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An interest rate model for the eurozone and the US

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KEY FACTS IN BRIEF

Our extended interest rate model offers possible explanations for key interest rates, money market rates and long-term interest rates in the eurozone and the US that offer a high level of adaptability to the actual developments. The main results are set out below:

- The Fed's "new normal": the US Federal Reserve's pattern of behavior has changed considerably during the course of the financial crisis. Today, the Fed is probably assuming a much lower natural interest rate than it was before the crisis. If the reaction pattern we have identified for the period from 1990 to 2008 were to apply, then the US key rate would currently come to around 3.5%.

- Shift in ECB policy: the start of QE saw the ECB switch from a relatively stable pattern of behavior in terms of interest rate policy to an even more expansive course. While it was fairly easy to follow the ECB's interest rate policy reaction pattern from 2000 onwards based on inflation developments and the output gap, it will be virtually impossible to explain key interest rates of zero in the future in an environment where capacity utilization is close to normal and inflation is expected to pick up.

- QE effect on long-term rates significant, but not uniform: the impact of quantitative easing on US long-term interest rates in the period from 2009 to 2013 does not reveal a uniform pattern. QE actually served more to push interest rates up initially. What is more, until only recently, low inflation expectations were responsible for nudging US long-term interest rates down. In the eurozone, the unconventional measures taken by the ECB have played a key role in determining the yield level. It is estimated that the ECB's bond purchases have shaved almost 60 basis points off the yield on ten-year bonds.

- Current pattern of behavior could result in extremely low interest rates sticking around for some time to come: if the Fed remains true to its current behavior pattern, then, based on assumptions that appear to be plausible, it is likely to lift the federal funds rate only very slightly to 1% between now and the end of 2018. US long-term interest rates will have risen to 2.6% by the end of 2018. German long-term interest rates will also have risen to only around 1.5% by the end of 2018.

- Central banks are free to decide how quickly they want things to return to normal: if the Fed and the ECB abandon their very expansionary stance more quickly than expected, then our calculations suggest that the upward trend in yields on the bond market would be much more pronounced. The previous behavior patterns would justify a key rate hike to almost 3% in the US and over 2% in the eurozone by the end of 2018. In this alternative scenario, the US long-term rate rises to 3.2% and its German counterpart to 2.2% by the end of 2018.

AN INTEREST RATE MODEL FOR THE EUROZONE AND THE US

Short-term and long-term interest rates in the US, and particularly in Europe, are still sitting at a very low level. In the eurozone, the yield on ten-year benchmark bonds (ten-year German government bonds) has actually been hovering around the zero mark for half a year or so. In our Working Paper published in June 2015, entitled "ECB asset purchase program leaves substantial mark on yields", we had presented an econometric approach for German long-term interest rates which, based on the European and US money market rates, the ECB's asset purchase program and the US long-term interest rates, is capable of explaining more than 98% of the German interest rate fluctuations since 2000. So monetary policy influences and the international correlations between yields play a key role in determining German long-term rates. This, however, left one question unanswered, namely: what determines monetary policy on this and the other side of the Atlantic and how can US long-term interest rates be explained? After all, isn't the monetary approach to explaining the German long-term rates based on very conventional parameters like economic growth, employment and inflation?

This prompted us to develop an extended interest rate model that attempts to explain not only German long-term rates, but also US long-term rates, money market rates and key interest rates in both economic areas over the course of time. The explanations for the key interest rates are based on reaction functions derived from modified Taylor Rule approaches. Due to the inclusion of time series from the national accounts, the approaches could not be estimated using monthly data, but only using quarterly data.

Interest rate policy of the US Fed

Since the 1990s, any attempt to explain the interest rate policy pursued by central banks has focused on the Taylor Rule. As a monetary policy reaction function, it is based on two real economic decision-making parameters: "deviation between inflation and long-term target inflation" and the "output gap" (or "unemployment gap"[1]), as well as on the long-term targets for both parameters. Explicitly, the original Taylor Rule reads $i_t = \bar{r} + \bar{\pi} + \alpha_1(\pi_t - \bar{\pi}) + \alpha_2\tilde{y}_t$, where $\bar{r}$ is the natural real interest rate, π_t is the current inflation rate, $\bar{\pi}$ is the long-term inflation target and $\tilde{y}_t$ is the output gap, i.e. the relative deviation between macroeconomic production and its potential level.[2] It is often argued that, as it adapts so well, the Taylor rule should be used not only for descriptive purposes, but rather as a sort of normative guideline for structuring interest rate policy. Prior to the financial crisis, for example, the original Taylor Rule was usually considered to be a suitable empirical approximation of the actual key rate policy pursued by the US monetary authorities, meaning that it increasingly established itself as the preferred explanatory approach.

The macroeconomic implications of the financial crisis at the end of 2008, however, called for drastic cuts in the US key rate to virtually zero, as well as for a number of unconventional monetary policy measures designed to preserve the Fed's ability to act even in a zero interest rate environment. If the original Taylor Rule had formed the normative basis for the key rate decision made by the Open Market Committee at the time, then we ought to have seen negative interest rates in theory. Instead, various measures were taken that left the realm of conventional monetary policy, meaning that an ex-post description of US key rates based on a reaction function in the style of the original Taylor Rule was no longer adequate. Consequently, performing a rule-based assessment of the future key rate trajectory became more of a challenge. This is also likely to have promoted the increased use of preparatory measures by the central banks regarding the future course of monetary policy, also known as "forward guidance".

A large number of indicators suggest that the structure of the original reaction function underwent drastic changes in the course of the financial crisis. This could be due both to the inherent consequences of a change in monetary policy behavior, and to upheaval that was relevant from a macroeconomic perspective and could not be directly determined by the monetary policy pursued by the central banks. The former would

[1] The original Taylor Rule of 1999 is based on the production gap as opposed to the unemployment gap. In one of our previous research papers, however, we had shown that it makes sense to use the unemployment gap due to the nature of the Fed's dual mandate. As a result, the rest of this paper is based on the unemployment gap as the second determining factor (Allianz Research Paper no. 171).
[2] For more detailed information on the original Tayler Rule, see: Broyer, C., Heise, M. & Hofmann, T. (2014). Monetary policy exit scenarios in the euro area and in the US. Allianz Research Paper no. 171.

definitely have resulted in the reweighting of the original determining factors within the Taylor Rule. The latter factor (namely the external upheaval) in particular, however, is often cited as one of the key arguments justifying the extremely loose monetary policy pursued by the central banks. The central idea is that global supply and demand factors, lower trend productivity growth and a general slowdown in economic growth have recently been putting considerable pressure on the natural real interest rate. The natural real interest rate is significant because it is consistent with the potential level of labor and capital utilization. This means that, in times of buoyant economic momentum and relatively high future returns on investment, it should be at a fairly high level. By contrast, phases of weak growth marked by a lack of investment opportunities and low levels of profitability should push interest rates down.[3] If we rely on current estimates[4], then the natural real interest rate is currently at an all-time low in global terms. This would mean that the Fed's room for maneuver to implement an interest rate hike is considerably restricted, because it has to bring its inflation-adjusted key rate closer into line with the low natural real interest rate in order to ultimately achieve the utilization of the labor market and the available capital resources.

In light of the above, the question arises as to whether the Fed will once again assume a higher natural real interest rate in the event of a sustained upswing, gradually moving closer back into line with its old reaction pattern. At least a partial return to the original Taylor Rule would appear plausible. The speed of such a return can be measured using a Taylor Rule modified as set out below.

Since it has been possible, ever since interest rates touched the zero bound, to see the unconventional monetary policy measures more or less as a substitute for conventional rate moves, the following adjustment to the interest rate reaction function would appear appropriate. The insertion of a dummy variable is designed to achieve two objectives: first, to guarantee that key rates are effectively limited to a minimum level of zero percent and second, to allow us to estimate the return of monetary policy to "normal conditions" following the end of the unconventional measures. In order to meet these two requirements, the dummy variable has to become more significant in times when the central bank turns its back on conventional interest rate policy measures, i.e. when quantitative easing comes into force, thus reducing the significance of the previous parameters. This means that the dummy variable includes not only the impact of the unconventional intervention, but also the direct consequences of a drop in the natural interest rate level, even though their individual impact is not specified further. When it comes to evaluating the extent to which the weighting of the original parameters has shifted in the direction of the previous level following the end of the QE program, there is no need to do so either, because aggregating the unconventional interventions and the exogenous factors is sufficient to construct a counterweight to the normal situation.

So the aim is more to assess the significance of the Taylor Rule at the present point in time than to assess the continuing effects of the unconventional monetary policy.

A Taylor Rule modified in this matter facilitates an adequate description of the key rate structure before the start of the financial crisis, and also takes into account the "suspension" of the Taylor Rule when quantitative easing was introduced in the US.

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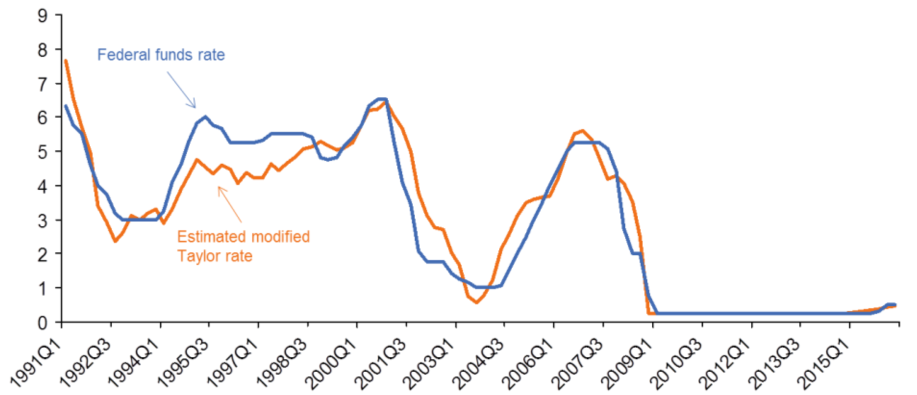
[3] Bernanke, Ben S. (2015). Why are interest rates so low? Brookings Institution.

[4] Holston, K., Laubach, T., & Williams, J. (2016, July). Measuring the natural rate of interest: International trends and determinants. In NBER International Seminar on Macroeconomics 2016. Journal of International Economics (Elsevier).

$$i_t - \bar{\pi} = \bar{r} + \alpha_\pi(\pi_t - \bar{\pi})(1 - D_{QE,t}) + \alpha_u(u_t - \bar{u})(1 - D_{QE,t}) + \alpha_{QE}D_{QE,t} + \epsilon_t$$

The resulting Taylor-type estimating equation is based on the Fed's dual mandate to keep the rate of inflation π_t) at a target($\bar{\pi}$) of around 2 percent in the long term and, at the same time, push the unemployment rate (u_t) back down to its natural level ($\bar{u}$). The interaction between the dummy variable and the original parameters of the Taylor Rule also guarantees a key rate that is not in negative territory. The results of the estimate are based on quarterly data for the period from 1991 (Q1) to 2016 (Q2). The inflation rate used here is the standard core inflation rate of the US Bureau of Labor Statistics. The core inflation rate is the annual change in the consumer price index after adjustments to remove food and energy prices from the equation in order to eliminate temporary price fluctuations. In order to determine the deviation between the current employment situation and the "normal situation", we have applied the natural unemployment rate as set out in the estimates of the Congressional Budget Office.

Federal funds rate and estimated modified Taylor rate



Source: Thomson Reuters Datastream, own calculations.

In the period leading up to the end of 2008, the results of our estimate of a modified interest rate rule are similar to comparable estimates of a Taylor-type reaction function, as intended. This means that, in the estimated value, the key rate reacts to an increase in the rate of inflation of one percentage point, assuming that the labor market situation remains the same, with a coefficient of around 1.57. The key rate also falls by around 181 basis points in the estimated value if the unemployment gap widens by one percentage point, assuming the same deviation between inflation and the long-term target.

Dependent variable: Federal funds rate

Estimate period 1991Q1 2016Q2

Variable	Coeffizient	t-statistic	p-value
Constant	1.56	14.94	0.00
Core inflation rate	1.57	13.55	0.00
Unemployment gap	-1.81	-15.91	0.00
QE dummy	-3.33	-20.28	0.00
Coefficient of determination	0.908		

Following the end of quantitative easing, the dummy variable is calibrated in such a way that the original weighting of the interest rate determinants gradually becomes more significant again and the interest rate rule modified in this fashion virtually replicates the key rate level at the current point in time. Assuming a linear return, the deviation from the Taylor-type reaction function used in our model would not, however, come to an end for a few years yet; something that is largely due to the restrained key rate hikes implemented to date. We nevertheless expect that future rate steps taken by the Fed will make it easier to estimate the return process. Despite the uncertainty hanging over the economy, however, a gradual normalization in monetary policy remains very likely.

Interest rate policy of the European Central Bank

Below, we have attempted to replicate the European Central Bank's interest rate policy reaction pattern using a modified Taylor Rule as well. Unlike in our approach for US key rates, the eurozone model looks not at the unemployment gap but at the relative deviation between real gross domestic product and its potential level, a parameter known as the output gap. Given that the ECB has a different mandate that does not focus on the employment situation, structuring the reaction function in this way is the preferable option. Although the ECB's mandate does not include any explicit focus on the production gap either, it is extremely likely that the ECB's macroeconomic projections influence the monetary policy course taken by the central bank, which justifies the inclusion of macroeconomic development in our model.

The bulk of literary sources on the empirical estimate of the Taylor Rule for the eurozone recommend that the original interest rate rule be modified[5]. Normally, besides the inflation rate and the production gap, the level of the current main refinancing operations rate is also combined with past values for the main refinancing operations rate. This can be justified by the argument that the European monetary watchdogs prefer to pursue a steady-hand monetary policy, meaning that they tend to steer clear of abrupt, dramatic changes of course, even in the event that the overall economic conditions change, and also give financial market participants time to prepare for any interest rate hikes in advance. The model approach for an interest rate reaction function used in our estimate is as follows

$$i_t = (1-\alpha_i)\big(\alpha_0 + \alpha_\pi \pi_t + \alpha_y \tilde{y}_t\big) + \alpha_i i_{t-1} + \epsilon_t$$

where the constant is defined as $\alpha_0 = \bar{r} + (1-\alpha_\pi)\bar{\pi}$ with $\bar{r}$ as the natural real interest rate and $\bar{\pi}$as the long-term inflation target. We have once again based our estimate on a long-term inflation target of around 2% and the aim of achieving production in line with the potential production level. The estimate is based on quarterly data for the period from 2000 (Q1) to 2016 (Q2), where the inflation rate corresponds to the annual change in the harmonized consumer price index and the production gap is derived from estimates from the macroeconomic database AMECO. In our approach, the parameter α_i assumes the weighting, resulting from the estimate, of past observations regarding the main refinancing operations rate in relation to the actual determining factors of the Taylor Rule $(\pi_t - \bar{\pi})$ and $\tilde{y}_t$. The results of our estimate are summarized in the following table:

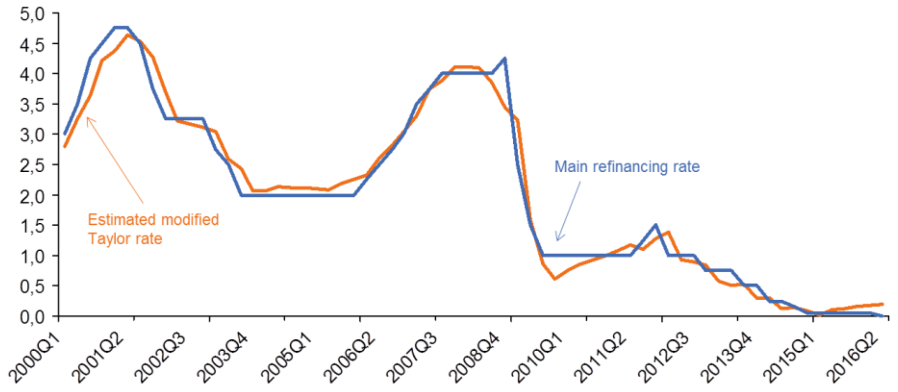
[5] Gerlach-Kristen, P. (2003). Interest rate reaction functions and the Taylor rule in the euro area. ECB Working Paper No. 258.

Dependent variable: ECB main refinancing rate

Estimate period: 2000Q1 2016Q2

Variable	Coefficient	t-statistic	p-value
Constant	0.42	4.09	0.00
Prior period main refinancing rate	0.75	21.09	0.00
Inflation rate	0.09	2.10	0.04
Output gap	0.21	7.59	0.00
Coefficient of determination	0.972		

ECB main refinancing rate and estimated modified Taylor rate



Sources: Thomson Reuters Datastream, own calculations.

The coefficient of determination points towards a very good fit, because around 97 percent of the variance in the main refinancing operations rate can be explained by our model. The impact of the individual coefficients also proves to be robust with regard to a significance level of 5%. By way of example, an increase in the production potential capacity utilization rate by one percentage point increases the main refinancing operations rate, all other things being equal, over the longer term by around 82 basis points, whereas a deviation between the inflation rate and its long-term target that is one percentage point higher generates an increase in the main refinancing operations rate of around 35 basis points over the longer term. Implicitly a real neutral interest rate of a good 0.3% results from the estimate via the link to the constant α_0. This is close to the current estimates[6] for the European Monetary Union and thus points to a very low real neutral interest rate.

Key rates and money market rates

Money market rates - i.e. the short-term market rates in interbank trading - are determined to a considerable degree by key rates. On occasion, however, the two deviate significantly from each other. This can be due to expectations regarding future interest rate policy, to scenarios in which the central banks provide a flood of liquidity, or to crises of trust among banks.

The basic estimate approach for the eurozone is a simple regression of the three-month money market rate (EURIBOR) to the main refinancing operations rate. Although this has

[6] Holston, K., Laubach, T. & Williams, J. (2016, July). Measuring the natural rate of interest: International trends and determinants. In NBER International Seminar on Macroeconomics 2016. Journal of International Economics (Elsevier).

already generated a relatively high adjustment, there were a number of very clear deviations between estimated and actual values in the course of the financial and debt crisis in particular. We can reduce these deviations significantly with the help of two dummy variables (one for the financial crisis and one for the debt crisis).

Dependent variable: Eurozone 3m money (Euribor)
Estimate period: 2000Q1 2016Q2

Variable	Coefficient	t-statistic	p-value
Constant	-0.14	-2.53	0.014
Main refinancing rate	1.08	48.72	0.000
Dummy financial crisis	0.57	4.36	0.000
Dummy debt crisis	0.29	2.02	0.048
First difference main refinancing rate	0.37	4.40	0.000
Coefficient of determination	0.981		

Although both dummy variables are different from zero to a statistically significant degree, narrowing down the time period for the debt crisis dummy was slightly more of a challenge than it was for the financial crisis dummy. This is reflected in a slightly higher empirical significance value (p value). We were also able to achieve a substantial adjustment improvement by including the first difference in the main refinancing operations rate in our estimate, which suggests, given the positive coefficient, that marked interest rate corrections by the ECB are often followed by expectations of further corrections in the same direction.

Dependent variable: US 3m money
Estimate period: 2000Q1 2016Q2

Variable	Coefficient	t-statistic	p-value
Constant	0.09	2.89	0.005
Federal funds rate	1.02	90.45	0.000
Dummy financial crisis	0.83	10.44	0.000
Coefficient of determination	0.992		

The US three-month rate can also be explained to a considerable degree by the US key rate. In addition, we have added a dummy variable for the period of the financial crisis. Including the first difference in the federal funds rate, on the other hand, did not have any significant effect. Nevertheless, there was a very high coefficient of determination of 0.99.

US long-term rates

Until shortly before the US elections the yield on 10yr Treasuries hovered between 1.4% and 1.7%, close to all-time lows. Given the interest rate turnaround enacted by the Fed and a pickup in underlying inflation rates this was not self-evident. It may be assumed that the US bond market – even if it is the biggest worldwide – is influenced by the international interest rate environment, especially in Japan and Europe. We have taken account of this in our specification for US long-term rates.

The explanation of the US long-term rate by means of linear regression takes the following shape in our approach:

$$usbond_{10y,t} = \alpha + \beta_1 \pi_t^e + \beta_2 usshort_{3m,t} + \beta_3 QE_t + \beta_4 optwist_t + \beta_5 gerbond_{10y,t} \cdot (1 - QE_t) + \epsilon_t$$

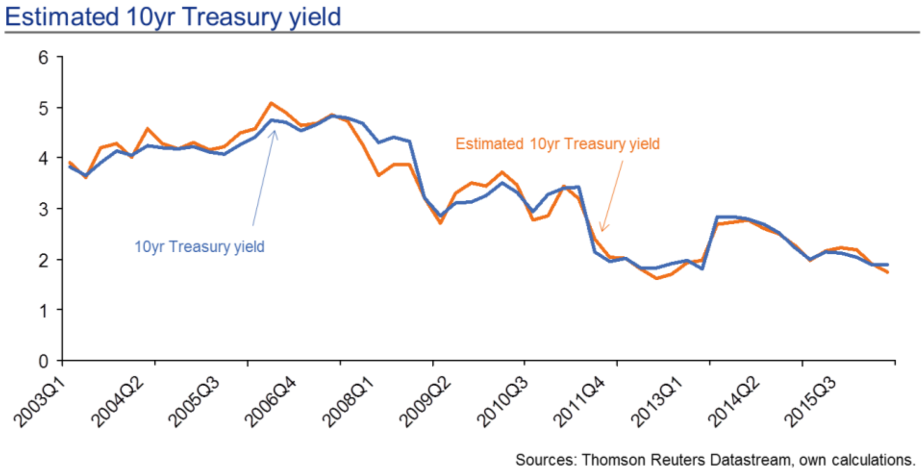
$usbond_{10y,t}$ corresponds here to the yield on 10yr US Treasuries, π_t^e corresponds to the expected 10yr break-even inflation rates[7], $usshort_{3m,t}$ depicts the 3-month US money market rate, QE_t is a dummy variable for the period of the first two QE programs (QE1 and QE2), $optwist_t$ corresponds to a dummy for the bond purchases carried out as part of the "Operation Twist" program and $gerbond_{10y,t}$ represents the yield on 10yr German government bonds. The results are contained in the following table:

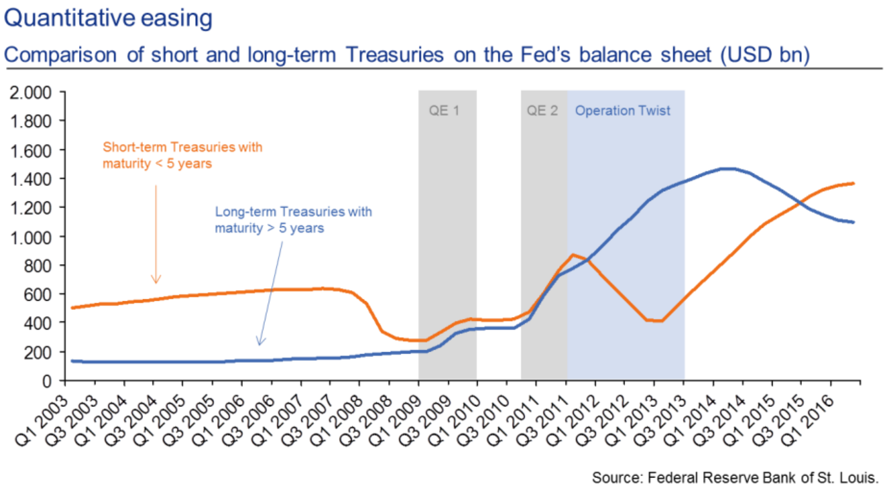
Dependent variable: US long-term rate (10yr)
Estimate period: 2003Q1 2016Q2

Variable	Coefficient	t-statistic	p-value
Constant	0.97	5.54	0.000
Expected inflation rates ("break-even")	0.48	5.36	0.000
US 3m money	0.15	5.95	0.000
Operation Twist dummy	-0.92	-9.28	0.000
QE dummy	1.23	10.17	0.000
German long-term rate (10yr) * (1-QE dummy)	0.44	12.57	0.000
Coefficient of determination	0.957		

As far as the trajectory of the US long-term interest rate is concerned, we felt that the following developments were the main factors at play and justify the structure of our regression equation. In the course of the financial crisis, the Fed ushered in several phases of quantitative easing in an attempt to keep the long end of the yield curve low. This saw the Fed focus primarily on purchases of long-term US government bonds in order to generate credible signals that key rates would remain low even in times of economic recovery.[8] In doing so, the Fed was supporting the logic that unconventional monetary policy could only have a significant impact on long-term rates under these circumstances.[9] This sort of signal was sent out by the purchase of long-term bonds in the sense that the central bank would make a loss if key rates were to rise.[10]

[7] The expected "break-even" inflation rates of the Federal Reserve Bank St. Louis are based on 10-year US Treasury Constant Maturity bonds and inflation-linked Treasury Constant Maturity bonds, meaning that they act as market-based estimates of the future inflation rate over the course of the next 10 years.
[8] Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). The effects of quantitative easing on interest rates: channels and implications for policy (No. w17555). National Bureau of Economic Research.
[9] Eggertsson, G. B., & Woodford, M. (2006, September). Optimal monetary and fiscal policy in a liquidity trap. In NBER International Seminar on Macroeconomics 2004 (pp. 75-144). The MIT Press.
[10] This signal of looming losses is only effective if one assumes that the central bank attaches importance to such losses.



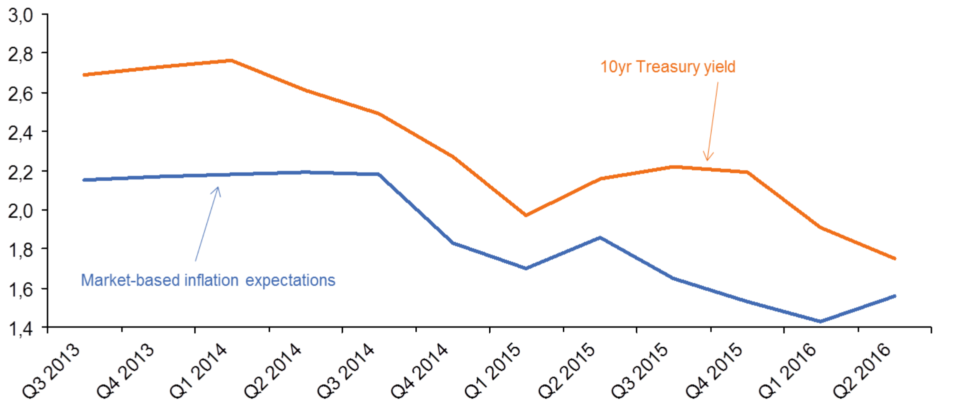


However, the rise in long-term Treasury yields seen in the course of the first two QE programs (QE1 from Q1 2009 to Q1 2010 and QE2 from Q3 2010 to Q3 2011) does not really fit into this argumentation. One possible explanation lies in the rise of market-based inflation expectations seen in the course of the first two purchasing programs. Simultaneously with the start of the purchasing program inflation expctations rose to 2.3% during the first QE phase and further to 2.4% during the second phase and were thus well up on the respective starting point of around 1.0% in Q3 2009 and around 1.7% in Q3 2010. In addition, in the course of the purcahse program the importance of the liquidity channel is often stressed, which in the case of the first two QE phases is likely to have had a rate boosting effect. According to this thinking, Treasury prices included a high liquidity premium during the financial crisis with its market bottlenecks. But as liquidity on the side of investors rose with the start of the purchase programs, the liquidity premiums for US Treasuries fell as a result. Lower liquidity premiums exerted downward pressure on prices and thus an inverse impact on long-term bond yields. This effect of the first two QE programs on US long-term rates is reflected in the framework of our model via a positive coefficient of the QE dummy variables.

A massive drop in long-term rates was not seen until implementation of the program “Operation Twist”, with the repercussions of the balance sheet restructuring the key. For the first time on a substantial scale the Fed sold short-term bonds, reinvested the proceeds in the purchase of long-term bonds and thereby extended the average maturity of the bonds on its books.[11] A clearly negative coefficient of -0.92 replicates this effect and as a result warrants a two-part analysis of quantitative easing.

More recently the steep drop in inflation expectations appeared to be playing a role in the path of long-term rates. In a period from 2013 (Q3) to 2016 (Q2) we established a correlation coefficient of 0.9 for the connection between US long-term rates and market-based inflation expectations, pointing to strong correlation in recent years.

10yr Treasury yield and market-based inflation expectations



Sources: Thomson Reuters Datastream, Federal Reserve Bank of St. Louis.

Studies show that the reason behind the decline in inflation expectations over the period under review is in part the amplified link between the oil price and the break-even inflation expectations used here.[12] The Federal Reserve Bank of St. Louis also highlights an enhanced link above all in the wake of the oil price slide in Q3 2014 and presumes heightened sensitivity towards oil prices in formulating inflation expectations.[13] As a result, this would suggest that a recovery in oil prices could contribute to a turnaround in US long-term rates via the inflation expectations channel. The current upward movement in rates stems largely from the rise in inflation expectations following the US elections.

German long-term rates

As explanatory approach for German long-term rates we use the same specification we outlined in our Working Paper No.186 of June 2015, with the following differences: The estimate uses quarterly not monthly data, the period has been extended to 2000 to Q2 2016 and instead of two dummy variables for the ECB's bond purchasing program there is only one. The following are included as explanatory factors:

- Eurozone money market rate,
- US money market rate,
- US long-term interest rates,
- Dummy variable for quantitative easing.

[11] Board of Governors of the Federal Reserve System (2013). Maturity Extension Program and Reinvestment Policy
[12] Sussman, N., & Zohar, O. (2015). Oil prices, inflation expectations, and monetary policy.
[13] Badel, A., McGillicuddy, J. (2016). What Future Oil Price Is Consistent with Current Inflation Expectations? Federal Reserve Bank of St. Louis.

The eurozone money market rate contributes more to explaining the yield on 10yr German government bonds than the ECB key rate. Although with its key rates the ECB broadly controls interest rates on the interbank market, money market rates in recent years have at times been appreciably below the ECB's main refinancing rate. The main reason can likely be found in the unlimited supply of liquidity by the ECB to commercial banks. So, apart from key rates, a further money policy instrument feeds into money market rates. In the estimation approach for German long-term rates we have therefore included the 3-month Euribor.

Dependent variable: German long-term rate (10yr)

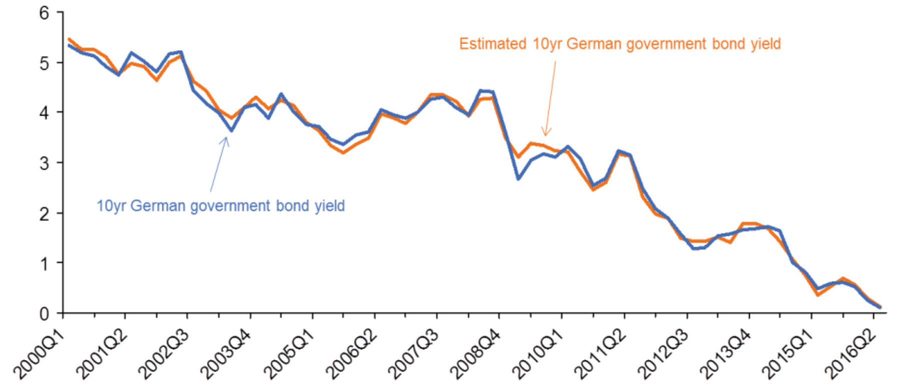
Estimate period: 2000Q1 2016Q2

Variable	Coefficient	t-statistic	p-value
Constant	-0.21	-2.48	0.016
10yr US Treasury yield (pre June 2013)	0.90	30.38	0.000
10yr US Treasury yield (post June 2013)	0.69	16.31	0.000
Euribor	0.11	5.39	0.000
Euribor minus US 3m money	0.28	15.51	0.000
QE expectations	-0.57	-7.08	0.000
Coefficient of determination	0.991		

German long-term rates are influenced by developments on the international bond markets. Considerable influence on the German market comes from the US market, the world's largest. Long-term US yields (yield on 10yr US Treasuries) were therefore included in the estimation approach for German long-term interest rates. As was to be expected, they prove to be highly significant. However, their influence has subsided somewhat since 2013. This potential structural break can be seen in a lower coefficient of US rates from June 2013 compared with that for the period 2000 to May 2013. In late May 2013 a positive economic backdrop prompted the Fed to raise the prospect of a reduction in bond purchases. In October 2014 the Fed's purchasing program came to an end. Hence, from June 2013, the Fed's policy has differed substantially from that of the ECB. This provides an explanation for the shift in the interest rate context.

In addition the estimate could be substantially improved by including the difference between short-term rates (eurozone 3m rate minus US 3m rate), which shows a highly significant positive coefficient. At first glance this could raise the question as to why an increase in US short-term rates in combination with unchanged eurozone short-term rates serves to push yields on German bonds down. But that is only true to a certain degree when rising US short-term rates give a hefty lift to US Treasury yields which are also included in the estimate. Moreover, rising US short-term rates lead to a flattening of the US interest rate curve. Via the international interest rate context, this should at least help mitigate the steepness of the German interest rate curve which, given unchanged short-term rates, would go hand-in-hand with a depression of German long-term rates.

Estimated 10yr German government bond yield



Sources: Thomson Reuters Datastream, own calculations.

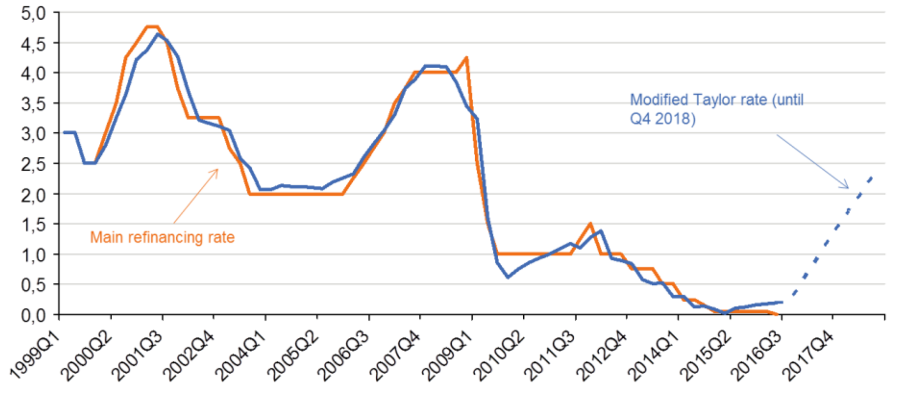
In order to quantify the effects of ECB bond purchases on yield levels, we incorporated a zero/one variable into the estimate: It includes ones fromQ3 2014 when the purchasing program was anticipated on the markets. Implementation of the program started in March 2015.

The approach shows a high degree of conformation. Only around 1% of the dispersion remains unexplained, the standard error amounts to only around 15 basis points. According to this estimate, a 100bp increase in short-term eurozone rates would on its own push up yields on 10yr German government bonds by around 40 basis points. The estimated downward effect on yields of the bond-purchasing program (anticipation and implementation) amounts to just under 60 basis points. These results highlight the strong influence of monetary policy on yield levels on the bond market.

Conclusion and outlook

The explanatory approaches for key interest rates, money market rates and long-term interest rates in the eurozone and in the US produce a broad conformation with the actual development. The determining factors behind long-term interest rates are the interest rate policy and the bond purchases of the central banks, the international interest rate context and, in the case of the USA, inflation expectations. Money market rates are largely determined by the central banks, as was to be expected. The interest rate policy of the central banks is influenced by the development of inflation and the unemployment or output gap, although in crisis periods unconventional measures represent a substitute for technically unfeasible interest rate measures and the behavior of the US bank has changed considerably in the wake of the financial market crisis. It is likely that today it is assuming a considerably lower neutral rate than before the crisis. There are also indications for the ECB that its relatively stable pattern of behavior in interest rate policy changed more or less with the start of quantitative easing. At any rate, going forward our modified Taylor rule struggles to explain key interest rates of zero given practically normal capacity utilization and the expected pickup in inflation away from the zero line.

Ex-ante forecast of eurozone main refinancing rate (modified Taylor rate)



Sources: Thomson Reuters Datastream, own calculations.

The most striking results in our estimated behavioral equations are:

- If the reaction pattern of the US central bank in the period from 1990 to 2008, guided as it was by inflation and the labor market situation, still applied today, US key rates would currently be around 3.5%. This shows that the normalization of US monetary policy has not yet advanced very far and the Fed is probably working on the basis of a model of a new economic normality.

- The policy response pattern of the ECB from the year 2000 could be quite well explained by the inflation development and the output gap. Changes in the output gap evidently played at least as great a role as deviations from the desired inflation rate. More than the Fed, the ECB has preferred a steady-hand policy and has therefore not carried out any abrupt and sharp policy corrections, even in the case of changes in the economic data. More recently, however, it appears that on interest rate policy it has altered its earlier reaction pattern in favor of even more expansive behavior.

- Inflation expectations play a significant role for yields on long-term US bonds. The impact of quantitative easing from 2009 to 2013 on US long-term yields was not uniform and at the beginning in fact tended to push yields up. The US bond market – even if it is the biggest in the world – is influenced by the international interest rate environment. The yield on 10yr German government bonds – the eurozone benchmark – has a significantly positive impact on the corresponding US yield.

- The yield on ten-year government bonds is heavily influenced by monetary policy and the international interest rate context. In addition to interest rate policy, the ECB's unconventional measures also play a significant role for the level of yields. Our estimates show that the bond purchases by the ECB have lowered yields on ten-year bonds by almost 60 basis points.

We combined the six behavioral equations into one overall model. With a dynamic ex-post simulation we tested the stability of the interdependent model (US rates affect European rates and vice versa). The results are encouraging, with no pronounced systematic deviations from the actual development. One exception is merely the reaction function of the ECB which, on the basis of former reaction patterns, flags modest contemporaneous rate hikes and appreciable rate hikes in the near future. But this is unlikely as long as the purchasing program is still under way.

In a next step we have calculated a forecast for the interest rate variables explained in the model (with the exception of the ECB key rate) up to the end of 2018. This is of course a limited projection as some of the determinants of interest rate developments have to be provided exogenously. In other words we are looking here at a scenario under apparently plausible assumptions. The following exogenous parameters were included:

- Long-term inflation expectations in the US stand at 1.7% in 2018. US core inflation (CPI) remains mired at a good 2%.

- The US unemployment rate remains more or less in line with the neutral rate.

- The normalization of US monetary policy in the sense of a return to former behavioral patterns takes place only very gradually – i.e at the (snail's) pace evident since bond purchases were ended.

- In the eurozone the underlying reduction in the output gap continues, in 2017 capacity utilization is at a normal level, in 2018 actually slightly above average.

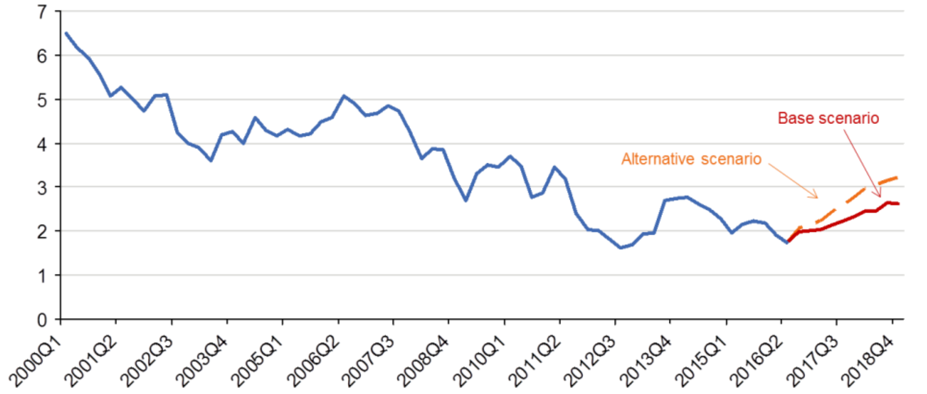
- Consumer price inflation picks up appreciably and reaches a good 1.5% in 2018.

- The ECB reins in its bond purchasing program from March 2017 and concludes tapering at the end of 2017. ECB key rates remain at 0% in 2016 and 2017. Up to the end of 2018 the ECB then hikes rates to 0.5%.

Against this backdrop the US Fed nudges up the fed funds rate only very moderately. Based on the estimation approach, the federal funds rate stands at 1% at the end of 2018. US long-term rates climb to 2.6% at the end of 2018. German long-term rates break away from the zero line. Especially in the course of ECB tapering yields rise appreciably in the course of 2017. But even at the end of 2018 yields only reach a level of around 1.5%.

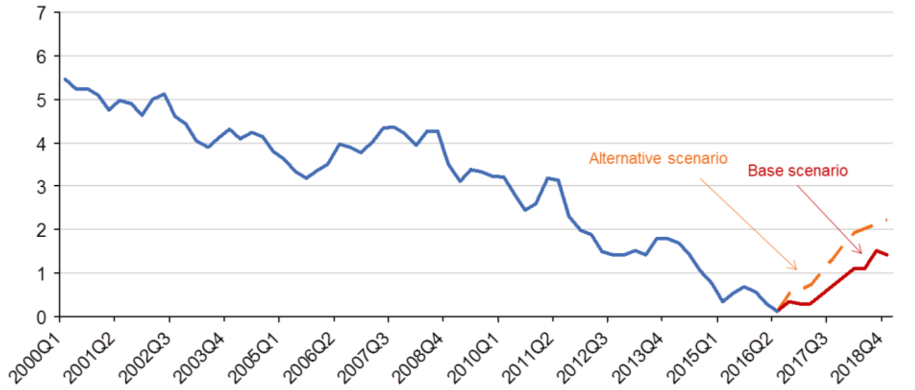
Should the Fed and the ECB return to former behavioral patterns more swiftly – i.e. turn their backs on ultra-loose mode more quickly, the uptick in bond market yields would be markedly stronger according to our model connections. In an alternative scenario we have assumed that the ECB raises its policy rate to above 2% by the end of 2018, as would by all means have been to be expected given the estimated former reaction pattern. For the federal funds rate we assume a level approaching 3% for end-2018. In this alternative scenario of a normalized monetary policy, US long-term rates climb to 3.2% and German long-term rates to 2.2% by the end of 2018. In the eurozone this would result in a return to positive real interest rates, in the US the real interest rate would actually be marginally above 1%. These calculations suggest that it is by all means in the hands of central banks to eliminate overvaluations on the bond markets and return things more or less to normal.

Forecast of 10yr Treasury yield



Sources: Thomson Reuters Datastream, own calculations..

Forecast of 10yr German government bond yield



Sources: Thomson Reuters Datastream, own calculations.

These assessments are, as always, subject to the disclaimer provided below.

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This business success with insurance, asset management and assistance services is based increasingly on customer demand for crisis-proof financial solutions for an aging society and the challenges of climate change. Transparency and integrity are key components of sustainable corporate governance at Allianz SE.

CAUTIONARY NOTE REGARDING FORWARD-LOOKING STATEMENTS

NO DUTY TO UPDATE