Interest and inflation rates through the lens of the theory of Irving Fisher

Magnus Jonsson and André Reslow*

Magnus Jonsson has a PhD in Economics and André Reslow has a Master's Degree in Economics. Both work in the Monetary Policy Department at the Riksbank.

The nominal interest rate and inflation are positively correlated with each other in the short run and in the long run, in Sweden as well as in other countries. In this article, we show that the positive correlation can be understood through Irving Fisher's theory of the relationship between the nominal interest rate, the inflation rate and the real interest rate. In our analysis, the short run correlation can be explained by supply and demand shocks in a standard macroeconomic model, where Fisher's theory is a key factor. If we assume long run monetary neutrality, Fisher's theory implies that the correlation between the nominal interest rate and inflation is positive also in the long run. Finally, we show that if the real interest rate is equated to the GDP growth rate per capita, the long run implications of Fisher's theory fit the data in Sweden and several other countries. This provides empirical support to the idea that a low policy rate over the long run could lead to low inflation, as has been proposed by Narayana Kocherlakota, among others.

Almost seven years have passed since the investment bank Lehman Brothers declared bankruptcy in the autumn of 2008 and the global financial crisis broke out with full force. The crisis brought with it the largest fall in GDP since the Great Depression of the 1930s. Moreover, the recovery after the crisis has been unusually slow in many countries, see Figure 1(a). In the euro area and Japan, GDP is at about the same level as when the crisis broke out, while in Sweden, the US, the UK and Canada the level is five to ten per cent higher. Additionally, GDP per capita is at the pre-crisis level in all these countries, see Figure 1(b). Sweden only just reaches the pre-crisis level and both the euro area and the UK are below that level.

The central banks reacted promptly and cut the policy rates to near zero per cent at the outset of the financial crisis in order to avoid a further deepening of the crisis, see Figure 2(a). However, the policy rates have remained at these low levels. In Sweden, the policy rate is currently slightly negative and in several other countries it is close to zero per cent.

Inflation fell rapidly at the beginning of the financial crisis, even though it recovered relatively quickly, see Figure 2(b). For example, in Sweden inflation was above two per cent around 2011, but since then it has been falling again and remained at low levels. The low inflation rates in the recent years are, however, not just a Swedish phenomenon, but are being experienced by several other countries.

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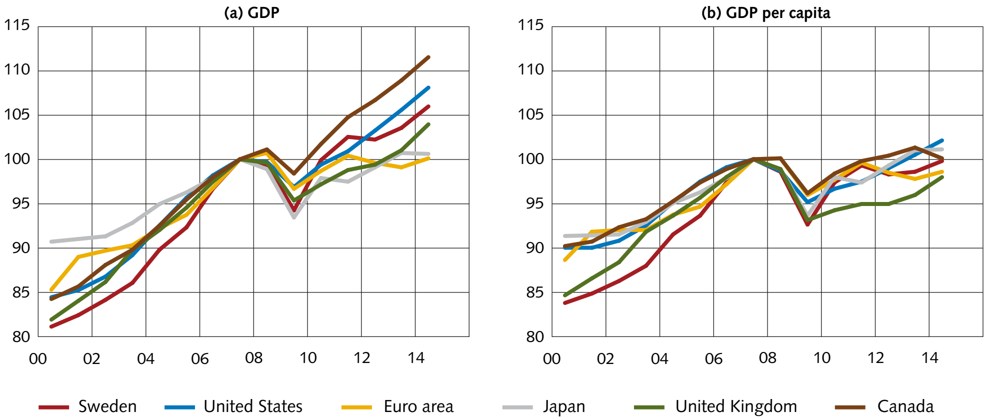
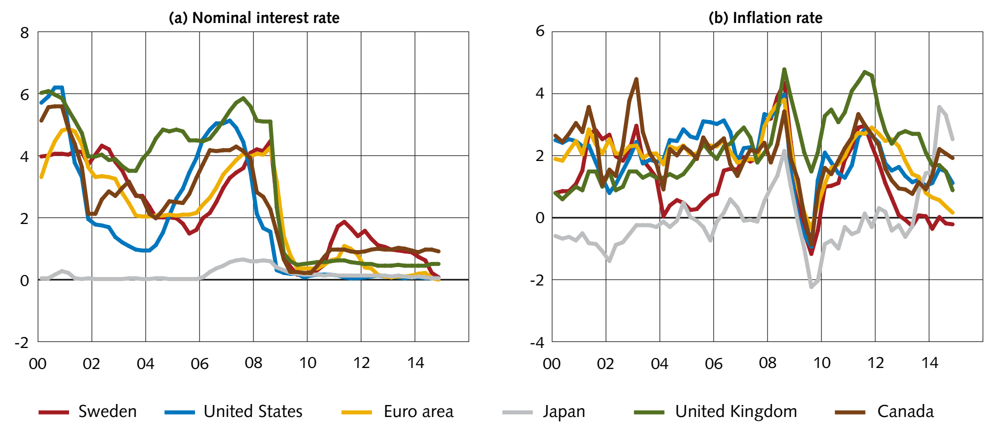
Figure 1. GDP and GDP per capita in Sweden, the US, the euro area, Japan, the UK and Canada
Index, 2007 = 100



Sources: Eurostat, Japanese Cabinet Office, Official Statistics of Japan, Statistics Sweden, Statistics Canada, UK Office for National Statistics, US Bureau of Economic Analysis and US Census Bureau

Figure 2. Nominal interest and inflation rates in Sweden, the US, the euro area, Japan, the UK and Canada
Per cent



Note. The nominal interest rates are measured by three-month treasury bills, except in the euro area where the nominal interest rate is measured by EONIA. Inflation is measured by CPI inflation in all countries, except in the US where it is measured by PCE inflation, and the euro area where it is measured by HICP inflation. Note that the high rates of inflation in Japan in 2014 were mostly, 2 percentage points, due to temporary effects from increased taxation on consumption (the calculations in the article is adjusted for this).

Sources: ECB, Eurostat, Macrobond, OECD, Statistics Sweden and the US Bureau of Economic Analysis

WHY IS INFLATION NOT RISING?

Monetary policy has thus been characterised by policy rates near zero per cent since the beginning of the crisis. In addition, several central banks have purchased government bonds and adopted other so-called unconventional measures to make monetary policy even more expansionary. At the same time, inflation has been low and below the inflation target in many countries. What is causing these low inflation rates? Why has monetary policy, which has been exceptionally expansionary in a historical perspective, not led to higher rates of inflation?

A common explanation is that monetary policy has been constrained by the zero lower bound, i.e. the policy rate cannot be substantially below zero per cent. Proponents of this view argue that demand is still below normal and is therefore not creating any upward pressure on inflation. In other words, monetary policy has not been expansionary enough.[1]

Another explanation that has been put forward is that increasing competition, entailed by globalisation and digitalisation, has made it more difficult for firms to raise prices without losing customers.[2]

CAN LOW POLICY RATES OVER THE LONG RUN LEAD TO LOW INFLATION?

Perhaps a more challenging explanation is that low policy rates over the long run could lead to low inflation. This may sound contradictory, as policy rate cuts according to standard theory should lead to rising inflation. Nevertheless, Narayana Kocherlakota, president of the Federal Reserve Bank of Minneapolis, explored this idea in a speech 2010, see Kocherlakota (2010):

> *Long run monetary neutrality is an uncontroversial, simple, but nonetheless profound proposition. In particular, it implies that if the FOMC maintains the fed funds rate at its current level of 0-25 basis points for too long, both anticipated and actual inflation have to become negative. Why? It's simple arithmetic. Let's say that the real rate of return on safe investments is 1 percent and we need to add an amount of anticipated inflation that will result in a fed funds rate of 0.25 percent. The only way to get that is to add a negative number, in this case, –0.75 percent. To sum up, over the long run, a low fed funds rate must lead to consistent, but low, levels of deflation.*

Kocherlakota's claim is based on two well-known economic theories. The first is the theory of long run monetary neutrality, which says that a change in the policy rate does not affect long run values of real interest rates and other real variables. The second is Irving Fisher's theory of the long run relationship between the nominal interest rate, the inflation rate and the real interest rate.[3] Fisher's theory is simple and intuitive: in the long run, inflation has to correspond to the difference between the long run levels of the nominal and the real interest rates. Taken together, these two theories imply that a long-lived change in the nominal interest rate corresponds to an equal change in inflation.

1 See Hall (2014).
2 See Apel et al. (2014). See also Jonsson (2007) who quantifies the effects of increased competition on inflation in the Riksbank's macroeconomic model Ramses.
3 See Fisher (1977).

Central banks use changes in a short-term nominal interest rate (i.e. the policy rate) to influence inflation.[4] But how these changes affect inflation depend on several different factors.[5] Kocherlakota emphasised that the length of the change may be an important factor. We therefore dedicate a large part of the article to explain why short-lived changes may affect inflation differently than long-lived changes.

OUTLINE AND SUMMARY

The outline of the article is as follows: The next section describes Irving Fisher's theory of the relationship between the nominal interest rate, the inflation rate and the real interest rate. This section also describes the assumptions under which the real interest rate can be equated to the GDP growth rate per capita.

The following section sheds light on the short run relationship between the nominal interest rate and inflation. We first show that the correlation between these two variables is positive in Sweden and other countries. This may appear contradictory, as short-lived cuts in the policy rate normally lead to rising inflation and increases to falling inflation, which should imply a negative correlation. However, this fact need not necessarily imply that the correlation in the data is also negative. Changes in the policy rate are generally not an important factor behind the business cycle fluctuations. These are instead mainly driven by supply and demand shocks. We therefore conclude this section by explaining why these shocks give rise to a positive correlation between the nominal interest rate and inflation.

We then, in the next section, look at the long run relationship. Also the long run correlation between the nominal interest rate and inflation is positive in the data. We demonstrate that in a standard macroeconomic model, where Fisher's theory and long run monetary neutrality are key assumptions, a long-lived change in the policy rate leads to an equal change in inflation, which explains the positive correlation and also confirms Kocherlakota's claim.

In the subsequent section, we make use of the fact that under certain assumptions the real interest rate can be equated to the GDP growth rate per capita. We show that the average inflation in Sweden and other countries can be explained by the difference between the average nominal interest rate and the GDP growth rate per capita. This suggests that the long run implications of Fisher's theory fit the data in several countries. Furthermore, it provides empirical support to Kocherlakota's claim.

Japan was badly hit by a financial crisis in the beginning of the 1990s. The Japanese experience in the post-crisis period is of particular interest, since Japan's economy has been characterised by low nominal interest rates and inflation. We show that the average

4 The terms nominal interest rate and policy rate are used interchangeably in the article. In the empirical analysis, the nominal interest rate is measured by the yield on a three-month treasury bill. The difference between this interest rate and the policy rate is normally marginal.

5 Milton Friedman said that monetary policy works with long and variable lags, by which he meant that the effects on inflation of changes in monetary policy takes time and varies over time, see Friedman and Schwartz (1963).

inflation in Japan, both in the pre-crisis and post-crisis periods, can be explained by the difference between the average nominal interest rate and the GDP growth rate per capita.

Following this, there is a section that takes a much-debated article, Bullard (2010), as a starting point for a discussion of the effects of low nominal interest rates over a longer period.[6] Bullard's article explains why Fisher's theory together with the zero lower bound may imply a steady state characterised by near-zero nominal interest rates and low or negative inflation.[7] The data suggest that it is still too early to determine whether Sweden and other countries have moved into such a steady state following the financial crisis. Seven years of data is not enough to determine this. On the other hand, it appears as if Japan, following the financial crisis at the beginning of the 1990s, has moved into a steady state of low inflation. Finally, we make some concluding remarks.

The relationship between the nominal interest rate, the inflation rate and the real interest rate according to Irving Fisher

Irving Fisher's theory of the relationship between the nominal interest rate, the inflation rate and the real interest rate, the so-called Fisher relation, is fundamental in monetary theory. This relation is also a key feature in the micro-founded macroeconomic models that central banks use in their forecasting and policy work. The Riksbank's model Ramses is an example of such a model.[8]

The Fisher relation is formally an arbitrage condition between a real and a nominal asset and can be written in the following way,

$$1+R_t=(1+E_t\pi_{t+1})(1+r_t), \tag{1}$$

where R denotes the nominal interest rate, π inflation, E expectations ($E_t\pi_{t+1}$ thus denotes expected inflation in time $t+1$ that an agent has at time t), and r the real interest rate.

A mathematical derivation of the Fisher relation can be found in several textbooks, see for example Walsh (2003). Here we explain the intuition behind the relation through a verbal reasoning. Suppose that we have a real asset that costs one apple in period t and that gives the return of $(1+r_t)$ apples one period later. In nominal terms, the real asset costs P_t in period t and P_{t+1} in the next period. The nominal price of the real asset in period $t+1$ is thus $(1+r_t)P_{t+1}$ and the nominal return will be $((1+r_t)P_{t+1}-P_t)/P_t$. In order to avoid arbitrage opportunities, the return on the real asset must be as high as on a nominal asset, R_t, i.e. $R_t=((1+r_t)P_{t+1}-P_t)/P_t$. This expression can be re-written in terms of inflation rates, $1+R_t=(1+\pi_{t+1})(1+r_t)$. If we also take into account that the future price level is unknown, we get equation (1).

6 See Bullard (2010).
7 Bullard's article builds on insights from Benhabib et al. (2001).
8 See Christiano et al. (2011).

For small values of the inflation and real interest rates, equation (1) can be approximated with the following expression,

$$R_t = E_t \pi_{t+1} + r_t. \tag{2}$$

Equation (2) is the "short run" Fisher relation, since it is valid at each point in time t. In macroeconomic models, a time period is usually a quarter. The Fisher relation is also valid in the long run, i.e. in steady state, where it is written as,

$$\bar{R} = \bar{\pi} + \bar{r}\,, \tag{3}$$

where a bar indicates that it is a long run (steady state) value of a variable. Long run values are usually calculated as the average over a longer period, usually ten years or more.

THE REAL INTEREST RATE CAN BE EQUATED TO THE GDP GROWTH RATE PER CAPITA UNDER CERTAIN ASSUMPTIONS

The following factors can be shown to determine the long run real interest rate under certain assumptions on the households' preferences and the firms' production technologies,[9]

$$1 + \bar{r} = \frac{1}{\beta}(1+\gamma)^{\sigma}, \tag{4}$$

where β denotes the households' discount factor, γ the (real) GDP growth rate per capita (working age population) and $1/\sigma$ the households' intertemporal elasticity of substitution. Equation (4) shows that the long run real interest rate depends on two fundamental factors. The first is how households value consumption today versus consumption tomorrow, β, and the second is the GDP growth rate per capita, γ.[10]

Explaining why the real interest rate depends on β is best done through an example. Assume that households are impatient, i.e., they prefer consuming today as opposed to consuming tomorrow. If households are to value consumption tomorrow as highly as consumption today, they must be compensated for deferring their consumption.[11] That is to say, if they save and postpone some of today's consumption until tomorrow, there must be a positive real interest rate on this saving.

In addition, the real interest rate depends on the growth rate. The marginal utility of consumption is normally diminishing, i.e. a small increase of consumption increases households' utility but at a diminishing rate. Or, to put it differently, the utility of eleven apples is greater than that of ten, but the marginal utility of the eleventh apple is less than that of the tenth. In a growing economy, the consumption level today is lower than

9 See Jonsson (2002).
10 "The GDP growth rate per capita" will hereafter be called "the growth rate".
11 Utility maximisation implies that households are indifferent about consuming today or tomorrow.

future levels, which implies that the marginal utility of consuming today is greater than the marginal utility of consuming in the future. The real interest rate must therefore be positive if households are to be indifferent between consuming today and in the future. How high the interest rate has to be depends on the intertemporal elasticity of substitution of the households. If the willingness of substituting consumption between periods is relatively low, i.e. if σ is relatively high, the real interest rate needs to be relatively high.

Note that according to equation (4), if $\beta = \sigma = 1$ the real interest rate equals the growth rate. If $\beta = 1$ then today's generation will value its own consumption as highly as future generations' consumption, which could be a reasonable assumption from the perspective of justice. It may be more difficult to justify a certain value for σ. It has also proved to be difficult to estimate this parameter with any certainty. However, a common value for this parameter in many macroeconomic models is 1, which, for example, is the case in the Riksbank's macroeconomic model Ramses. If we assume that $\beta = \sigma = 1$ the long run Fisher relation can be defined as follows,

$$\bar{R} = \bar{\pi} + \gamma. \tag{5}$$

The nominal interest rate and inflation are positively correlated in the short run

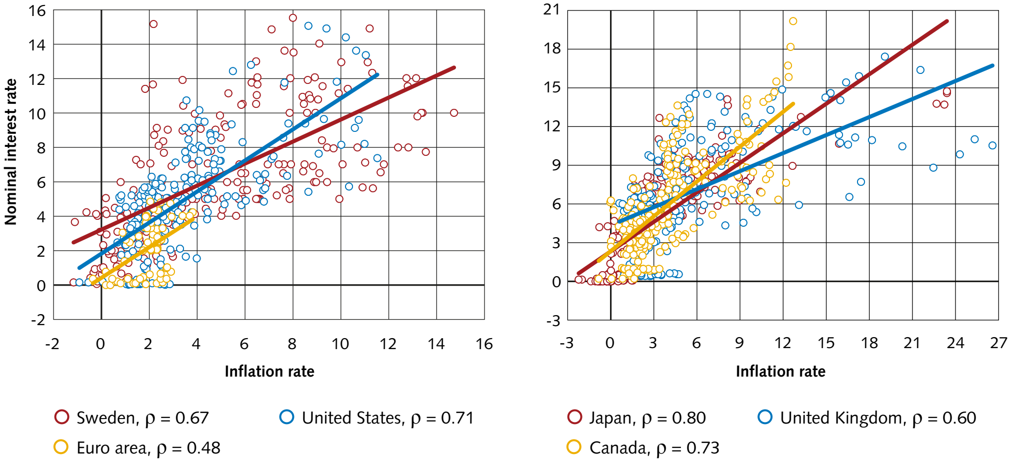
The nominal interest rate in the Fisher relation should according to theory be measured by a short-term risk-free nominal interest rate. Given that, we use the yield on a three-month treasury bill as a measure of the nominal interest rate in Sweden, the US, Japan, the UK and Canada. For the euro area, where there are no treasury bills issued jointly by the member states, we use EONIA (Euro OverNight Index Average), which is a reference rate for loans between banks with a maturity of one banking day. Regarding inflation, there are several different measures to choose from. Although there is no indisputable measure, which is reflected in that central banks usually report several measures in their reports. We follow this practice and report two measures. The first is inflation according to the consumer price index, i.e. CPI inflation.[12] The second is a measure of so-called core inflation.[13]

Figure 3 shows the correlation between the nominal interest rate and inflation in six countries: Sweden, the US, the euro area, Japan, the UK and Canada. The time period is 1961-2014 for all countries, except the euro area, where it is 1999-2014. As can be seen, the correlation is positive throughout. It is strongest in Japan, with a correlation coefficient of 0.80, and weakest in the euro area, where the correlation coefficient is 0.48.

12 However, for the US, we use PCE inflation (the consumption deflator), which is the preferred measure by the Federal Reserve.

13 Core inflation is measured by CPI excluding food and energy, except in Sweden, where it is measured by CPIF excluding food and energy, the US, where it is measured by PCE inflation excluding food and energy, and the euro area, where it is measured by HICP excluding food, energy, alcohol and tobacco. Note that measures of core inflation are not available for the 1960s and 1970s.

Figure 3. Correlation between the nominal interest rate and inflation in Sweden, the US, the euro area, Japan, the UK and Canada
Per cent



Note. ρ denotes the correlation coefficient. Quarterly data 1961-2014 for all countries, except the euro area, which is based on quarterly data 1999-2014. The nominal interest rates are measured by three-month treasury bills, except in the euro area where the nominal interest rate is measured by EONIA. Inflation is measured by CPI inflation in all countries, except in the US where it is measured by PCE inflation, and the euro area, where it is measured by HICP inflation.

Sources: ECB, Eurostat, Federal Reserve, Macrobond, OECD, Statistics Sweden and US Bureau of Economic Analysis

MONETARY POLICY SHOCKS RESULT IN A NEGATIVE CORRELATION BETWEEN THE NOMINAL INTEREST RATE AND INFLATION

The positive correlation between the nominal interest rate and inflation may appear contradictory at first glance. Policy rate cuts normally lead to rising inflation, while increases lead to falling inflation, which should imply a negative correlation. However, this does not necessarily imply that the correlation in data also has to be negative. We can explain why this is the case with the help of a simple macroeconomic model, in which the Fisher relation is a key feature.[14]

The central bank follows a simple, linear rule à la Taylor (1993) with the following parameterisation,[15]

$$(6) \qquad R_t = 0.8\,R_{t-1} + (1-0.8)\,[\bar{R} + 1.5\,(\pi_t - \bar{\pi}) + 0.1\,(y_t - \bar{y})] + \varepsilon_t,$$

where R denotes the policy rate, $\bar{R}$ the policy rate's long run level, π inflation, $\bar{\pi}$ inflation's long run level (i.e. the inflation target), y output, $\bar{y}$ the long run output level, and ε a monetary policy shock. The differences, $\pi_t - \bar{\pi}$ and $y_t - \bar{y}$, are thus inflation's deviation from the inflation target and the output gap, respectively.

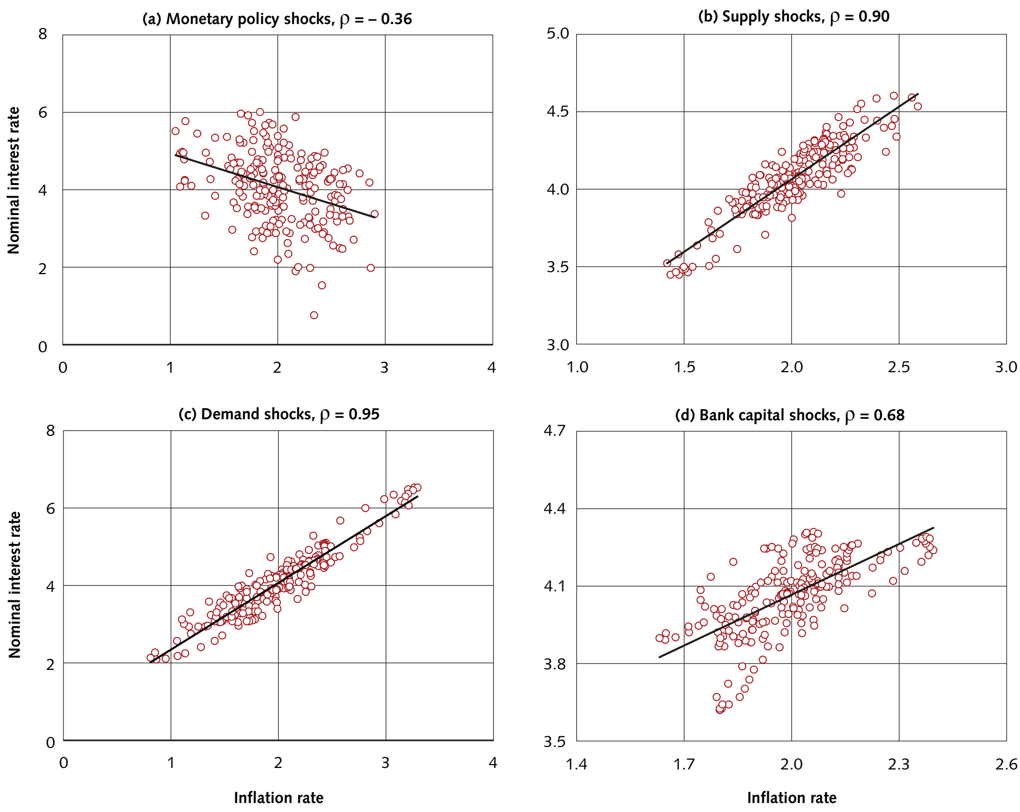
14 See Meh and Moran (2010) and Jonsson and Moran (2014) for a description of the model.

15 The Taylor rule is a simple recommendation for how monetary policy should be conducted under normal circumstances. The rule has also been shown to work well in many different types of macroeconomic models, see Plosser (2008).

Business cycle fluctuations are due to different types of shocks hitting the economy, to which prices and quantities adjust. This implies that the correlation between different variables will depend on these shocks. Hence, in order to explain, for example, the correlation between the nominal interest rate and inflation it is necessary to know which shocks that have created the fluctuations.

The monetary policy shock in the Taylor rule may be interpreted as a change in the policy rate that is due to neither deviations of inflation from the target nor deviations of output from its normal level. We can thus illustrate how short-lived changes in the policy rate affect inflation by allowing monetary policy shocks to drive the business cycle. Figure 4(a) shows the correlation between the nominal interest rate and inflation in this case. As expected, the correlation is negative and the correlation coefficient is –0.36.

Figure 4. Correlation between the nominal interest rate and inflation after monetary policy shocks, supply shocks, demand shocks and bank capital shocks
Per cent



Note. ρ denotes the correlation coefficient.

Source: Own calculations

An important assumption in the model is that prices are sticky in the short run, i.e. some firms are not changing their selling prices along with changes in demand. Assume a short-lived cut in the policy rate and that the prices are so sticky that they initially remain unchanged. This means that the cut, $R_t \downarrow$, must be matched by an equally large fall in the real interest rate, $r_t \downarrow$, i.e.,

$$R_t \downarrow = \bar{\pi} + r_t \downarrow , \tag{7}$$

where $\bar{\pi}$ indicates that inflation initially remains on the long run level. However, as time passes, the falling real interest rate tends to increase households' consumption and firms' investment. This boosts demand, which pushes up inflation when firms eventually start to change their prices. Short-lived policy rate cuts are thus associated with rising inflation and, conversely, increases are associated with falling inflation. This explains the negative correlation after monetary policy shocks in Figure 4(a).

But how can it then be that the nominal interest rate and inflation are positively correlated in the data when monetary policy shocks give rise to a negative correlation? This is simply because monetary policy shocks are in general not an important cause of business cycle fluctuations. These are usually due to other shocks.

BUT SUPPLY AND DEMAND SHOCKS RESULT IN A POSITIVE CORRELATION

Supply and demand shocks are often the main drivers of the business cycle and, hence, the correlations in the data. The supply shock is modelled as a shock to the firms' production technology. This shock affects the production possibilities of the firms and therefore has a direct effect on the supply of goods and services. An improvement of the production technology means that the firms' production possibilities increase, but it also means that the cost of production decreases and that the firms can lower their prices. A positive supply shock thus leads to falling prices. The central bank reacts to this by cutting the policy rate to bring inflation back to the target. Hence, the correlation between the nominal interest rate and inflation becomes positive. The correlation coefficient is 0.90, see Figure 4(b).

The demand shock equals public consumption in the model, since changes in public consumption have direct effects on aggregate demand. An increase in public consumption pushes demand up and therefore also increases inflationary pressures. To keep inflation on target the central bank raises the policy rate. This gives rise to a positive correlation between the nominal interest rate and inflation, see Figure 4(c), and a correlation coefficient of 0.95.

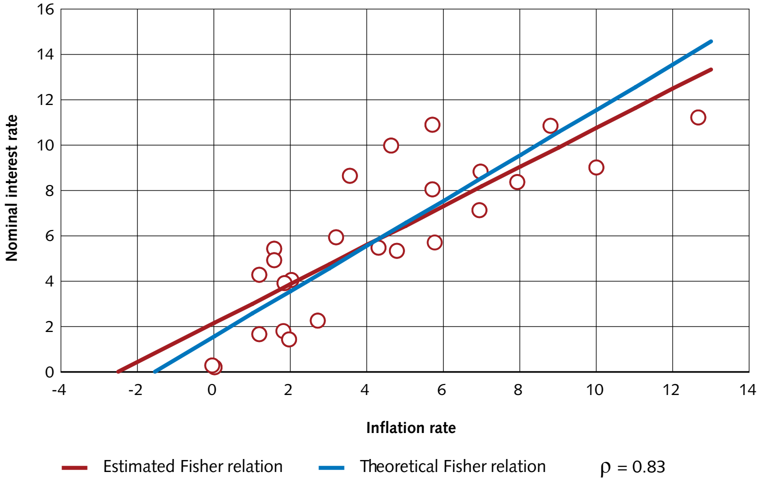
We have claimed that supply and demand shocks are the most common shocks, but other shocks do also occur. The credit crunch associated with the financial crisis of 2008 is an example of a financial shock (a so-called bank capital shock) where the effects spread rapidly to other parts of the economy. This type of shock is unusual and, like the monetary policy shock, does not provide an important explanation of the correlations in data over longer periods. Nevertheless, the macroeconomic model shows that the correlation between the nominal interest rate and inflation is positive, as in the data, and measures 0.68 when the banks' lending is exposed to bank capital shocks, see Figure 4(d).

The nominal interest rate and inflation are positively correlated also in the long run

Figure 5 shows the long run correlation between the nominal interest rate and inflation in five countries: Sweden, the US, Japan, the UK and Canada. The long run values have been calculated as ten-year averages. The time period covers 1965 to 2014, meaning five observations for each country and a total of 25 observations. As we can see, the correlation is positive throughout and the correlation coefficient is 0.83.

The blue line in the figure shows the theoretical Fisher relation, in which we have calculated the long run real interest rate as the average difference between the nominal interest rate and inflation for all countries over the entire period. This gives a value of 1.56 per cent. The red line shows an estimate of the Fisher relation. The estimated slope coefficient is 0.86, which is relatively close to the theoretical value of 1. Also, a statistical test does not reject the null hypothesis that the slope is 1.[16]

Figure 5. Long run correlation between the nominal interest rate and inflation in Sweden, the US, Japan, the UK and Canada, ten-year averages, 1965-2014
Per cent



Note. ρ denotes the correlation coefficient. The nominal interest rates are measured by three-month treasury bills. Inflation is measured by CPI inflation in all countries, except in the US where it is measured by PCE inflation. The blue line shows $\bar{R}_t = 1.56 + \bar{\pi}_t$. while the red line shows $\bar{R}_t = 2.16 + 0.86\bar{\pi}_t$.

Sources: Federal Reserve, Macrobond, OECD, Statistics Sweden, US Bureau of Economic Analysis and the Riksbank

16 An F-test with the null hypothesis that the slope is one in the estimated Fisher relation gives a p-value equal to 0.06 (F-value = 3.79, covariance = 0.01 and degrees of freedom (1, 23)).

We can see in the figure that the estimated Fisher relation lies relatively close to the theoretical relation, but several isolated points nevertheless lie some distance away. This can be due to several things. The long run real interest rate may not have been the same in all countries over the entire period. It is also likely that the long run real interest rate has varied between the ten-year periods within the different countries.

A LONG-LIVED POLICY RATE CUT IMPLIES THAT INFLATION WILL BE LOWER OVER THE LONG RUN

We can understand the long run correlation between the nominal interest rate and inflation through the implications of the long run Fisher relation. Assume, like Kocherlakota, that the real interest rate is independent of monetary policy in the long run (monetary neutrality) and that the central bank determines the policy rate. This second assumption means that the causality between the policy rate and inflation runs from the policy rate to inflation.

Let us assume that the central bank carries out a long-lived (in this scenario permanent) cut to the policy rate, $\bar{R}\downarrow$, see equation (8). Monetary neutrality implies that the real interest rate remains unchanged at the long run level, $\bar{r}$. Hence, the policy rate cut only affects long run inflation (i.e. the inflation target), which is adjusted downwards, $\bar{\pi}\downarrow$. It is adjusted downwards as much as the policy rate in order to avoid arbitrage opportunities between nominal and real assets. A long-lived policy rate cut thus leads to lower long run inflation in accordance with Kocherlakota's claim. This also explains the long run positive correlation,

$$\bar{R}\downarrow = \bar{\pi}\downarrow + \bar{r}. \tag{8}$$

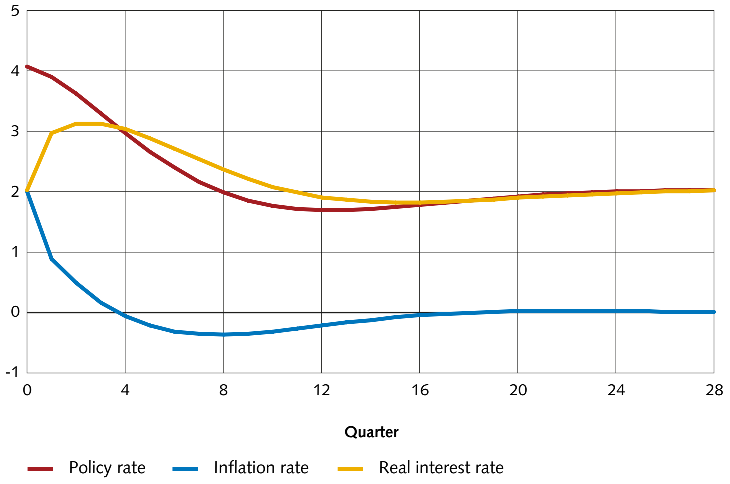
Note the difference to a short-lived change in the policy rate. As we have seen, in this case there is a change in the real interest rate, since prices in the model are sticky. This means that the nominal interest rate and inflation, in the short run, need not necessarily move in the same direction.

The macroeconomic model can be used to illustrate how the real interest rate and inflation may adjust after a long-lived policy rate cut. Assume that the long run levels of the policy and real interest rates are initially four and two per cent, respectively. Inflation is thus two per cent. The central bank cuts the policy rate successively to two per cent, where it remains, see Figure (6). The real interest rate initially rises slightly, but then falls back to the long run level of two per cent. Inflation falls successively over the whole period to its new long run value, which according to the Fisher relation must be zero per cent.

A notable feature of this scenario is that inflation successively adjusts downwards to its new long run level. The main reason for this is that agents in the economy have what is known as rational expectations. This means that the households and the firms do not make any systematic errors when they form expectations of future monetary policy. They understand that the policy rate cut will be long-lived. They also understand that a long-lived cut is associated with a lower inflation rate over the long run. The firms therefore start adjusting their prices downwards at the moment of the policy rate cut.

Figure 6. The policy rate, the inflation rate and the real interest rate after a long-lived (in this scenario permanent) cut in the policy rate with two percentage points

Per cent



Source: Own calculations

According to the long run Fisher relation there is only one level of the policy rate that is consistent with a specific inflation target, given the long run real interest rate. If the policy rate deviates from this level during a longer period, there is a risk that agents in the economy may interpret this as a change in the inflation target. The agents may therefore have interpreted the long-lived cut in the policy rate as an intention to lower the inflation target from two to zero per cent in this scenario. In other words, if the central bank has an inflation target of two per cent and the long run real interest rate is two per cent, the policy rate must on average be four per cent if the inflation target is to be attained. If the policy rate instead averages two per cent, the inflation rate, as we have seen in Figure (6), will on average be two percentage points lower, i.e. zero per cent.

This scenario also illustrates why the level of long run real interest rate is important to the central bank. It must be aware of this level in order to set a policy rate level that is consistent with the inflation target. In the wake of the financial crisis, Larry Summers and other economists have advanced a thesis of secular stagnation.[17] Among other things, they argue that the long run level of the real interest rate may have fallen. If this is correct, the long run level of the policy rate must be adjusted downwards in proportion to the fall in the real interest rate, otherwise inflation will be too high.

17 See Summers (2014).

The long run Fisher relation fits the data in Sweden and other countries

Kocherlakota's claim that low policy rates over the long run can lead to low inflation relies on the long run Fisher relation. In this section, we carry out an empirical test of this relation. To do so, we calculate the inflation implied by the long run Fisher relation and compare it to the observed average inflation. In these calculations we make use of the fact that the real interest rate under certain assumptions can be equated to the growth rate, see equation (4). Hence, we calculate inflation from the Fisher relation as the difference between the average levels of the nominal interest rate and the growth rate.[18] This inflation rate is called the Fisher inflation, and is thus defined as,

$$\bar{\pi}^F = \bar{R} - \gamma. \tag{9}$$

To determine whether the long run Fisher relation fits the data, we show the difference between the Fisher inflation and the observed inflation from different countries in bar charts as well as results from a statistical test. Note that the real interest rate in this test, which is equated to the growth rate, may vary from country to country, unlike the calculations in Figure 5.

To test long run relationships the time period examined should be as long as possible, at the same time as the data should not display any clear trends. It may also be an advantage if the monetary policy regime is the same over the entire period. To take this into account, we present results from two different periods. The first longer period is limited by access to data and stretches from 1961 to 2014. For this period, we have data for Sweden, the US, Japan, the UK and Canada.

The second shorter period is, to the extent possible, characterised by a stable monetary policy regime and no clear trends in the data. Alan Greenspan was appointed Chairman of the Federal Reserve in 1987. The period prior to Greenspan was characterised by both high nominal interest rates and high inflation. We therefore start the second period for the US in 1987. For the UK, Canada and Sweden, the second period starts one year after the inflation targets were announced in each country, i.e. 1992 for Canada, 1993 for the UK and 1994 for Sweden. Starting the year after the announcement of inflation targeting allows us to avoid including the effects of the economic and financial crisis that hit these countries at the start of the 1990s. During the 1960s and 1970s, Japan underwent a transition from relatively low GDP levels to levels in parity with those of the developed industrial countries. The shorter period for Japan therefore starts in 1981. This period also includes the euro area. The euro was officially introduced on 1 January 1999, which is why the period starts in 1999 for the euro area.

18 Hence, the empirical test does not just include the Fisher relation but also how well the long run real interest rate can be approximated by the growth rate. The reason we make this approximation is because the long run level of the real interest rate is not observable.

The nominal interest rate in Sweden averaged just over six per cent between 1961 and 2014, while the growth rate was just over two per cent, see Table 1. This means that the Fisher inflation was around four per cent, which was only slightly lower than the CPI inflation, see Figure 7(a). For the shorter period we can see that the Fisher inflation was in line with the observed inflation, i.e. both the CPI and core inflation, see Figure 7(b).

In the US, the nominal interest rate averaged five per cent and the growth rate averaged almost two percent over the period 1961-2014, see Table 1. The Fisher inflation was therefore about 3.2 per cent. This was just a few tenths of a percentage point lower than the PCE inflation, see Figure 7(a). The Fisher inflation also corresponded well with both the PCE and core inflation for the shorter period, see Figure 7(b).

In the UK, the Fisher inflation underestimated the observed inflation slightly for the longer period, while it overestimated the CPI and core inflation slightly for the shorter period, see Figures 7(a) and 7(b). In Canada, the Fisher inflation was in line with the observed inflation in both the shorter and the longer periods, see Figures 7(a) and 7(b).

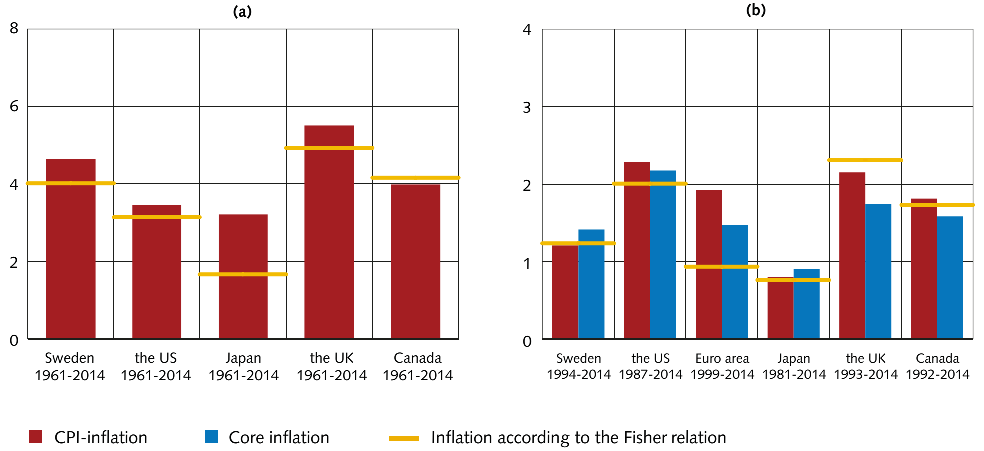
The Fisher inflation in the euro area was lower than both the CPI and the core inflation, although it was not that far from the core inflation, see Figure 7(b). Nevertheless, the result indicates that the Fisher relation seems to fit somewhat less well in the euro area than in the other countries. This could be due to a number of factors. The time period is relatively short, 15 years, and almost half of these years have been characterised by the financial crisis. Another problem could be that it does not exist treasury bonds issued jointly by the member states, i.e. the EONIA rate may have been a poor approximation of a short-term risk-free rate in several of the countries in the euro area.

Table 1. The nominal interest rate and the GDP growth rate per capita in different countries and time periods
Per cent and annual percentage change respectively, averages

COUNTRY	PERIOD	THE NOMINAL INTEREST RATE	THE GDP GROWTH RATE PER CAPITA
Sweden	1961-2014	6.3	2.2
	1994-2014	3.3	2.0
United States	1961-2014	5.0	1.8
	1987-2014	3.6	1.5
Euro area	1999-2014	2.2	1.2
Japan	1961-1980	8.5	5.4
	1981-1990	6.1	3.7
	1981-2014	2.5	1.7
	1991-2014	1.0	0.9
United Kingdom	1961-2014	7.0	2.0
	1993-2014	4.1	1.7
Canada	1961-2014	6.0	1.8
	1992-2014	3.4	1.5
Russia	1999-2013	9.4	4.9
India	1994-2013	7.4	4.8
China	1998-2013	3.4	8.3

Sources: ECB, Eurostat, Federal Reserve, Japanese Cabinet Office, Macrobond, OECD, Reserve Bank of India, Statistics Canada, Statistics Sweden, the World Bank, UK Office for National Statistics and US Bureau of Economic Analysis

Figure 7. Inflation according to the Fisher relation and observed inflation in Sweden, the US, the euro area, Japan, the UK and Canada
Per cent



Note. Core inflation is measured by CPI excluding food and energy, except in Sweden, where it is measured by CPIF excluding food and energy, the United States where it is measured by PCE inflation excluding food and energy, and the euro area where it is measured by HICP excluding food, energy, alcohol and tobacco.

Sources: ECB, Eurostat, Federal Reserve, Japanese Cabinet Office, Macrobond, OECD, Statistics Sweden, Statistics Canada, the World Bank, UK Office for National Statistics, US Bureau of Economic Analysis and the Riksbank

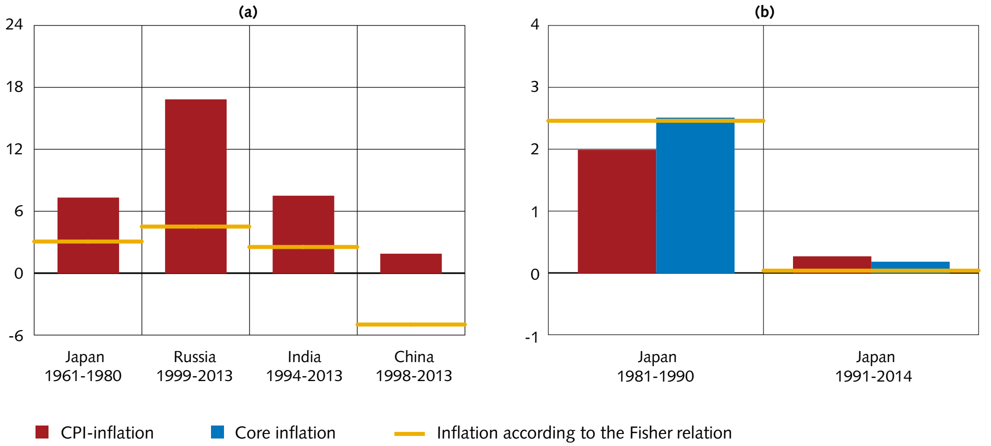
THE LONG RUN FISHER RELATION DOES NOT FIT THE DATA IN JAPAN IN THE 1960s AND 1970s – AND FOR GOOD REASONS

In Japan, the Fisher inflation was almost 1.5 percentage points lower than the observed inflation for the period 1961-2014, see Figure 7(a). On the other hand, for the shorter period, 1981-2014, the Fisher inflation was entirely in line with the observed inflation, measured by both the CPI and core inflation, see Figure 7(b).

In order for the long run Fisher relation to fit the data the economy needs to be in a steady state with no clear trends in the data. The Japanese economy grew rapidly following the end of the Second World War, with growth rates of about 10 per cent per year. These high growth rates lasted until the beginning of the 1970s, when the economy suffered from the effects of rising oil prices. Hence, the Japanese economy in the 1960s and 1970s was in a transitional phase, as it moved from relatively low GDP levels to levels in parity with those of the developed industrial countries. Consequently, we should not expect the long run Fisher relation to fit the data during this period.

Japanese growth rates in the 1960s and 1970s averaged 5.5 per cent and the nominal interest rate was just over 8.5 per cent, see Table 1. This means that the Fisher inflation was around 3 per cent. The CPI inflation was around 7.5 per cent during this period, see Figure 8(a). Hence, the Fisher inflation underestimated the CPI inflation by more than four per cent.

Figure 8. Inflation according to the Fisher relation and observed inflation in Japan, Russia, India and China
Per cent



Note. Core inflation is measured by CPI excluding food and energy.

Sources: Japanese Cabinet Office, Macrobond, OECD, Reserve Bank of India and the World Bank

We can observe a similar pattern, as in Japan's transition phase, in countries such as Russia, India and China, where the growth rates have been high in the last 15-20 years. In Russia and India, the growth rates have been just below five per cent and, in China, just over eight per cent, see Table 1. In other words, growth rates in parity with those during Japan's transition phase. However, it is not likely that these growth rates will be sustainable over the long run – those of Japan were not.

Figure 8(a) shows that the Fisher inflation in Russia, India and China was clearly below the observed inflation, just as the Fisher inflation was in Japan's transition phase. In line with the theory, this confirms that long run relations do not apply to transitional phases. In addition, and also in line with the theory, it is likely that the growth rate is a poor measure of the real interest rate in transitional phases with high growth rates.

A STATISTICAL TEST CONFIRMS THAT THE LONG RUN FISHER RELATION FITS THE DATA

By using simple "eyeball econometrics", we have shown that the Fisher inflation is in line with the observed inflation in Sweden and several other countries. This conclusion can be confirmed by a t-test with the null hypothesis that the Fisher inflation corresponds to the observed inflation in each country. The average difference between the Fisher inflation and the core inflation is –0.06, with a p-value of 0.73, while the difference between the Fisher inflation and the CPI inflation is –0.20, with a p-value of 0.28, see Table 2. For the longer period, 1961-2014, we have only 4 observations. In this case, the difference between the Fisher inflation and the CPI inflation is –0.34, with a p-value of 0.17, see Table 2.

Table 2. Matched t-test with the null hypothesis that the Fisher inflation equals the observed inflation

	MEAN VALUE	T-VALUE	STANDARD DEVIATION	DEGREES OF FREEDOM	P-VALUE
Δ^{KPI}	−0.34	−1.81	0.37	3	0.17
Δ^{KPI}	−0.20	−1.21	0.41	5	0.28
Δ^{Und}	−0.06	−0.36	0.37	5	0.73

Note. In the empirical test, $\Delta^{KPI} = \bar{\pi}^F - \bar{\pi}^{KPI}$ and $\Delta^{Und} = \bar{\pi}^F - \bar{\pi}^{Und}$ are calculated. A t-test is made of the Δ-series, which tests the null hypothesis that the three Δ-series comes from a normal distribution with mean zero. Row 1 refers to Figure 7(a), excluding Japan. Rows 2 and 3 refer to Figure 7(b).

DOES THE LOW POLICY RATE IN JAPAN EXPLAIN THE LOW INFLATION?

The financial markets in Japan witnessed widespread deregulation in the 1980s, which among other things led to a steep rise in stock and property prices. This came to an abrupt end at the beginning of the 1990s when both the stock and property prices fell in the wake of a financial crisis. Since then, Japan's central bank has held the policy rate at low levels, and at the same time the inflation has been close to zero or negative. This period, which began at the beginning of the 1990s and which, in all essentials, is continuing today, is known as Japan's "lost decades".

It may be of particular interest to apply the Fisher relation to Japan's lost decades, since they were characterised by both low policy rates and low inflation. In fact, we can show that the Fisher inflation is entirely in line with the observed inflation not only during the lost decades, but also in the preceding period.

In the pre-crisis period, 1981-1990, the average nominal interest rate was about six per cent and the growth rate almost four per cent, see Table 1. This implies that the Fisher inflation was just over two per cent, which was in line with the observed inflation, see Figure 8(b). During the lost decades, both the nominal interest rate and the growth rate fell to about one per cent. This implies a Fisher inflation around zero per cent, which was also the level of the observed inflation, see Figure 8(b).

Does this mean that the low inflation in Japan's lost decades was due to the low policy rate? Our results are consistent with such a conclusion, but we cannot rule out other explanations.[19] Nevertheless, it is worth noting that the average growth rate in Japan's lost decades was just below one per cent, which can be compared to 1.4 per cent in the US and 1.3 per cent in Canada. In other words, Japanese growth rates were about the same as those of the US and Canada – unlike its monetary policy. The nominal interest rate in Japan was about one per cent, while in the US it was 2.9 per cent and in Canada it was 3.5 per cent. Hence, the Fisher inflation was 1.5 per cent in the US and 2.2 per cent in Canada, which corresponds relatively well with the actual outcome of about two per cent in both countries. In Japan, as we have seen, the inflation was about zero per cent on average in the data and according to the Fisher relation.

19 Shirai (2012) discusses, for example, the role of demography in economic developments and shows, among other things, estimates of the output gap which indicate that it has been negative over almost the entire period since the mid-1990s. However, he also notes that there is, as of yet, no consensus over the factors that could explain such a development.

James Bullard on the effects of low nominal interest rates over a longer period

In a much-debated article from 2010, James Bullard, president of the Federal Reserve Bank of St. Louis, discussed the effects of low nominal interest rates over a longer period of time, see Bullard (2010). The purpose was to shed light on the risk that the US could be moving to a new steady state with deflationary tendencies like those in Japan. His analysis was based on insights from earlier work by Benhabib et al. (2001), in which the Fisher relation and the zero lower bound were key ingredients.[20]

Monetary policy is often described by a linear Taylor rule in standard macroeconomic models.[21] As a consequence, there exists no zero lower bound for the policy rate. Furthermore, there is only one steady state inflation rate, which coincides with the central bank's inflation target. However, if there exists a zero lower bound, there may be a second steady state, in which the policy rate is close to zero per cent and inflation is low or negative.

In Figure 9 we illustrate the two steady states. The solid line shows the Fisher relation, given a long run real interest rate of 0.5 per cent. The dashed line shows a non-linear Taylor rule, where the non-linearity is due to the zero lower bound. Hence, there are two points where the Fisher relation and the non-linear Taylor rule intersect, marking the two steady states. The blue area marks the steady state where the nominal interest rate is well above the zero lower bound and inflation is on target. This steady state is known as the "targeted" steady state. The other steady state, marked red, may appear when there is a lower zero bound. As mentioned, in this steady state, inflation may be low or even negative, which means that it will be below the central banks inflation target. This steady state is therefore known as the "unintended" steady state.

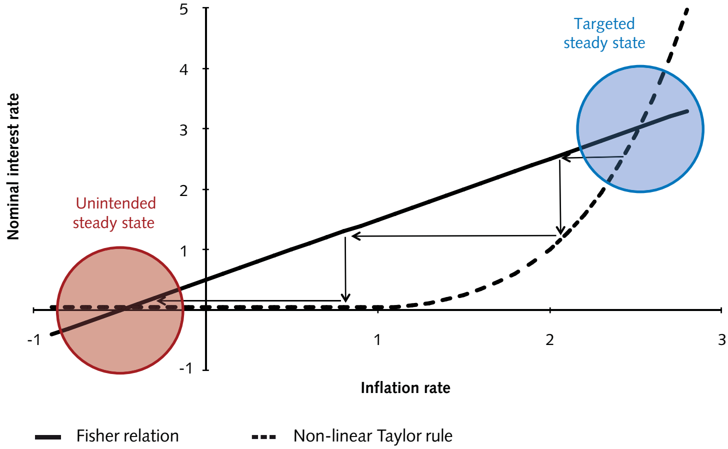
The arrows in the figure illustrate a possible transitional path from the targeted steady state to the unintended steady state. Note that monetary policy becomes passive once the economy gets stuck in the unintended steady state, since the policy rate will not react to changes in inflation. If inflation were to fall, the central bank would be unable to cut the policy rate due to the zero lower bound. If, on the other hand, inflation were to rise, the policy rate cannot be raised either, since inflation is far below the inflation target. Inflation expectations therefore remain at a level consistent with a nominal interest rate of zero per cent and a real interest rate of 0.5 per cent, i.e. a negative inflation rate of –0.5 per cent.

When the economy gets stuck in the unintended steady state, it can be difficult to escape from it, since standard monetary policy actions are ineffective. The central bank may in such a situation resort to unconventional measures. Bullard argues that quantitative easing (purchasing government bonds) is the measure that has the best chance of taking the economy back to the targeted steady state.

20 The level of the lower bound is not important to the analysis in this section. The important point is that there *de facto* exists a lower bound. For the sake of simplicity, this lower limit is assumed to be zero per cent.

21 The monetary policy rule in equation (6) is an example of this.

Figure 9. The two steady states for the nominal interest rate and inflation when monetary policy is constrained by the zero lower bound
Per cent



Source: Own illustration

JAPAN APPEARS TO HAVE GOT STUCK IN THE UNINTENDED STEADY STATE

Japan has been characterised by low nominal interest rates and inflation since the outbreak of the financial crisis in the beginning of the 1990s. Does this suggest that Japan has got stuck in the unintended steady state? To investigate this, we look at the movements of the nominal interest rate and inflation before and after the crisis.

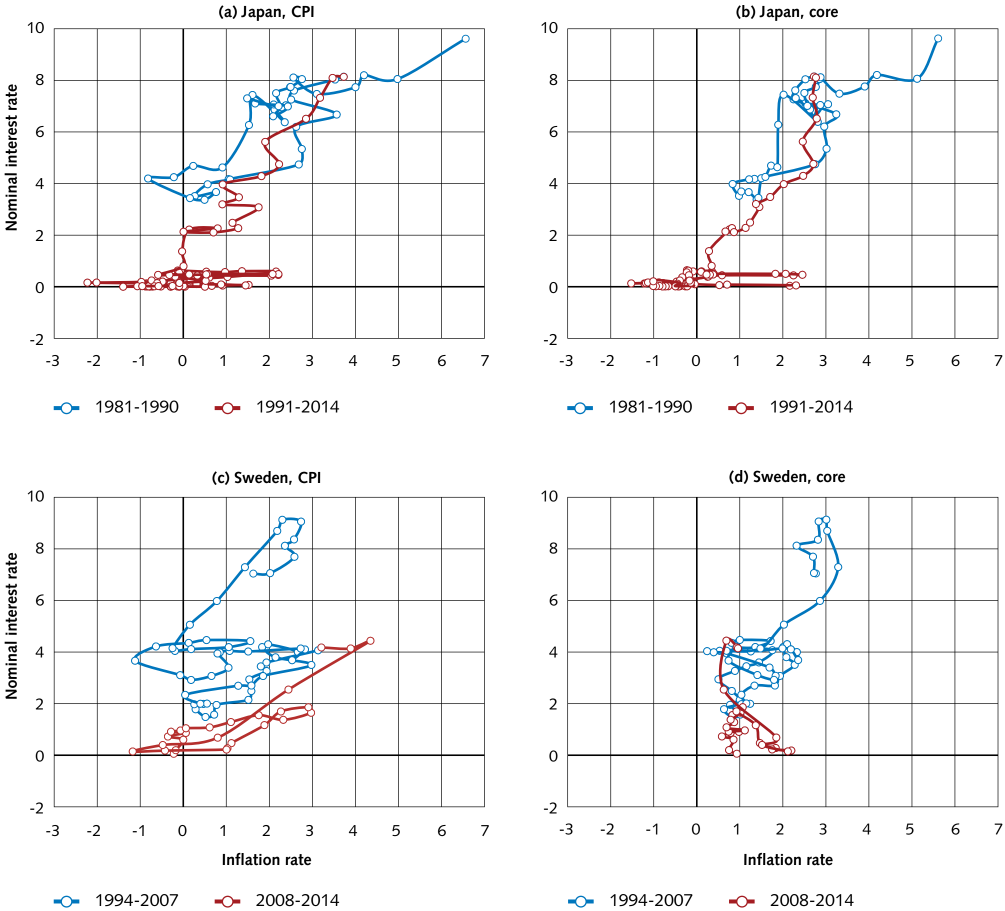
The nominal interest rate in the pre-crisis period appears to have varied around a long run level of 6-8 per cent and inflation around a level of 2-3 per cent, see the blue outcomes in Figures 10(a) and 10(b). Outcomes in the post-crisis period are marked red. The nominal interest rate appears to fluctuate around zero per cent. The inflation rate has varied, but most of the observations are still around zero per cent. This indicates that Japan may have moved from the targeted steady state to the unintended steady state.[22]

SEVEN YEARS OF DATA IS NOT ENOUGH TO DETERMINE WHETHER SWEDEN AND OTHER COUNTRIES HAVE MOVED TO THE UNINTENDED STEADY STATE

Sweden and several other countries have since the outbreak of the financial crisis in 2008 had nominal interest rates close to zero and low inflation. Does this suggest that these countries are about to move to the unintended steady state? Seven years of data is not enough to determine this, but it may be enough to distinguish certain tendencies.

22 This is also confirmed by Aruoba et al. (2014).

Figure 10. Nominal interest rates and inflation in Japan and Sweden
Per cent



Note. The nominal interest rates are measured by three-month treasury bills. Core inflation is measured by CPI excluding food and energy in Japan and by CPIF excluding food and energy in Sweden.

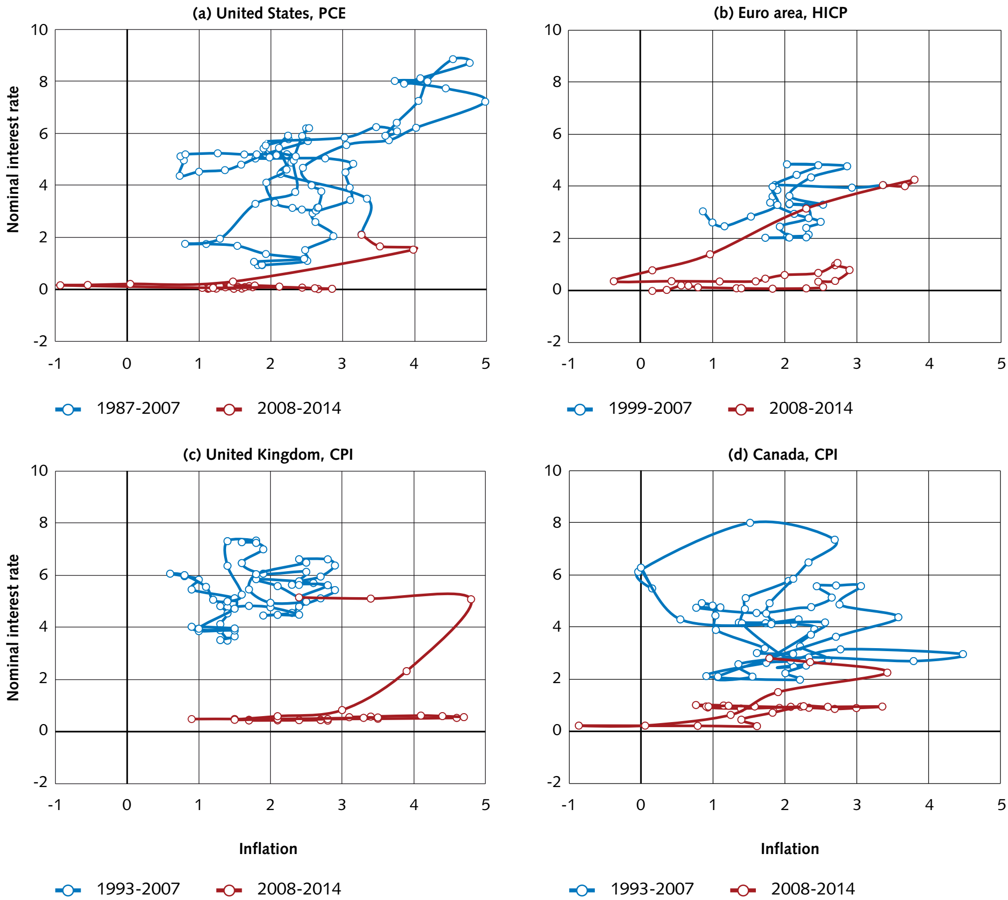
Sources: Macrobond, OECD, Statistics Sweden and the Riksbank

Figures 10(c) and 10(d) show the nominal interest rate and inflation in Sweden between the years 1994 and 2014. In the pre-crisis period the nominal interest rate varied around 3-4 per cent and inflation around 1-2 per cent. After the outbreak of the crisis, the nominal interest rate has been falling to around zero per cent, although it is not possible to distinguish a new steady state. This is the case regardless of whether we look at CPI inflation or core inflation.

In the US, the steady state prior to the financial crisis appears to have been about 4 per cent for the nominal interest rate and about 2 per cent for inflation, see Figure 11(a). In the post-crisis period, the nominal interest rate has been about zero per cent, but inflation has varied a good deal and most of the observations fluctuate around 1-2 per cent.

In the euro area inflation has been fluctuating extensively in the post-crisis period. At lowest, it was –0.3 per cent and, at highest, 3 per cent, see Figure 11(b). We note that the most recent observations indicate that inflation is approaching deflation territory. But it is hard to distinguish a new steady state on the basis of this, even if the euro area appears to have left the steady state it was in prior to the crisis. Neither do the developments in the UK and Canada in the post-crisis period indicate that these countries have been falling into the unintended steady state, see Figures 11(c) and 11(d). However, like the euro area, the UK appears to have left the steady state it was in before the financial crisis.

Figure 11. Nominal interest rates and inflation in the US, the euro area, the UK and Canada
Per cent



Note. The nominal interest rates are measured by three-month treasury bills, except in the euro area where the nominal interest rate is measured by EONIA.

Sources: ECB, Eurostat, Macrobond, OECD and the US Bureau of Economic Analysis

Concluding remarks

One of the objectives of this article has been to explore Narayana Kocherlakota's claim that a low policy rate over the long run can lead to low inflation. The idea relies on long run monetary policy neutrality and the long run Fisher relation. Under these assumptions, it follows that a long-lived cut in the policy rate leads to a proportional fall in inflation.

However, even if economic theory predicts low inflation if the policy rate is held at a low level over a longer period, this does not necessarily imply that this also will be the case in reality. Economic theories are based on various simplified assumptions and are therefore, by definition, inaccurate in one way or another. It is therefore important to empirically test to which extent the economic theory is consistent with data. We have shown that, if the real interest rate is equated to the GDP growth rate per capita, the average inflation in Sweden and other countries can be explained by the difference between the average nominal interest rate and the growth rate. We find this interesting, since it indicates that, in several countries, the long run Fisher relation is consistent with the data. In addition, it provides empirical support to Kocherlakota's claim.

Several scientific articles have recently been published where the Fisher relation is one of the key factors behind the results. Schmitt-Grohé and Uribe (2013) is one example. They present a scenario which is intended to resemble the experiences of the US following the outbreak of the financial crisis in 2008, i.e. a long period of nominal interest rates close to zero, inflation expectations below the inflation target and slow employment growth. The Fisher relation plays a key role in how households and firms interpret changes in the policy rate in their model. A policy rate increase is a signal of higher future inflation. One of their conclusions is that an increase in the policy rate pushes up inflation expectations and promotes employment.

Another example is Leeper and Leith (2015). They present a model in which the fiscal theory of the price level and the Fisher relation are two key features in determining inflation.[23] The fiscal theory of the price level is relevant when expansions in nominal debt are not expected to be funded by higher taxes or lower expenditure, i.e. when households and firms do not expect fiscal policy expansions to be funded by a future surplus. When this is the case, raising the policy rate raises the nominal interest rate receipts of the bond holders (i.e. the households). Since they do not expect higher future taxes to finance the increased expenditures their nominal wealth also increase. The increase of wealth pushes up consumption and demand, which eventually also pushes up inflation.

23 See also Leeper and Yun (2006) for a description of the fiscal theory of the price level.

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