bound parameter (see the left-hand-side panel of Fig. 3). It is not straightforward to compare the shadow rate estimates across different model frameworks, but, in general, shadow rates for the euro area declined more upon the start of the ECB's asset purchase programme.

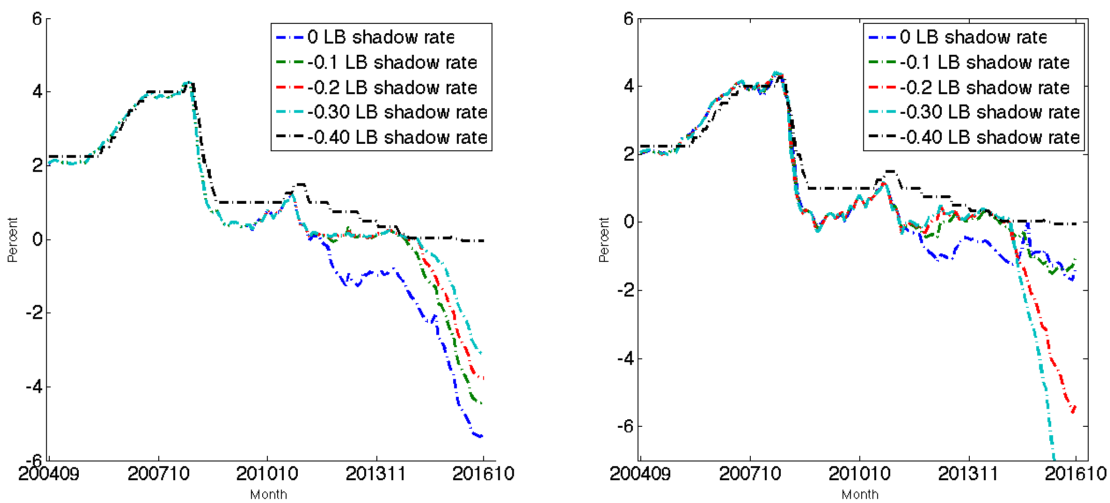

Fig. 3. Replications by Comunale and Striaukas (2017) of the shadow short rates: Bauer and Rudebusch (2015) (right panel) vs Wu and Xia (2016) (left panel) estimates with different levels of the lower bound parameter.

The main critique of the shadow rate term structure models is that shadow rate estimates are sensitive to the specific short-term yields included in the model and the assumption about the lower bound, $\underline{i}$, whose choice is largely arbitrary. Bauer and Rudebusch (2015) argue that, given their findings of a lack of robustness in estimates, the use of estimated shadow rates as

[11]The replications provided in Fig. 3 are based on yield curve data estimated from filtered bond prices.

indicators of the monetary policy at the lower bound is problematic.

4.3 Interpreting shadow rates

When we plot the recommended policy rate according to the Taylor rule in the period with the policy rate at the lower bound, the recommended short-term rate is negative. When unconventional policy measures are used, the literature provides one possible way to tell if those policies are working by comparing shadow short-term nominal interest rates with the prescribed policy rate by the Taylor rule. If, for example, the estimated shadow policy rate is lower than the rate recommended by the Taylor-type prescription, then the monetary policy stance may be more accommodative than the monetary policy rule (based on traditional relationships) recommends.

Hakkio and Kahn (2014) measure the overall stance of monetary policy with a shadow federal funds rate estimated in Wu and Xia (2016). The shadow rate is then compared to the prescriptions of two estimated policy Taylor-type rules (Fig. 4). Based on these comparisons they conclude that the implementation of unconventional measures in the U.S. was not sufficient, because the shadow rate did not go down as far as the estimated policy rules prescribed. Later, at some point between mid-2011 and mid-2012, the prescribed federal funds rate went above the shadow rate, indicating that there has been more accommodation than the Taylor-type rules have prescribed. Similar conclusion is provided by Bullard (2012) who compared shadow rates

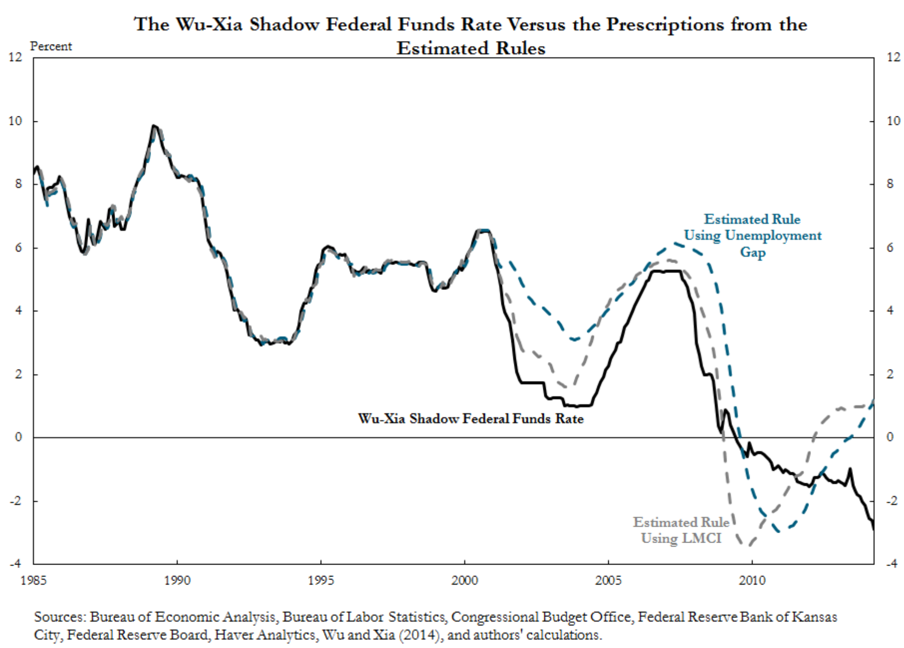

Fig. 4. The prescriptions of the two estimated Taylor-type rules (the estimated rule with the LMCI and the rule with the unemployment gap) and Wu and Xia (2016) shadow federal funds rate for the US. Reprinted from Hakkio and Kahn (2014).

in Krippner (2013a) and the interest rate prescribed by the Taylor rule for the U.S. – the author concluded that the monetary policy in the U.S. was too loose somewhere in between 2011 and end of 2012.

One way to interpret estimated shadow rates is to say something about the time of the lift-off of the policy rate from the lower bound. During times of the ZLB, there is a question of how long such a situation would last and when one can expect this to change. The yield curve conveys information about the expectations of the market participant for the timing of the lift off. Bauer and Rudebusch (2013) show that their approach accurately estimates the duration of the lower bound period, i.e., time to lift-off, and this estimate is very robust to different choices of the lower bound parameter.

5 Other monetary policy stance measures

Measures, other than the benchmark interest rate, have been developed in the literature to describe the policy stance. Lombardi and Zhu (2014) argue that the shadow interest rates (estimated á la Black (1995)) are noisy indicators of monetary policy stance, especially in turbulent times when volatility is high, because many factors other than the policy measures experience changes. The authors apply a dynamic factor model and, after pooling together a dataset with variables that are closely associated with different types of monetary policy operations, map their changes onto a single shadow federal funds rate (the alternative to the shadow rate estimated á la Black (1995)). They argue that their shadow rate indicates how the funds rate would have behaved if policy makers could have driven it negative. The authors argue that their approach is model-free and provides a synthetic measure of monetary policy that is more comprehensive as it summarises many different facets of policy and yet remains directly comparable to the federal funds rate. Fig. 5 shows shadow rates from Lombardi and Zhu (2014), Wu and Xia (2016) and Krippner (2013a) together with the Fed rate. We see that the levels of the shadow rate estimates differ in the period of the lower bound. However, the direction of change through time is more or less comparable, though in some periods the shadow rates of Lombardi and Zhu (2014) are more comparable to the shadow rates of Krippner (2013a) and in others – to the ones of Wu and Xia (2016).

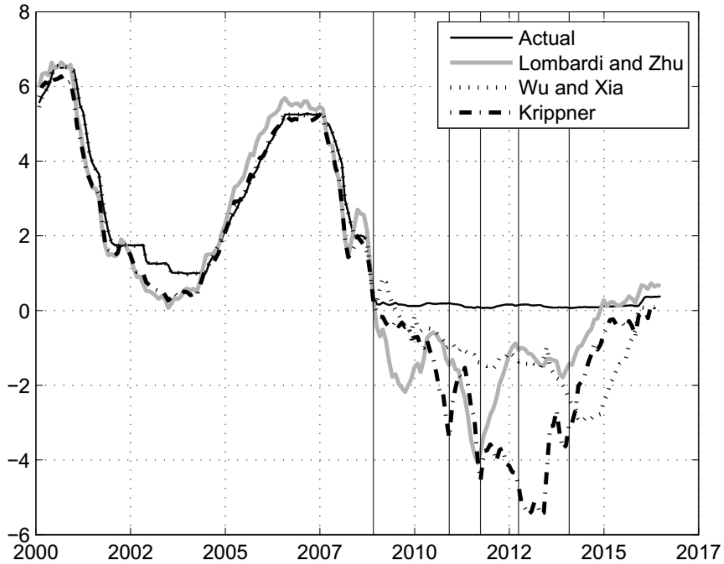

Fig. 5. Shadow rates by Lombardi and Zhu (2014), Wu and Xia (2016) and Krippner (2013a). Reprinted from Lombardi and Zhu (2014)

The indices may be used to say something about monetary policy stance. Financial conditions indexes (FCI) incorporate information from a broad set of variables indicating borrowing conditions in the economy; therefore, these indexes avoid the shortcomings of the policy rules based on the short-term interest rates. FCI is measured with the purpose of reflecting financial conditions and can be used to explore further macro-financial linkages in the economy (see, for example, Angelopoulou et al., 2014; Matheson, 2012). The literature on financial conditions indexes originated from evidence on the importance of financial variables in monetary policy transmission (see credit channel literature, e.g., Bernanke and Gertler (1995)). The FCI literature focuses on a broad range of variables describing conditions in the financial system and the stance of monetary policy. The measures are aggregated into the index using weights derived using, for example, principal component analysis (extracting the common movement among the financial variables) or measuring the impact of each indicator on the macroeconomy (structural or reduced-form models).

However, in order for the index to say something about the level of accommodation in the monetary policy stance, one needs to benchmark it against some measure. One way to do so is to compare the current levels with the historical averages. Another way is to condition the index on the business cycle (Wacker et al., 2014). The idea is to use a benchmark: to “purge” the index from business cycle effects (similarly to what is done in the Taylor-type rules for the short-term rate). When FCI is conditioned on the state of the economy (for example, each indicator is purged of the effects of inflation and economic activity and then aggregated by means of principal component analysis or using macroeconomic weights into FCI), one can interpret its levels as the degree of financing conditions relative to the level of accommodation that has been observed in similar macroeconomic circumstances in the past. However, one also needs to keep in mind that FCIs may raise concerns about the reverse causality issue, especially, when central banks provide forward guidance on the future developments of policy rates and asset purchase programmes.

Angelopoulou et al. (2014) construct indices (with a number of indicators describing financial market conditions and the stance of monetary policy) which both exclude and include monetary policy variables in order to examine the impact of monetary policy in the euro area. Using principal components analysis, they construct two indices: one with and one without the effect of monetary policy (for the period of 2003–2011). In their analysis, monetary policy stance is understood as the level of the policy rate and the net provision of liquidity by the Eurosystem. Therefore, they assess the monetary policy stance by comparing FCIs with and without monetary policy. They find that in the period of 2003–2011 monetary policy has been "leaning against the wind": in periods of worsening financial conditions, monetary policy has mitigated it, while in periods of loosening financial conditions – monetary policy has contributed to it.

Kucharčuková et al. (2016) follow the logic of Lombardi and Zhu (2014) and calculate a synthetic index, which represents the euro area monetary conditions and incorporates both conventional and unconventional instruments. The authors include interest rates, monetary aggregates, selected ECB balance sheet items and the exchange rate and use a dynamic factor model. Their index is similar to a shadow rate: it tracks the interest rate instrument closely in normal times and tracks how unconventional measures propagate monetary conditions in times when policy rate is bounded. Kucharčuková et al. (2016) show that their index is a good synthetic measure of the euro area monetary policy, because it allows generating similar results as in a classical structural VAR analysis using only the short-term interest rate.

6 Conclusions

We have described the monetary policy stance assessment during the periods of both standard and non-standard monetary policy. Prior to the financial crisis, major central banks had one primary target and one instrument, the short-term rate. In the post-crisis period, many policy makers faced economic development which required unconventional policy making. Thus, one instrument no longer sufficed and unconventional measures, such as big scale asset purchases and forward guidance, together with the negative rates, were put in the policy makers' agendas. The standard rules prescribe negative rates way below what actual policy rates can move to and there is no guidance on what to do with the prescribed rate in a negative territory, while major central banks face the lower bound.

Another concern and the topic under debate is the low levels of the estimated ERRI. The low level of these rates are a result of the long-term forces which were combined with the adverse implications of the global financial crisis and the sovereign debt crisis. A textbook prescription for the use of the ERRI is quite clear: to steer the policy rate according to the estimated levels of the equilibrium rate. However, in practice this exercise is not quite as simple. The challenges include the conceptual and measurement issues, also the current lower bound, which prevent policy makers from lowering the policy rate according to the current estimates of the equilibrium rate. All these reasons make application of the equilibrium rate in monetary policy less straightforward.

The shadow rate literature is able to circumvent the lower bound constraint and incorporate the monetary policy accommodation provided by the asset purchase programmes. Therefore, this literature suggests that the shadow short-term rate is a relevant measure for assessing the monetary policy stance. However, the application of the shadow rate estimates in order to assess monetary policy stance has to be done with caution since the estimates lack robustness.

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