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Understanding low interest rates

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- The customary neoclassical model of interest rate determination is neither rooted in the institutional set-up of the credit markets nor supported by the data.
- The Wicksell-Mises-Hayek model of the credit and business cycle offers a much better description of reality. In accordance with this model, we find short-term interest rates to have a strong influence on long-term interest rates and not vice versa, as suggested by the neoclassical model. We also find population ageing not to exert downward pressure on long-term interest rates (and find the opposite effect in half of our sample countries).
- As central bank policy makers are more likely than market participants to lack the knowledge to push market rates to levels consistent with economic fundamentals, there is a high chance of misalignments of market rates.

In this paper we argue that the customary neoclassical model of interest rate determination, in which long-term market interest rates are determined by the supply of and demand for investable funds, is neither rooted in the institutional set-up of the credit markets nor supported by the data. Instead, we find the Wicksell-Mises-Hayek model of the credit and business cycle to offer a much better description of reality. From this we conclude that central bank policy has guided long-term interest rates to their low level and not vice versa. Other variables, such as the ageing of the population, have not added to the downward pressure on interest rates on their own.

Our findings have three important implications: First, long-term market interest rates are strongly influenced by central banks' perceptions of reality rather than by the perceptions of market participants. Second, as central bank policy makers are more likely than market participants to lack the knowledge to push market rates to levels consistent with economic fundamentals, there is a high chance of misalignments of market rates. Third, misalignments of market rates can cause severe economic distortions, and their correction severe economic disruptions.

[1] We would like to thank Michael Biggs, Daniel Gros, Joscha Beckmann, and other colleagues for helpful comments on earlier versions of this paper.

Why interest rates are low: the policy makers' view

In a recent speech, Peter Praet, the chief economist of the European Central Bank, offered an explanation for the presently low level of interest rates:[2] "It is important to understand why interest rates are so low. And a closer examination reveals that the underlying drivers are not so much central bank policies as global and euro area-specific economic factors, some of which are more secular in nature and others which are more associated with the legacy of the post-Lehman financial crisis."

With regard to the factors that "are more secular in nature", he said: "If one takes the textbook Solow growth model as an organising device for the different forces driving real interest rates in the long run, they ultimately pertain to productivity and population growth, and savings behaviour. The intuition is that these forces determine investment and therefore the demand for loanable funds, which have to be matched by savings." He then went on to explain that the growth rate of total factor productivity had been slowing in the euro area for decades, and population growth had declined from about 0.7% in the early 1970s to around 0.3% in recent years. Looking into the very distant future, he expected that the downward pull from adverse demographics – notably a rising supply of funds provided by an ageing population – could result in a significant reduction in the real rate in the long-run.

Praet's comments echo views on the causes of low interest rates exposed by other influential economists in recent years. Already in 2005, Ben Bernanke, member of the Federal Reserve Board at this time, pointed to a "global savings glut" as the main reason for the low level of US interest rates. In his view, large capital flows to the US from countries with current account surpluses, particularly from China, depressed US long-term interest rates. In 2013, former US Finance Minister Larry Summers suggested that the economy had entered a period of very low growth in which "…the short-term real interest rate that was consistent with full employment had fallen to negative two or negative three percent sometime in the middle of the last decade."[3] His view echoed earlier diagnoses of "secular stagnation" from the first half of the 20th century, even though these were refuted by subsequent developments.[4] In Germany, Carl Christian von Weizsäcker has argued that in the aging economies of the OECD and China, people's desired savings for retirement exceed companies' desired investments with the result that interest rates may turn negative.[5]

Why interest rates are low: The Wicksell-Mises-Hayek view

The views of policy makers (and economists) referred to above are based on a neoclassical understanding of the credit market. There, banks act as intermediaries between savers and investors. Interest rates (*i*) adjust to equilibrate the supply of savings (*S*) to the demand for funds to finance investment (*I*), as show in equation (1):

$$S(i) = I(i) \tag{1}$$

If economic fundamentals exert upward pressure on savings and/or downward pressure on investment, market rates fall to ensure equilibrium in the investable funds market. Central bank rates move along with market rates as

[2] See Peter Praet, "The low interest rate environment in the euro area", Keynote speech at a Pension Funds Conference organised by De Nederlandsche Bank in Bussum, The Netherlands, 10 September 2015

[3] Transcript of Larry Summers speech at the IMF Economic Forum, November 8, 2013.

[4] Alvin Hansen, "Economic Progress and Declining Population Growth", Presidential address to the American Economic Association delivered in Detroit, 28 December 1938.

[5] Carl Christian von Weizsäcker, Der Vorsorge Albtraum. Wirtschaftsdienst Sonderheft 2013, pp.7-15.

monetary policy reacts to the same pressures from economic fundamentals as market rates.

Even though this model has entered many economic textbooks describing banks as intermediators between the demand for and supply of investable funds, it is a false description of reality. Banks do not fund lending to investors from existing deposits obtained from savers. They create deposits for investors by extending credit to them out of nothing. The interest rate they charge borrowers are determined by existing and expected inter-bank lending rates and premia to compensate for liquidity and credit risk associated with lending. Inter-bank lending rates are important because banks have to borrow from other banks when borrowers move the deposits created by the extension of credit to them from one bank to another. These rates are determined by central bank policy either via open market operations (as in the US) or lending rates for central bank money to meet reserve requirements (as in the euro area).

Reflecting the real life process of credit extension in our monetary system, Claudio Borio of the Bank for International Settlement describes the influence of central banks on credit rates in the following way: “Central banks set the nominal short-term rate and influence the nominal long-term rate, through signals of future policy rates and purchases of assets. Market participants adjust their portfolios based on their expectations of central bank policy, their views about the other factors driving long-term rates, their attitude towards risk and various balance sheet constraints. Given these nominal interest rates, actual inflation determines ex post real rates and expected inflation determines ex ante real rates. Thus, the influence of saving and investment is only indirect, through these proximate factors and, in particular, through their influence on central banks' and market participants' perceptions of equilibrium or natural rates.”[6]

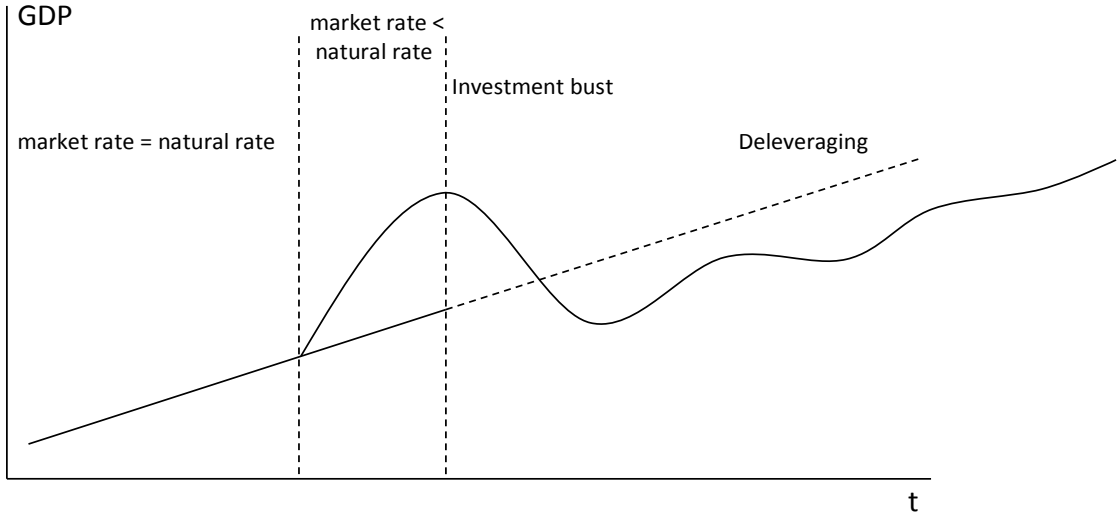
We need to add to Borio’s description that it is unclear at the time of credit extension whether the real demand for capital goods triggered by it will eventually be matched by real savings. This would be the case, if all participants had perfect foresight. Banks would then set credit rates and savings rates at levels that would induce a shift from sight to savings deposits equal to the new money created for investment through credit extension. The central bank would have to set present and expected interbank lending rates such that the sum out of these rates and the premia for liquidity and credit risk would match the equilibrium credit rates.

Obviously, none of the actors involved in this process has necessary information and foresight to satisfy the conditions for an eventual equilibrium between savings and investment. It is much more likely that the extension of bank credit out of nothing leads to dynamic disequilibria between investment spending and saving. In our credit money system, such disequilibria manifest themselves in credit and investment cycles. The emergence of credit and investment cycles in a credit money system has been described by Knut Wicksell, Ludwig von Mises and Friedrich von Hayek.[7] Figure 1 gives a stylized summary of this theory (“WMH” in the following).

[6] Claudio Borio, “On the centrality of the current account in international economics”, Keynote speech at the ECB-Central Bank of Turkey conference "Balanced and sustainable growth - operationalising the G20 framework", Frankfurt, 28 August 2015.

[7] Knut Wicksell, Geldzins und Güterpreise, Jena 1898, Ludwig von Mises, Geldwertstabilität und Konjunkturpolitik. Jena 1928, Friedrich A. von Hayek, Geldtheorie und Konjunkturtheorie. Wien/Leipzig 1929.

Figure 1. Credit and business cycles according to Wicksell, von Mises, and von Hayek.



Source: Own elaborations.

In Figure 1 the "natural rate" is the rate ensuring that all real investment is funded by real savings (as described above). If the market rate drops below the natural rate, more credit is extended to fund additional investment while the move of newly created money from transaction to savings accounts is discouraged. Growth of economic activity accelerates, but a part of investment is directed to marginal projects that are not viable at the natural interest rate and hence represent "malinvestment". When saving funds become scarce relative to the demand for investment funds as projects move towards completion the market rate increases above the natural rate. Credit collapses and many unfinished investment projects cannot be completed. A part of the capital stock becomes obsolete and economic activity plunges. Repeated policy interventions to soften the recessionary effect of deleveraging on economic activity may lead to further swings in the business cycle, albeit probably with higher frequency and smaller amplitudes, until another large downturn eliminates remaining misallocated investment. In the WMH model, the central bank drives the credit cycle by steering inter-bank lending rates in an error-correction-process around the natural rate.

How important is the short-term rate for the long-term rate?

The views reviewed in the previous two sections on the main drivers of long-term interest rates differ fundamentally. The policy makers and mainstream economists reviewed in the first section argue that long-term interest rates are determined by economic fundamentals in the same way as short-term policy rates. The central bank has no better choice but to adjust its policy rate to fundamentals. The alternative view, based on the WMH model presented in the second section, stipulates that short-term policy rates exert a key influence on long-term rates. In this section, we aim to empirically test the two hypotheses to see which one gives a better description of reality.

For the test of the first hypothesis (policy rates and market rates move in tandem), we regress 3-month money market rates on 10-year government bond yields (*gby*10).[8] We use Dynamic Ordinary Least Squares (DOLS) for the estimation, allowing us to test for unequivocal causality running from the independent to the de-

[8] We use government bond yields to exclude that the relationship between short- and long-term interest rates is influenced by the variation of credit spreads.

pendent variables (see Appendix). The hypothesis ("Policy Rates Model") cannot be rejected, if both rate series are cointegrated (i.e., if residuals of the regression follow a stationary stochastic process of order I(0)). We use the Dickey-Fuller (DF) test to check for I(0) of the residuals. We estimate equations for US, Germany, UK, and Japanese interest rates for the period from the first quarter of 1991 to the first quarter of 2015 (US and Germany) and the fourth quarter of 2014 (UK and Japan), respectively.[9] Results of the regressions are given in Table 1. The residuals of the regressions are plotted in Figure 2.

With the exception of Japan, the DF-test does not reject the null hypothesis of a unit root of regression residuals, and hence rejects cointegration between short-term and long-term interest rates. Also, the plots of the residuals of the regressions for US, German and UK short-term rates point to significant serial correlation and non-stationarity. Consequently, we must reject the Policy Rates Model for these countries.

For Japan, we cannot reject the Policy Rates Model. The DF-test does not reject cointegration between the two variables and the plot points to stationary regression residuals at least as of mid-1990. A possible explanation of the difference in results between Japan and the other countries is that Japan was not directly affected by the credit boom-bust cycle of the 1990s and 2000s. Japan experienced its own credit boom-bust cycle during the 1980s and has been in a state of post-crisis paralysis since the early 1990s.

Next, based on the same sample, we test the hypothesis that government bond yields can be explained by short-term (policy rates) and other variables (as described by Borio). Our "Bond Yield Model" is of the following form:

$$(2) \quad gby10_t = \alpha + \beta_1 \, i3m_t + \boldsymbol{\beta}_i \, \mathbf{v}_t + \varepsilon_t$$

where $gby10_t$ denotes government bond yields with 10-year maturity, $i3m_t$ 3-month money market rates, and $\mathbf{v}_t$ a vector of other variables. Apart from a time trend variable (included in the equation to abstract from the declining trend of long-term rates during the observation period), $\mathbf{v}_t$ consists of government debt (or budget deficits) and (old age) dependency ratios. We use nominal rather than proxis for real rates as subtracting inflation from both left-hand and right hand side nominal interest rates to proxy expected real rates would not materially change the relationship[10].

Table 1. DOLS estimates of the Policy Rates Model.

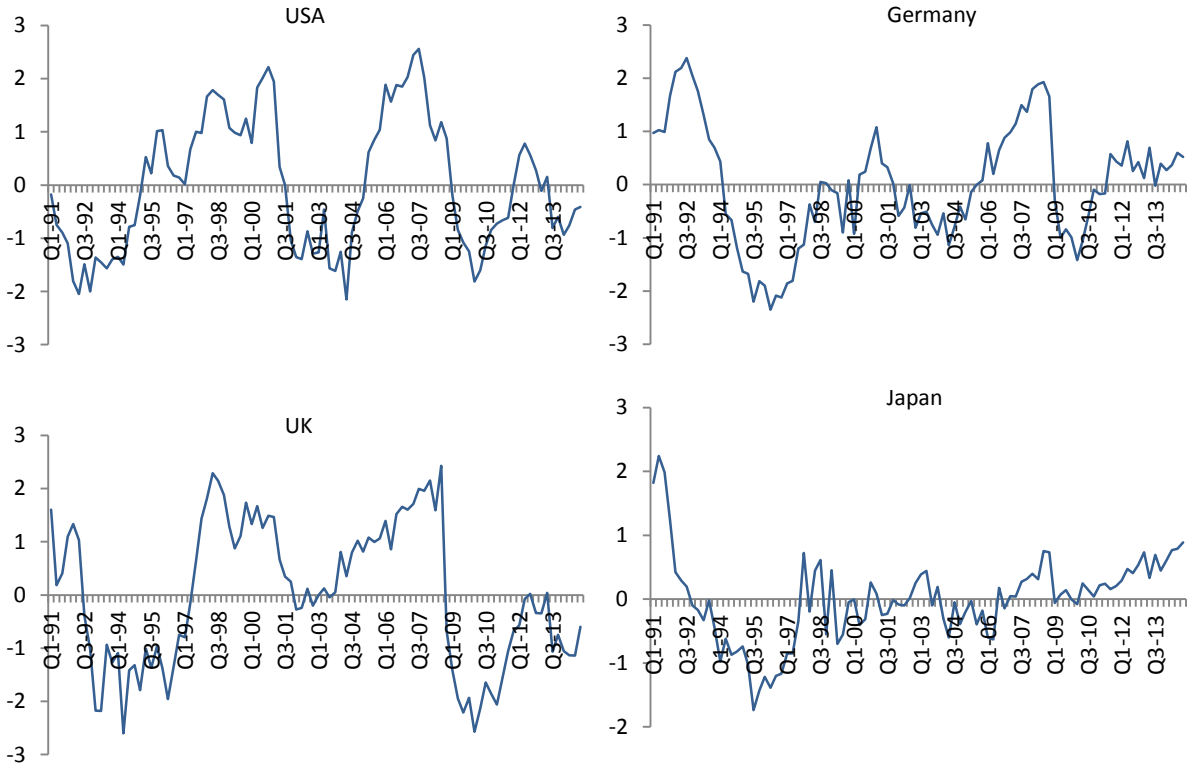
	US	Germany	UK	Japan
gby10	1.146***	1.156***	1.139***	0.988***
	(0.064)	(0.067)	(0.068)	(0.093)
N. obs.	96	96	96	96
R-squared adj.	0.672	0.787	0.760	0.824
DF test	-2.025	-2.153	-2.591	-5.070***
	[0.276]	[0.224]	[0.095]	[0.000]

Notes: Dependent variable is the 3-month money market rate. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Robust standard errors are in parenthesis. The last row reports the test statistic and, in squared parenthesis, its p-values of the Dickey-Fuller (DF) test. The null hypothesis of the test assumes the presence of a unit root.

[9] Descriptive statistics of the variables are summarized in Table A2 in the Appendix.

[10] The correlation between nominal and real rates over our sample period is 0.92 for short rates and 0.89 for long rates.

Figure 2. Residuals of regression of the Policy Rates Model.



Source: Own estimations.

The results of our estimations over the same period as before are given in Table 2.

Based on the results of the Dickey-Fuller unit root test on the residuals from the DOLS estimations, we cannot reject the hypothesis of cointegration for all estimation equations, suggesting that the Bond Yield Model is not misspecified (e.g. due to omitted variables). Since the DOLS methodology controls for endogeneity by accounting for possible influences of the past and future observations of the explanatory variables, the statistically significant variables in the equation are "super-exogenous", meaning that they reliably determine the dependent variables.

Our results show a strong influence running from short-term to long-term interest rates as suggested by the WMH model. Across all sample countries coefficients of short-term rates are statistically and economically significant. In the US, a one percentage point change in short-term interest rates leads to a 0.56 percentage point change in long-term rates. Thus, the decline of US short-term rates of 32 basis points per year during our estimation period contributed to the reduction of US long-term interest rates by 18 basis points per year. Effects are smaller in the UK, Japan and Germany, reflecting the existence of spill-over effects from the US bond market (captured by US bond yields as explanatory variables in the estimations for Germany, UK and Japan).

Another important question we pursue in this paper is the influence of demographic variables on interest rates. For the US and Germany, we use the total dependency ratio (defined as the percentage ratio of people aged 0-14 and over 64 to the working age population (people aged 15-64)). For the UK and Japan we use the old age dependency ratio (defined as the percent-

Table 2. DOLS estimates of Bond Yield Model.

	US	Germany	UK	Japan
i3m	0.562***	0.193***	0.243***	0.223**
	(0.088)	(0.050)	(0.038)	(0.101)
Dependency ratio[a]	0.572***	0.077	0.049	0.573**
	(0.168)	(0.074)	(0.067)	(0.194)
Government debt (USA and Japan) or deficit (Germany and UK)[b]	-0.032	0.068	0.291**	0.023**
	(0.027)	(0.060)	(0.018)	(0.010)
USA net foreign liability[b]	44.75	---	---	---
	(134.74)			
US debt x USA net foreign liability[b]	-1.084	---	---	---
	(2.178)			
US long rate	---	0.525***	0.765***	0.310***
		(0.119)	(0.124)	(0.087)
time trend	-0.036***	-0.025**	-0.013	-0.204**
	(0.006)	(0.013)	(0.005)	(0.066)
N. obs.	90	93	93	89
R-squared adj.	0.931	0.975	0.980	0.959
DF test	-5.487***	-4.287***	-5.500***	-5.111***
	[0.000]	[0.000]	[0.000]	[0.000]

[a] Total dependency ratio for the US and Germany, old age dependency ratio for the UK and Japan, as percentage.
[b] In percent of GDP.
Dependent variable is the interest rate on 10-year government bonds. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Robust standard errors are in parenthesis. The last row reports the test statistic and, in squared parenthesis, its p-values of the Dickey-Fuller (DF) test. The null hypothesis of the test assumes the presence of a unit root.

age ratio of people aged over 64 to the working age population (people aged 15-64)). The choice of the different variables was determined by the availability of data. For practical purposes, however, the two versions of the dependency ratio make no difference as both moved together during the observation period due to the aging of the population.

We found coefficients for the dependency variables to be positive and statistically significant at least on the 5% level of error probability for the US and Japan, and not significantly different from zero for Germany and the UK. In the US, an average 0.27 percentage point yearly increase in the dependency ratio (from 98% at the beginning of the observation period to 103% at the end of 2014) added 0.16 percentage points each year to long-term interest rates. With the population aging much faster in Japan, the effect is much more noticeable there: the doubling of the old age dependency ratio between 1991 and today, corresponding to an average yearly increase by one percentage point over the sample period, added 0.6 percentage points per year to long-term interest rates. Thus, our findings reject the hypothesis that interest rates decline in aging societies as people save more for retirement. To the contrary, results for the US and Japan lend some support to the alternative view that older populations save less and demand more capital (and other) resources to finance retirement.[11]

[11] This is consistent with the findings of Mikael Juselius and Előd Takáts ("Can demography affect inflation and monetary policy?" BIS Working Papers No 485, February 2015.

Finally, government budget deficits and debt exert a statistically significant upward pressure on government bond yields in the UK and Japan. In both countries, the government's fiscal accounts deteriorated considerably over the estimation period. In the case of Japan, the public debt ratio increased at an average yearly rate of 6.7 percentage points from 48% of GDP in 1991 to 211% in 2014. This added 0.15 percentage points to long-term interest rates. Similarly, the yearly rise in the UK government budget deficit by 0.1 percentage points of GDP from 0.2% in 1991 to 2.8% in 2014 added 0.03 percentage points per year to long-term interest rates.

However, government budget deficit or debt variables are insignificant in the equations for Germany and the US. This may well reflect the high demand for US and German government bonds as safe assets in global capital markets. Indeed, the government debt ratio alone enters the US equation with a negative sign (in a regression equation not shown here), suggesting that higher debt would lead to lower rates. The counter-intuitive ("wrong") sign is more likely to be due to omitted variables, in this case foreign demand for US debt as safe assets, than reflecting a true influence. If we control for this by including US foreign liabilities (in percent of GDP) and the interaction between supply and demand for US debt (captured by the product of the debt and foreign liability ratios), the debt variable turns insignificant. Thanks to strong foreign demand for safe assets, the rise in US and German government debt has been neutral for the government bond yields of these countries.

Both short- and long-term interest rates have been subject to a strong downward trend since the early 1980s, and this is captured in the trend variable, which is statistically significant in all equations. However, the trend has not affected short-term and long-term rates equally. If it had, we would have found a cointegration between the two variables in the Policy Rates Model and no significant influence of short-term rates on long-term rates in the Bond Yield Model. Unfortunately, we cannot unambiguously say what the trend variable may reflect. It may stand for other variables that we did not include in our set of explanatory variables. But for the reasons given above we can be reasonably sure that the relationship we found between short-term and long-term rates is economically and statistically sound, and not due to spurious correlation.

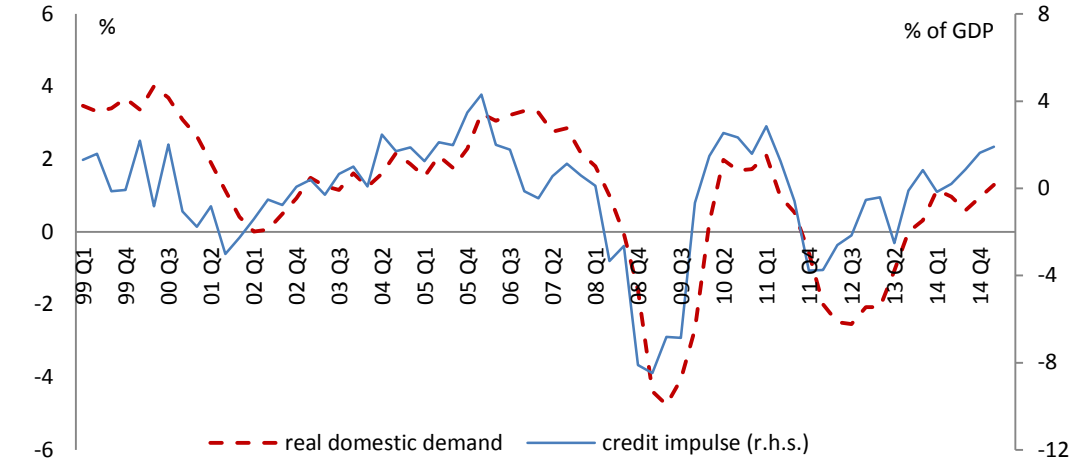
Evidence for the Wicksell-Mises-Hayek cycle

Having found evidence that short-term interest rates influence long-term interest rates in line with the proposition of the WMH model, we can now explore (in a descriptive way) the interaction between credit and the business cycle also stipulated in this model.

The relationship between credit cycles and economic cycles is shown for the euro area and the US in Figures 3-5. Figure 3 shows the change in credit flows relative to GDP (which we call "credit impulse") and real domestic demand growth in the euro area.[12] As proposed by WMH, cyclical movements of credit flows drive real demand flows. The lead of credit over demand is clear in both the downturn of the cycle in 2007 and the upturn in 2009. Figure 4 shows the same variables for the US. In this case, the lead of credit flows is not so clear in the downturn in 2008, but clearly visible in the upturn in 2009.

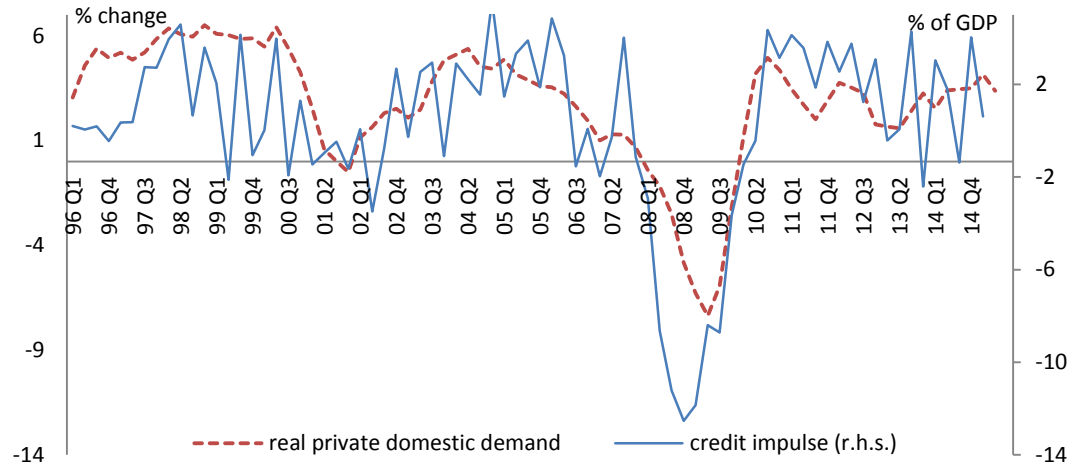
[12] It is important to compare credit flows with demand flows to identify a relationship between the two variables. Comparisons of credit stocks and demand flows, as has been customary in the economic literature, fail to capture the relationship. See Michael Biggs, Thomas Mayer, and Andreas Pick, "Credit and Economic Recovery: Demystifying Phoenix Miracles." March 15, 2010 (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1595980), and Michael Biggs and Thomas Mayer, "Bring credit back into the monetary policy framework, PEFM Policy Brief, Oxford University, August 2013.

Figure 3. Credit impulse and demand in the euro area, 1996Q1-2015Q2.



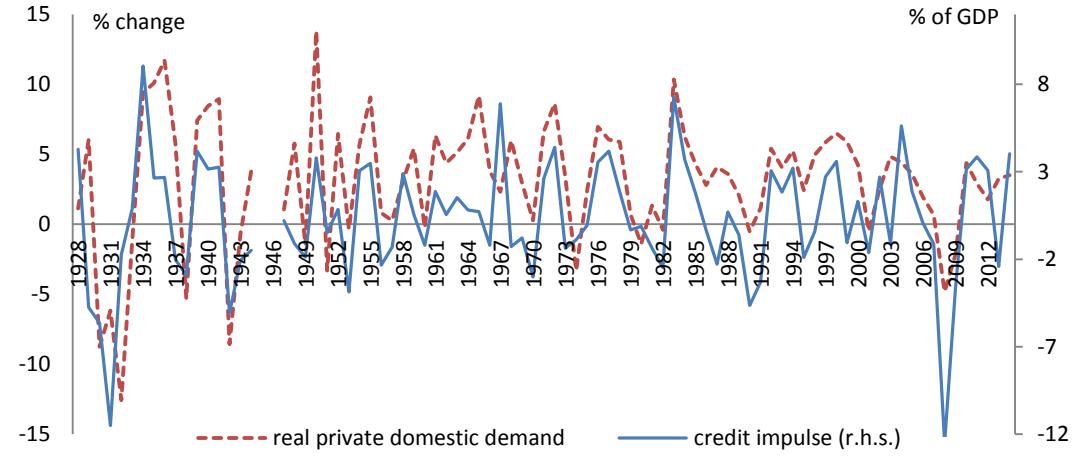
Source: Authors' calculations, Haver Analytics.

Figure 4. Credit impulse and demand in the US, 1996Q1-2015Q2.



Source: Authors' calculations, Haver Analytics.

Figure 5. Credit impulse and demand in the US, 1928-2014.



Source: Authors' calculations, Haver Analytics.

Figure 5 shows these variables on an annual basis for the US for the period of 1928 to 2014. There, we can see a clear lead of the credit variable during the Great Depression of 1929-1934 and the similarity between the Great Depression and the more recent Great Recession.

Conclusions

In this paper, we argued that the customary neoclassical model of interest rate determination, in which long-term interest rates are determined by the supply of and demand for investable funds, is neither rooted in the institutional set-up of the credit markets nor supported by the data. Instead, we found the Wicksell-Mises-Hayek model of the credit and business cycle to be a much better description of reality. From this, we conclude that central bank policy has been largely responsible for the low level of interest rates. Other variables, such as the ageing of the population, have not added to the downward pressure on interest rates on their own.

We have tried our best to let the data speak. Naturally, our results stand to be refuted by studies using more comprehensive data samples or more efficient techniques for analysis. But until refuted by a more powerful analysis, our findings have three important consequences: First, long-term market interest rates are strongly influenced by central banks' perception of reality rather than by the perceptions of market participants. Second, as central bank policy makers are more likely than market participants to lack the knowledge to push market rates to levels consistent with economic fundamentals, there is a high chance of misalignments of market rates.[13] Third, misalignments of market rates can cause severe economic distortions, and their correction severe economic disruptions.

[13] We assume here that central planning committees are inferior decision makers than markets.

Technical Appendix: Data and estimation technique

The Dynamic Ordinary Least Squares (DOLS) estimation technique used in this paper allows us to control for endogeneity of explanatory variables (Stock and Watson 1993; Wooldridge 2009).[14] Endogeneity in the form of feedback effects or reverse causality between the dependent and independent variables would lead to a misspecification of our estimation model, in which we want to identify the effects of short-term rates on long-term market rates. The DOLS procedure controls for endogeneity of all explanatory variables by inserting leads and lags of the changes of all exogenous variables. The model to estimate assumes the following form:

$$y_t = \alpha + \beta_1 x1_t + \beta_2 x2_t + \beta_3 x3_t + \beta_4 x4_t + \omega_t$$

where

$$\omega_t = \sum_{-p}^{+p} b_{1p} \Delta x1_{t-p} + \sum_{-p}^{+p} b_{2p} \Delta x2_{t-p} + \sum_{-p}^{+p} b_{3p} \Delta x3_{t-p} + \sum_{-p}^{+p} b_{4p} \Delta x4_{t-p} + \varepsilon_t$$

DOLS is a powerful estimation technique according to Saikkonen (1991) and Stock and Watson (1993).[15] Within this estimation framework, standard errors are corrected for heteroscedasticity and cross-section correlation. It can be shown that by inserting the leads and lags of the exogenous variables in first differences, these variables become (super-) exogenous and the regression results unbiased (Wooldridge, 2009). The leads and lags enter the error term which can be decomposed into the endogenous and exogenous changes of the right-hand side variables as shown above.

Application of the DOLS procedure requires the series to be non-stationary and in a long-run relationship, i.e. to be cointegrated over time. Only when cointegration is established can we be sure that we do not estimate spurious relationships and that omitted variables (which are lumped together in the error term) do not systematically influence the long-run relationship between the endogenous and exogenous variables.

[14] James H. Stock and Mark W. Watson. A simple estimator of cointegrating vectors in higher order of integrated systems. Econometrica, 61(4), 783-820, July 2013, Jeffrey Wooldridge. Introductory econometrics: A modern approach. South-Western, Ohio, 2009.

[15] Pentti Saikkonen. Asymptotically efficient estimation of cointegration regression. Economic Theory, 7(1), 1-21, March 1991.

Table A1 gives a description of the data used in our estimation.[16]

Table A1. Description of data.

	USA	Germany	UK	Japan
gby10	10-year Treasury bond yield at constant maturity, %	Govt securities with residual maturities of 9-10 years, %	Govt Bonds, 10-year nominal par yield, %	10-Year benchmark govt bond yield, %
i3m	3-month London Interbank Offered Rate for US$ fund, %	3-month FIBOR: Frankfurt Interbank Offer Rate, %	3-Month London Interbank Offered Rate for British Pound funds, %	Call rate for uncollateralized 3-month money, %
deficit / debt	Gross Federal Debt as a percent of GDP	Federal Govt budget balance as a percent of GDP	Central Govt budget balance as percent of GDP	Gross Federal Debt as a percent of GDP
US foreign liabilities	US govt and other long-term liabilities, % of GDP*			
debt x foreign liabilities	product of debt and foreign liabilities (to capture interaction)			
(old age) dependency ratio	dependency ratio in % (pop 0-14 & 65+)/pop 15-64)	dependency ratio in % (pop 0-14 & 65+)/(pop 15-64)	old age dependency ratio in % (pop 65+)/(pop 15-64)	old age dependency ratio in % (pop 65+)/(pop 15-64)

Note: * Own calculation based on Haver Analytics.
Source: Haver Analytics and Eurostat (for the German dependency rate).

Table A2 shows descriptive statistics of the variables included in the analysis.

Table A2. Descriptive statistics.

	Mean	St. Dev.	Min.	Max.
		USA		
gby10	4.777	1.681	1.640	8.130
i3m	3.315	2.261	0.228	6.873
government debt	69.7	15.8	53.8	103.6
USA net foreign liability	0.014	0.015	0.001	0.140
US debt x USA net foreign liability	0.934	0.930	0.062	8.246
dependency ratio	99.0	1.775	96.5	103.6

[16] Data used for the estimation are available from the authors on request.

	Mean	St. Dev.	Min.	Max.
		Germany		
gby10	4.481	1.972	0.310	8.570
i3m	3.469	2.495	0.050	9.760
government deficit	1.134	1.217	-8.000[17]	3.390
dependency ratio	48.5	2.152	45.0	52.0
		UK		
gby10	5.331	2.185	1.680	10.380
i3m	4.710	2.868	0.507	12.500
government deficit	2.023	2.351	-2.990[17]	6.020
old age dependency	24.6	0.726	23.9	27.0
		Japan		
gby10	2.108	1.502	0.325	6.774
i3m	1.000	1.667	0.000	8.000
government debt	126.4	57.2	46.7	214.0
old age dependency	28.0	6.706	18.0	40.4

[17] Budget surpluses in Germany and the UK reflect the receipts from the sale of G3 telephone licenses in 2000.

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