Why are real interest rates so low? Evidence from a structural VAR with sign restrictions

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Abstract

Numerous explanations for the low World real interest rate have been discussed in the literature, but only a handful of studies attempt to disentangle the relative importance of the different factors. Sign restrictions are useful for analyzing this problem since shocks to the supply of savings can be separated from shocks to investment demand using the fact that these shocks have effects of opposite signs on the equilibrium real interest rate. The bivariate model with only the real interest rate and investment indicates that shocks to investment demand have been twice as important to the recent decline in real interest rates as shocks to savings. When more shocks are included, we find that 1.26 percent of the low real interest rate 2012–2015 is due to negative business cycle shocks and 1.11 percent is due to low productivity. According to these structural VARs with sign restrictions, high savings has not been a major factor behind the recent decline in World real interest rates.

Keywords: Real interest rate, sign restrictions, global savings and investment.
JEL classifications: E43, E44.

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1 Introduction

World nominal interest rates have fallen to record low levels in the aftermath of the global financial crisis. With inflation rates picking up, real interest rates remain depressed also as the business cycle picks up. British forward real interest rates in 2027, 10 years into the future, were −1.3 percent in October 2017.\(^1\) Have we entered a new state characterized by low real interest rates? The term 'Secular Stagnation' was re-introduced by Larry Summers in 2013. According to this hypothesis, a combination of weak aggregate demand and less productive investment opportunities has depressed real interest rates (Summers, 2013). Other explanations include increased World savings (Bernanke, 2005, Caballero et al., 2008), and slower steady state growth (Holston et al., 2017, Laubach and Williams, 2016).

While several studies provide empirical evidence in favour of a particular explanation of the low real interest rates, only a handful of papers evaluate the relative importance of different factors. Gerali and Neri (2017) estimate a closed economy medium scale DSGE model and find that persistent, negative risk premium shocks have caused most of the recent decline in the U.S. real interest rate. Eggertsson et al. (2017) calibrate a life cycle model and conclude that demographic factors dominate. Hence, a consensus about why real interest rates are so low has not yet emerged from the literature.

This paper estimates a structural VAR model with sign restrictions to investigate which structural shocks that have caused the observed decline in World real interest rates. Sign restrictions is a useful method for disentangling the effects of e.g. changes in the supply of savings from changes in investment demand given that these two categories of shocks have effects

\(^1\)http://www.bankofengland.co.uk/statistics/pages/yieldcurve/default.aspx.
of different signs on real interest rates and savings/investment. Higher savings decrease the equilibrium real interest rate as savings and investment increase, while lower investment demand results in a lower equilibrium real interest rate and lower equilibrium savings/investment. Our main results are based on historical decompositions of real interest rates during the recent period. According to our two-variable model with only the real interest rate and investment, weak World investment demand was the main factor caused behind the low real interest rate in 2012–2015, causing it to be $-1.58$ percentage points below equilibrium.

Since there appears to be business cycle movements in the data, we proceed from a two-variable model with only investment and real interest rates to a larger model that includes changes in GDP. In addition to the business cycle, this variable also contains information about movements in steady state growth. Given that business cycle demand shocks cannot be distinguished from productivity shocks using sign restrictions in such a three-variable setting, we also add inflation. Positive productivity shocks that increase investment demand decrease nominal prices, while positive business cycle demand shocks increase them. When business cycle shocks are incorporated, they turn out to have the largest influence on the 2012–2015 real interest rate ($-1.26$), followed by low productivity ($-1.11$).

Even if the development since the financial crisis has been particularly dramatic, real interest rates have been trending downward for decades (King and Low, 2014, Thwaites, 2015). Since the equilibrium real interest rate is determined by the supply of savings and investment demand for funds, the two main categories of explanations focus on higher World supply of savings and lower World demand for investments. Higher savings could in turn be due to demographic factors, redistribution of relative wealth to countries
with high savings rates, or increased inequality (Lisack et al., 2017). Low investment demand could be due to slower steady state growth (as in Gordon, 2015, and Laubach and Williams, 2016) or less productive investment opportunities (Gordon, 2012). As discussed by Thwaites (2015) and others, low real interest rates caused by increased savings should be accompanied by higher equilibrium investments, which is not observed in the data. According to Krugman (2014), slow growth of working age population has lead to low demand for new investment, since less new capital is required to maintain a given ratio of capital to labor. Another potential explanation is that the relative price of capital goods has fallen, which implies that a given amount of savings can buy more investments (Thwaites, 2015). Higher risk premia on un-levered capital and low supply of (or high demand for) safe assets in the aftermath of the global financial crisis could also contribute to the low equilibrium real interest rates (Caballero and Fahri, 2014, Caballero et al., 2017).

Several studies quantify the relative importance of various factors behind the observed decline in real interest rates. Barsky et al. (2014) use a calibrated DSGE model and find that a highly persistent negative risk shock is the main factor behind the low equilibrium real interest rate in 2013. This can be interpreted as a business cycle demand shock in the sense that it affects output and prices in the same direction and is mean reverting. According to the calibrated life cycle model of Carvalho et al. (2016), demographic factors like increased life expectancy and decreased population growth caused a decline of equilibrium real interest rates of 1.5 percentage points in 2014. Rachel and Smith (2015) quantify the effects of shifts in global savings and investment schedules using a modified accounting framework to pin down the effects of slower trend growth on real interest rates and
previous estimates of partial equilibrium effects to analyze other variables. They conclude that one percentage point of the decline in the World real interest rate is due to slower steady state growth, followed by demographic changes (0.9 percentage points), increased spreads between risk free and actual interest rates (0.7 percentage points), lower relative price of capital (0.5 percentage points), rising inequality within countries (0.45 percentage points), and a preference shift towards higher savings in emerging markets (0.25 percentage points). While the all-embracing approach of Rachel and Smith is intuitively appealing, a unified econometric framework may provide complementary information about the sources of real interest rate fluctuations. Eggertsson et al. (2017) use a calibrated medium scale life cycle model to analyze the forces behind the four percentage points drop in real interest rates since 1970. They find that demographic factors dominate: reduced fertility and reduced mortality account for 3.76 percent of the decline in real interest rates. Slow productivity growth is also important at −1.90 percent, while government debt has increased real interest rates by 2.11 percent. They also document a moderate influence of lower relative prices of capital goods, −0.44 percentage points.

The remainder of this paper is organized as follows. Section two discusses sign restrictions as a method for identifying structural shocks. Section three presents the data, while Section four contains the main empirical results. The robustness of our findings is investigated in Section five and Section six concludes.
2 Identifying shocks using sign restrictions

Traditionally, structural shocks in VAR models are identified using either short run restrictions on the timing of the effects of shocks, or long run restrictions on the accumulated effects of shocks. A different approach introduced by Blanchard and Diamond (1990), Faust (1998), and developed further by Uhlig (2005) is to identify structural shocks using restrictions on the signs of the effects of a shock on the endogenous variables. A first major field of application was the oil market, where sign restrictions allowed shocks to the supply of oil to be separated from shocks to the demand for oil using the fact that higher supply of oil drives prices down as the equilibrium quantity increases, while higher demand push prices up. Oil price hikes caused by higher demand for oil turn out to have very different macroeconomic effects compared to oil price hikes caused by reductions in the supply of oil (Lutz and Murphy, 2012). VAR models with sign restrictions have also been used to analyze monetary policy shocks (Uhlig, 2005), fiscal policy shocks (Montford and Uhlig, 2009), news shocks (Beadry et al., 2011), and technology shocks (Dedola and Neri, 2007), among other issues.

Identification through sign restrictions is a relevant method for analyzing the sources of movements in real interest rates since standard macroeconomic theory has implications for the signs of the effects of different shocks. The equilibrium real interest rate is determined by the intersection of the savings supply schedule and the investment demand schedule. Shocks to the supply of savings decrease real interest rates as equilibrium savings and investment increase, while shocks that work through lower demand for investment decrease real interest rates as savings and investment fall. Hence, these two types of shocks can be identified and their relative importance for
movements in real interest rates can be estimated.

We first estimate a bivariate model with only the World real interest rate and equilibrium savings/investment, and then add changes in World GDP and nominal prices in order to allow for a richer variety of shocks. Changes in GDP capture both business cycle variation and movements in steady state growth. However, business cycle shocks cannot be separated from productivity shocks using sign restrictions on the effects of shocks in a model with only these three variables since these shocks have effects of identical signs. A fourth variable is required for full identification. Since productivity shocks increase the supply of goods and decrease prices, while demand shocks affect prices and quantities in the same direction, adding inflation allows productivity shocks to be separated from business cycle demand shocks. Instead, a new identification problem occurs as cost push inflation shocks have theoretical effects on prices and GDP that are similar to the effects of productivity shocks. This separation is achieved by assuming that cost push shocks increase real interest rates as they increase prices given inflation targeting central banks. Results by Gali and Gertler (2007), Clarida et al. (2001) and similar DSGE models support this assumption. The restrictions used to identify structural shocks in the four-variable model are shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Sign restrictions in the four-variable model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Savings</strong></td>
</tr>
<tr>
<td>Real Interest Rate</td>
</tr>
<tr>
<td>Investment rate</td>
</tr>
<tr>
<td>Changes in GDP</td>
</tr>
<tr>
<td>Inflation</td>
</tr>
</tbody>
</table>

Sign restrictions do not uniquely identify the structural shocks. Instead,
a set of structural models that are consistent with the imposed restrictions is extracted. This has far reaching consequences for statistical inference of e.g. impulse response functions from VAR models that are identified using sign restrictions. Different impulse responses stem from different structural models rather than from different draws from a given model. However, since this paper focuses on point estimates rather than confidence intervals, we do not dwell on this issue.

Identification through sign restrictions on the effects of shocks involves drawing a large number of random matrices that transforms the reduced form VAR to a structural VAR, checking whether the resulting impulse response functions fulfill the restrictions, and discarding matrices or structural models that do not. Formally, the construction of structural impulse response functions requires estimate of the matrix $B$ in $e_t = B \varepsilon_t$, where $e_t$ are the reduced form residuals from the VAR model and $\varepsilon_t$ are the structural residuals. Let $\sum e = BB'$. Then $\tilde{B} = BD$ also satisfies $\sum e = \tilde{B} \tilde{B}'$ for any orthogonal matrix $D$. This matrix algebra implies that there are infinitely many structural VAR models that can give rise to a given estimated reduced form VAR. Each $D$ matrix represents a different structural VAR. One can examine a wide range of possibilities for $D$ by repeatedly drawing random orthogonal matrices. The procedure follows Rubio-Ramirez, Waggoner, and Zha (2010) and constructs the set $\tilde{B}$ of admissible models by drawing from the set $D$ of rotation matrices and discarding candidate solutions for $\tilde{B}$ that do not satisfy a set of a priori restrictions on the implied impulse response functions. The procedure consists of the following steps:

1. Draw an $N \times N$ matrix $K$ of $NID(0,1)$ random variables. Derive the $QR$ decomposition of $K$ such that $K = Q \cdot R$ and $QQ' = I_N$.

2. Let $D = Q$. Compute impulse responses using the orthogonalization
\( \tilde{B} = BD \). If all implied impulse response functions satisfy the identifying restrictions, retain \( D \). Otherwise discard \( D \).

(3) Repeat the first two steps a large number of times, recording each \( D \) that satisfies the restrictions and storing the corresponding impulse response functions. The resulting set \( \tilde{B} \) comprises the set of admissible structural VAR models. The loop continues until we have 1000 admissible \( D \) matrices.

For each empirical specification, impulse responses, variance decompositions, and historical decompositions are obtained. Historical decompositions for the years 2012–2015 reveal which shocks that have caused the recent decline in the World real interest rate.

### 3 Data

Long time series on World output and investment are only available annually. We use data on World GDP growth, investment rate, and inflation from the World Bank’s World Development Indicators. World inflation is collected from the same source.\(^2\) Data on GDP and investment are available in current prices and constant prices, which allows us to construct a proxy for the relative price of capital goods. Unless otherwise specified, the sample period is 1961 to 2015.

In order to study the sources of movements in World real interest rates, we want to measure variables that are unobservable in several dimensions. First, real as opposed to nominal interest rates are either unobservable or imperfectly measured. Inflation adjusted bond rates are available for several

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\(^2\)The GDP deflator is used rather than World CPI because the latter is not available from 1960. The GDP deflator is calculated by dividing GDP in current prices (USD) by GDP in constant prices (USD).
countries, but only for the most recent decades. Since a long sample period is required, real interest rates have to be constructed using nominal long term bond yields and inflation rates. Furthermore, a proxy for the World interest rate has to be constructed from country data. The real interest rate of any individual country depends on real interest rates in other countries. This makes the World a natural entity for studying the determination of real interest rates. Unfortunately, there are no World bonds or World policy interest rates that can be used to measure the World real interest rate. In contrast, data on World GDP, World investments, and World inflation are actually collected by several organizations. In lieu of data on World interest rates, other authors have used averages of the real interest rates of major economies (sometimes weighted by GDP). We construct a measure
of the World real interest rate from individual country data using principal component analysis to extract a common factor from country real interest rates.\(^3\) The World real interest rate is extracted from the real interest rates of the six countries for which long time series on nominal ten-year interest rates and inflation rates are available (Canada, Germany, France, Switzerland, the United Kingdom, and United States). Data on nominal interest rates is collected from the OECD data base Main Economic Indicators.

Real interest rates for the individual countries are constructed using nominal ten year government bond rates and ex post inflation rates. Several studies use long (five or seven year) moving averages of lagged inflation to remove non-fundamental inflation noise from the real interest rate. However,\(^3\) As shown in Section 5, the results are similar when the real interest rate is calculated using lagged inflation and the average across countries rather than the first common factor.
the main findings are reproduced also with this proxy for expected inflation. Principal Components Analysis (PCA)\textsuperscript{4} is used to extract common components from the individual country interest rates. Specifically, our proxy for the World real interest rate is the first factor identified by PCA. Figure 2 shows the individual country real interest rates and the first factor from the PCA. The factors are de-meaned, which is why this measure of the World real interest rate is lower than individual country rates. For the full sample, this measure of the real interest rate is about two percentage point below its mean in 2015. A second sample covering only 1985 to 2015 (the period with falling real interest rates) yields a gap to be explained of 2.5 percentage points. Both these magnitudes are smaller than the estimated deviation from equilibrium in Rachel and Smith (2015), which is 4.5 percentage points.

4 Empirical results

The structural shocks affecting real interest rates and other variables are identified using sign restrictions on the effects of shocks. The first model contains only the real interest rate and World investment (which equals World savings by definition since the World is a closed economy). The two structural shocks are shocks to the supply of savings and shocks to investment demand. They are identified using the assumption that a positive shock to the supply of savings lead to a lower equilibrium real interest rate, while a positive productivity shock that increases demand for investment leads to a higher equilibrium real interest rate.

The output from the two-variable model indicate that there are business

\textsuperscript{4}Principal component analysis was first formulated by Persson (1901) and is used in numerous fields to reduce data dimensionality.
cycle shocks in the data. We proceed to incorporate changes in GDP, a variable that also captures movements in steady state growth. However, sign restrictions do not provide a full set of identifying restrictions unless a price variable is added as well. This allows us to distinguish business cycle shocks from productivity shocks since the latter have negative effects on inflation. In the second specification, four variables are included: The real interest rate, GDP, investment and inflation. The four shocks are shocks to the supply of savings, productivity shocks, cost push shocks, and business cycle demand shocks. Table 1 summarizes the identifying assumptions.

4.1 Bivariate results

In the two variable model with only the real interest rate and investment, shocks to the supply of savings are separated from shocks to the demand for investment using the assumption that the former increase the interest rate while the latter decrease it as equilibrium savings/investment decline.

Forecast error variance decompositions provide information about which shocks that are important at different horizons. As shown in Table 2, 70–74 percent of the real interest rate movements at horizons above two years are caused by shocks to savings demand in this model.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings</td>
<td>0.2998</td>
<td>0.7033</td>
<td>0.7323</td>
<td>0.7358</td>
</tr>
<tr>
<td>Investment</td>
<td>0.7002</td>
<td>0.2967</td>
<td>0.2677</td>
<td>0.2642</td>
</tr>
</tbody>
</table>

Historical decompositions is the most informative type of output from the SVAR given that we want to know which shocks that have caused the recent slump in real interest rates. Figure 3 shows how the movements in the
World real interest rates that are captured by this model can be separated into parts due to changes in the supply of savings versus the demand for investment. According to the bivariate model, the low real interest rates in the 1960s was mainly due to high savings, while weak investment demand dominate the recent slump.

Figure 3: Historical decompositions of the real interest rate, bivariate model

Table 3 shows the historical decompositions for the World real interest rate for the years 2012 to 2015. Low investment demand is the main driving force behind the recent decline in World real interest rate, causing it to be on average 1.58 below equilibrium. High supply of savings also has a negative effect, but of a smaller magnitude. According to this model, the World real interest rate was 2.84 (1.90) percentage points below equilibrium in 2012 (2015). Rachel and Smith (2015) are able to explain a deviation from equilibrium of four percentage points, but their measure of the real interest rate is lower in 2015 than our measure (−4.5 versus −2.0 percentage points)
below equilibrium). The bivariate model with only shocks to the supply of savings and the demand for investment leaves 0.15 percentage point of the average observed real interest rate gap 2012–2015 unexplained.\footnote{Since the VAR is stationary, the equilibrium real interest rate is just a constant.}

<table>
<thead>
<tr>
<th>Structural Shock</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings</td>
<td>-0.7761</td>
<td>-0.6296</td>
<td>-0.6627</td>
<td>-0.5480</td>
<td>-0.654</td>
</tr>
<tr>
<td>Investment</td>
<td>-2.0710</td>
<td>-1.4126</td>
<td>-1.4841</td>
<td>-1.3548</td>
<td>-1.581</td>
</tr>
<tr>
<td>Total</td>
<td>-2.847</td>
<td>-2.042</td>
<td>-2.147</td>
<td>-1.903</td>
<td>-2.235</td>
</tr>
</tbody>
</table>

4.2 A four-variable model

Movements in the supply of savings are often contributed to changes in demographics, or income distribution, while movements in investment demand could be due to e.g. productivity or business cycle shocks. With a richer empirical specification, more structural shocks can be analyzed. Data on changes in GDP contain both business cycle shocks and movements in steady state growth. However, incorporating changes in GDP requires an additional variable that allows productivity shocks to be separated from business cycle demand shocks. As can be seen from the first three rows of Table 1, these two types of shocks have effects of identical signs on the real interest rate, investment, and GDP in standard models. Including nominal prices in the model fulfills this function since productivity shocks and business cycle demand shocks have opposite effects on inflation. A productivity shock that increases output and the real interest rate decreases inflation through higher supply of goods, while a business cycle demand shock that increases output and the real interest rate also boosts the inflation rate. We
are hence left with a four variable model including the real interest rate, investment, changes in GDP, and inflation. This implies that there are four shocks: savings supply shocks, productivity shocks, business cycle demand shocks, and cost push inflation shocks.

All four shocks are uniquely identified using sign restrictions. Shocks to the supply of savings increase equilibrium savings and investment, but decrease the equilibrium interest rate. Productivity shocks increase equilibrium investment, but are associated with a higher equilibrium real interest rate. They also decrease inflation. Business cycle demand shocks increase GDP growth, the real interest rate, and inflation. Cost push shocks increase inflation and the real interest rate but decrease growth. The sign restrictions for the four-variable model are shown in Table 1.

<table>
<thead>
<tr>
<th>Horizon, years</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Productivity</strong></td>
<td>0.223</td>
<td>0.092</td>
<td>0.081</td>
<td>0.078</td>
</tr>
<tr>
<td><strong>Savings</strong></td>
<td>0.320</td>
<td>0.517</td>
<td>0.516</td>
<td>0.520</td>
</tr>
<tr>
<td><strong>Business Cycle</strong></td>
<td>0.418</td>
<td>0.392</td>
<td>0.385</td>
<td>0.372</td>
</tr>
<tr>
<td><strong>Cost Push</strong></td>
<td>0.039</td>
<td>0.019</td>
<td>0.018</td>
<td>0.029</td>
</tr>
</tbody>
</table>

Forecast error variance decompositions show how important the different shocks have been on average across the sample. Here, shocks to the supply of savings dominate at horizons above two years and have caused slightly more than half of the variations. Business cycle shocks is the second most important factor at 40 percent, while productivity shocks and cost push shock have had marginal effects.
Historical decompositions of the real interest rate 2010–2015 indicate that negative business cycle shocks is the main factor behind the low real interest rate, followed by negative productivity shocks. According to this model, high savings has not been quantitatively important to the recent decline in real interest rates and cost push shocks have even had positive effects.

<table>
<thead>
<tr>
<th>Structural Shock</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>-1.688</td>
<td>-1.336</td>
<td>-0.953</td>
<td>-0.461</td>
<td>-1.110</td>
</tr>
<tr>
<td>Savings</td>
<td>0.083</td>
<td>-0.172</td>
<td>-0.400</td>
<td>0.037</td>
<td>-0.113</td>
</tr>
<tr>
<td>Business Cycle</td>
<td>-1.239</td>
<td>-0.809</td>
<td>-1.068</td>
<td>-1.916</td>
<td>-1.258</td>
</tr>
<tr>
<td>CostPush</td>
<td>0.321</td>
<td>0.414</td>
<td>0.561</td>
<td>0.598</td>
<td>0.474</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5 Robustness

Since the results are conditioned on a model specification, we alter various characteristics of the baseline VAR: the measure of the real interest rate, the number of lags, and the sample period and investigate whether the main results are affected.

The baseline specification use the first factor from a principal component analysis of the real interest rate of six major countries (G7 minus Japan, for which corresponding long time series on ten-year nominal interest rates are missing), where nominal interest rates are converted to real interest rate using current CPI inflation as proxy for expected inflation. A more common measure of the World real interest rate is to use the average of the individual country real interest rates, constructed using a five-year moving average of past CPI inflation rates. Figure 5 shows our baseline measure and the alternative proxy for the World real interest rate. While the overall patterns are similar, the real interest rate constructed using lagged inflation is lower during the 1980s and reacts later to the oil price hikes of the 1970s. Column one in Table 6 contains the average historical decompositions of the 2012–2015 real interest rate when the VAR models are estimated using this proxy. Compared to the baseline results from the bivariate model in the final column, shocks to investment demand are more important relative to shocks to the supply of savings. In the four-variable model, negative productivity shocks become slightly more relevant when this proxy is used, while shocks to savings lose their importance.

As shown in the third column in Table 6, adding more lags has small effects on the results. Finally, we change the sample to focus only on the recent period with falling real interest rates (from 1985). Non-stationarity
could be an issue, but the VAR models are stable also in this case (the inverse of the roots of the characteristic polynomial are inside the unit circle). Column four in Table 6 shows that negative business cycle shocks have caused most of the recent fall in the real interest rate also in this specification, again followed by negative productivity shocks. The total deviation from equilibrium explained by the model is considerably lower than in the other specifications, only $-1.20$ percentage points.

The results from the bivariate model with only the real interest rate and investment are robust in the sense that shocks to investment demand are more important than shocks to the supply of savings in all specifications, but the relative sizes of the contributions vary considerably. The four-variable models assign the bulk of the real interest rate drop to negative business cycle shocks and productivity shocks, with the former dominating in three out of four specifications.
Table 6: Decompositions of the real interest rate 2012-15: Robustness

<table>
<thead>
<tr>
<th></th>
<th>Two-variable model</th>
<th>Alternative R</th>
<th>3 lags</th>
<th>1985 – 2015</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Savings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
<td>−0.1102</td>
<td>−0.8446</td>
<td>−0.8438</td>
<td>−0.6541</td>
</tr>
<tr>
<td></td>
<td>Investment</td>
<td>−2.1228</td>
<td>−1.5447</td>
<td>−0.9015</td>
<td>−1.5806</td>
</tr>
<tr>
<td><strong>Four-variable model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Savings</strong></td>
<td></td>
<td>0.0627</td>
<td>−0.0936</td>
<td>0.0623</td>
<td>−0.3032</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td>−0.7931</td>
<td>−0.8539</td>
<td>−0.2916</td>
<td>−0.5719</td>
</tr>
<tr>
<td><strong>Business Cycle</strong></td>
<td></td>
<td>−1.4207</td>
<td>−0.6563</td>
<td>−0.9392</td>
<td>−1.4801</td>
</tr>
<tr>
<td><strong>CostPush</strong></td>
<td></td>
<td>0.1990</td>
<td>0.2488</td>
<td>−0.0322</td>
<td>0.5814</td>
</tr>
</tbody>
</table>

In the first column, country real interest rates are constructed using five-year moving averages of inflation and the World real interest rate is the average across countries.

In the next column, the baseline model is estimated using three lags in the VAR.

In the column "1985-2015" the baseline model is estimated using a shorter sample.

The final column contains the baseline results from Table 5 for comparison.

The magnitude of the downturn in the real interest rate explained by the model is around minus two percentage points below equilibrium, except for the two specifications focusing on the shorter sample period. Perhaps surprisingly, it is not easier to account for the downfall using data from a period that mainly covers falling real interest rates. Rachel and Smith (2015) are able to explain a drop of four percentage points, but their measure of the real interest rate is much lower for these years (−4.5 percentage points below average). Our baseline measure is −2.37 below average 2012–2015, while the more standard measure used for the robustness exercises in column of Table 6 is slightly lower, −2.60. Hence the VAR models do explain most of decline in real interest rates in our data.
6 Conclusions

Has the World entered a new state of permanently low real interest rates, as discussed in the "secular stagnation" literature, or are we mainly observing the consequences of "persistent headwinds", as suggested by Rachel and Smith (2015)? Given that the equilibrium real interest rate is determined by the intersection of the savings supply schedule and the investment demand for funds schedule, the main explanations focus on higher World savings and/or lower World demand for investments. Sign restrictions are useful for separating shocks to the supply of savings from shocks to investment demand since these two types of shocks have effects of different signs on the real interest rate and savings/investment. According to historical decompositions from a two-variable model with only World investment and a measure of the World real interest rate, shocks to the demand for investment have been almost three times as important as shocks to savings in 2012–2015. This is an intuitive result given that high savings would lead to low real interest rates accompanied by high investments, which is not observed in our data. Low demand for investment caused the real interest rate to be on average −1.58 percentage points below equilibrium, compared to −0.64 for increased savings. The bivariate specification explains virtually all the recent decline in the World real interest rate.

By extending the empirical model to include changes in GDP and inflation, we are able to identify shocks to savings, productivity, the business cycle, and cost push shocks as sources of movements in the real interest rate. The four-variable model indicates that persistent, negative business cycle shocks was the most important factor behind the low real interest rate 2012–2015, causing −1.26 percentage points of the total decline of −2.37
percentage points. Negative productivity shocks is the second most important factor (even dominating over business cycle shocks in one of the robustness exercises with more lags in the VAR), while increased savings only contributed marginally.

The finding that negative business cycle shocks is the main reason behind the low real interest rates is in accordance with the "persistent head wind" argument of Rachel and Smith (2015). The findings of Barsky et al. (2014) and (2017) that persistent, negative risk premium shocks caused most of the decline are also consistent in the sense that risk premium shocks would be classified as business cycle shocks in our sign restrictions scheme.

Since even persistent negative business cycle shocks eventually pass, our results indicate that most of the current decline in World real interest rates will be reversed as the international business cycle gains momentum. About a third of the drop in real interest rates is however caused by low productivity and is not spontaneously revoked as time goes by. Monetary policy could therefore be hampered by the zero lower bound on nominal interest rates more frequently in the future than what has been the case historically.

There are several potential policy conclusions from this. Unconventional monetary policy will be required more often and needs to be developed and studied further. The dominating two percent inflation targets are called into question given that higher target levels would increase the neutral nominal interest rate and allow the central bank to lower policy rates more in recessions before hitting the lower bound.
References


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