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Indexed Bonds and Revisions of Inflation Expectations

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Abstract

This paper investigates the impact of revisions in inflation expectations on the prices of UK inflation-indexed and conventional government bonds with a vector autoregressive (VAR) model. Downwards revisions of inflation expectations are associated with unexpected increases in the prices of conventional bonds, but the prices of indexed bonds are not significantly affected. This suggests that indexed bonds protect investors against inflation while nominal bonds are exposed to changing monetary conditions. This is consistent with the view that indexed bonds avoid the inflation risk premium of conventional bonds and reduce the government's long-run borrowing costs.

Keywords
Conventional and indexed bonds, inflation, macroeconomy, VAR

JEL Classification
E43, G12

Comments

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Contents

1 Introduction

Inflation-indexed bonds are savings contracts that account for changes in the general price level. Economists have identified inflation as an important source of risk and survey evidence suggests that individuals generally dislike inflation (e.g., Shiller 1996, Scheve 2002). An important argument for the use of inflation-indexed bonds in low inflation countries like the UK and US is the perception that these bonds do not require a compensation for inflation risk.[1] When indexed bonds avoid the inflation risk premium of conventional bonds they should result in lower long-run borrowing costs. A reduction of borrowing costs with inflation-indexed bonds has two components. First, a significant inflation risk premium inherent in conventional bond returns and, second, indexed bonds are not exposed to inflation. Campbell and Shiller (1996) and Buraschi and Jiltsov (2005) study the inflation risk premium. This paper is concerned with the second condition and empirically assesses whether inflation affects the prices of indexed bonds.

Indexed bonds may be naturally perceived to protect investors against unexpected inflation due to their ex-post compensation for inflation. However, to the extent that indexed bonds are real bonds they should reflect the behavior of real interest rates. Theoretical research often assumes that real interest rates are constant, but an extensive empirical literature documents a negative relationship between real interest rates and inflation in terms of both realized changes and expected values (e.g., Barr and Campbell 1997, Campbell and Viceira 2001, Ang and Bekaert 2004). When money is not neutral inflation may matter for real yields and the argument that indexed bonds avoid the inflation risk premium of nominal bonds no longer applies. Reschreiter (2004) finds significant risk compensations for British index-linked government bonds that may result from an inflation exposure of indexed bonds.

[1]The British government issues indexed bonds since 1981 and the UK index-linked gilts market is one of the largest markets for inflation-indexed government bonds. Since the introduction of Treasury Inflation Protected Securities (TIPS) in the US in 1997 several other countries with low inflation rates have started to issue inflation-linked bonds. Among these countries are large economies such as Germany, France, Italy, and Japan. This paper focuses on the UK experience.

Previous research consider the contemporaneous relation between unexpected inflation and unexpected returns on indexed bonds.[2] However, the contemporaneous relation does not reveal whether indexed bonds are exposed to inflation, because unexpected inflation should lead to an appropriate change in nominal prices of indexed bonds to protect investors against inflation. This suggests that a lack of a contemporaneous relation rather indicates an inefficient inflation indexation than no inflation exposure of indexed bonds. An alternative to unexpected inflation are revisions of inflation expectations. When a macroeconomic variable affects the prices of financial assets, informationally efficient market participants will form expectations about future values of the economic variable. This forward-looking behavior of agents is embedded in financial time series such as asset prices and interest rates. They reflect the view of the market as a whole and revisions of market expectations of price relevant economic variables should be associated with unexpected movements in the prices of financial assets.

We use a reduced-form vector autoregressive (VAR) model to investigate the impact of revisions in inflation expectations on the prices of UK inflation-indexed bonds. The VAR models the dynamic interaction between changes of inflation expectations at different time periods and unexpected movements (shocks) in the prices of indexed bonds. Changes in expected future inflation should have no impact on indexed bonds if they are hedged against inflation. In a similar study of US equity returns, Lee (1992) investigates dynamic relations among equity returns, inflation and economic activity. We also include economic activity in the analysis. The macroeconomic literature suggests a negative relation between inflation and output (e.g.,

[2]Factor models investigate the relation of unexpected returns with risk factors such as unexpected inflation. Elton, Gruber, and Blake (1995) find that inflation and economic activity are important risk factors for US conventional bonds and Reschreiter (2003) studies UK indexed and conventional government bonds. Similar in spirit, event studies look at the reaction of bond prices to macroeconomic news releases. Joyce and Read (2002) find that retail price news affect the prices of conventional bonds. In Tessaromatis (1990) conventional bonds are negatively related to unexpected money supply announcements but indexed bonds are not significantly affected.

Barro 1995, Boudoukh 1993). Based on a link between inflation and economic activity, the relation of indexed bonds with economic activity should mirror the relation of indexed bonds with inflation. Economic activity is also an important risk factor in the bond markets of the US and UK (Elton, Gruber, and Blake 1995, Reschreiter 2003).

We also include conventional bonds in the VAR model. Conventional bonds are an important benchmark in our analysis of indexed bonds. The price of an financial asset signals the future of an economic variable if (i) market participants consider the economic variable a determinant of the price of the asset and (ii) the market's forecast of the economic variable is skilful and therefore materializes. Conventional bonds help to separate these two components, because inflation is an important risk factor for conventional bonds. When the market is able to successfully forecast future inflation then revisions of expected future inflation rates should be associated with shocks in the prices of conventional bonds. However, revisions of inflation expectations should have no effect on the prices of indexed bonds if they are hedged against inflation. Thus, when conventional bonds signal future inflation but indexed bonds do not, then investors appear to price inflation into conventional bonds but disregard inflation when they price inflation-indexed bonds.

The rest of the paper is organized as follows. Section 2 considers the relation between bond price shocks and revisions of inflation expectations. Section 3 presents the empirical results and Section 4 concludes.

2 Modeling bond price shocks and inflation

Let $p_{m,t}$ denote the log of the nominal price of a m-period zero-coupon bond at time t. Returns and interest rates are continuously compounded. The holding period return is the difference between the log price at the end of the period and the beginning of the period, $h_{m,t+1} \equiv p_{m-1,t+1} - p_{m,t}$. Forward substitution of the holding period return up to period $t+m$ and taking conditional expectations yields, $p_{m,t} = E_t\, p_{0,t+m} - E_t \sum_{j=1}^{m} h_{m-j+1,t+j}$, where $E_t\, p_{0,t+m}$ is the expected nominal value of the principal repayment. The safe rate is the sum of the real interest rate and log inflation rate, $r_{t+1} - \pi_{t+1}$, and the excess return on the m-period bond is the difference between the holding period return and the safe rate, $x_{m,t+1} = h_{m,t+1} - r_{t+1} - \pi_{t+1}$.

2.1 Bond price shocks and revisions of expectations

Bond price shocks are unexpected price movements, $\tilde{p}_{m,t+1} \equiv p_{m-1,t+1} - E_t\, p_{m-1,t+1}$, and equal to unexpected holding period returns, $\tilde{h}_{m,t+1} \equiv h_{m,t+1} - E_t\, h_{m,t+1}$, and unexpected excess returns, $\tilde{x}_{m,t+1} \equiv x_{m,t+1} - E_t\, x_{m,t+1}$. For a conventional m-period zero-coupon bond the nominal value of the principal is known and the bond price shock becomes

$$\tilde{p}^n_{m,t+1} = -\Delta E_{t+1}\left[\sum_{j=2}^{m} r_{t+j} + \sum_{j=2}^{m} \pi_{t+j} + \sum_{j=2}^{m} x^n_{m-j+1,t+j}\right], \tag{1}$$

where $\Delta E_{t+1}[\cdot] \equiv E_{t+1}[\cdot] - E_t[\cdot]$ are revisions of expectations and superscript n stands for nominal bonds. For an indexed bond the value of the principal is fixed in real terms. The expected nominal value of the indexed principal changes with inflation, $\Delta E_{t+1}\, p^i_{0,t+m} = \tilde{\pi}_{t+1} + \Delta E_{t+1} \sum_{j=2}^{m-\ell} \pi_{t+j}$, where superscript i denotes indexed bonds, $\tilde{\pi}_{t+1} \equiv \pi_{t+1} - E_t\, \pi_{t+1}$ is unexpected inflation, and ℓ is the indexation lag.[3] The shock in the nominal price of an indexed m-period zero-coupon bond becomes

$$\tilde{p}^i_{m,t+1} = \tilde{\pi}_{t+1} - \Delta E_{t+1}\left[\sum_{j=2}^{m} r_{t+j} + \sum_{j=m-\ell+1}^{m} \pi_{t+j} + \sum_{j=2}^{m} x^i_{m-j+1,t+j}\right]. \tag{2}$$

The log-linear model of Campbell and Shiller (1988) yields similar approximate relations for conventional and inflation-indexed coupon bonds (e.g., Campbell and Ammer 1993, Barr and Pesaran 1997).

Equation (1) and (2) relate conventional and inflation-indexed bond price shocks to revisions of expected future real interest rates, future inflation rates and future excess returns. Only the impact of revisions in real interest rate expectations is the same for nominal and indexed bonds. Revisions of expected future excess returns

[3] The indexation lag is eight months for British index-linked gilts. From July 2005 onwards all new issues of index-linked gilts use a shorter indexation lag of three months.

affect both bonds, but expected excess returns should be different for indexed and conventional bonds because they have different risk characteristics. Revisions of inflation expectations affect the prices of indexed bonds directly only to the extend the inflation-indexation is not perfect.

The correlation of unexpected bond returns with unexpected inflation may be a poor guide on the inflation protection offered by indexed bonds and the inflation exposure of conventional bonds. In equation (2) the nominal log price of an inflation-indexed bond adjusts one-for-one to unexpected log inflation. This is what protects investors in inflation-indexed bonds from unexpected inflation. However, it also results in a correlation of unexpected returns on indexed bonds with unexpected inflation. Factor models determine the risks of financial assets from the covariability of returns with systematic risk factors. Thus, factor models may erroneously suggest that inflation-indexed bonds are exposed to inflation because of this covariability of indexed bond returns with unexpected inflation. On the other hand, in equation (1) unexpected inflation has no direct impact on nominal prices of conventional bonds. Unexpected inflation affects the prices of conventional bonds only if it leads to revisions of expected future real interest rates, inflation rates and excess returns that overall change the prices of conventional bonds.

Revisions of inflation expectations may lead to revisions of real interest rate expectations as well as revisions of expected future excess returns.[4] Thus, equation (1) and (2) do not reveal the full impact of revisions in inflation expectations on indexed and conventional bonds. For conventional bonds the negative correlation of real interest rates and inflation suggests that revisions of real interest rate expectations and inflation expectations may cancel each other partly out. For indexed bonds the negative correlation of real interest rates and inflation may reintroduce an impact of inflation on indexed bonds. We empirically investigates the relation between revisions of inflation expectations and bond price shocks with a reduced-form VAR model.

[4]In Barr and Pesaran (1997) revisions of inflation expectations are correlated with revisions of expected future excess returns on indexed bonds.

2.2 VAR modeling of shocks and revisions of expectations

The reduced-from VAR model treats all variables as endogenous and imposes a priori no restrictions on the coefficients from economic theory. The lag length, k, of the VAR is the only restriction imposed on the data. Let z denote the vector of variables. The VAR has a vector moving average representation of infinite order under standard stability conditions

$$z_t = E[z] + \sum_{s=0}^{\infty} C(s) u_{t-s}. \tag{3}$$

The shocks u_t are contemporaneously uncorrelated and have unit variance with the error orthogonalisation of Sims (1980). However, the ordering of the variables may matter when the shocks have strong contemporaneous correlations. Movements in the prices of financial assets are often highly correlated. Koop, Pesaran, and Potter (1996) suggest an alternative transformation that is invariant to the ordering of the variables, but then the transformed shocks are no longer orthogonal. For the first variable in the VAR both transformations yield the same result and they coincide when the variables are uncorrelated.

Economic theory may offer a guide for the ordering of the variables with the error orthogonalisation of Sims (1980). Asset prices can adjust to news immediately, but the response of economic variables to news is sluggish because the economy changes slowly. Thus, the economic variables should appear before the return variables in the VAR to allow for a contemporaneous impact of shocks in inflation and economic activity on bond prices. Inflation is the variable of main interest. With inflation as the first variable in the VAR the orthogonalisation of Sims (1980) and the transformation of Koop, Pesaran, and Potter (1996) yield identical results for inflation. Revisions of real interest rate expectations affect the prices of indexed and nominal bonds, but revisions of inflation expectations should only affect the prices of nominal bonds. Thus, the return on indexed bonds should appear before the return on conventional bonds in the vector of VAR variables.

A shock today is connected with revisions of expected future values of the variables. The infinite sequence of matrices $C(h)$ for $h \geq 1$ measures this dynamic interaction between the variables as

$$\Delta E_t[z_{t+h}] = E[z_{t+h}|u_{t-s}, s \geq 0] - E[z_{t+h}|u_{t-s}, s \geq 1] = C(h)u_t. \tag{4}$$

The plot of the elements in $C(h)$ over h is known as impulse response function. The element in row i and column j of the matrix,

$$R_h^2 = \left[\frac{\sum_{s=0}^{h-1} C(s)^2}{\sum_{s=0}^{h-1} \text{diag}[C(s)E(u_t u_t')C(s)']} \right], \tag{5}$$

is the ratio of the h-period ahead forecast error variance of z_i due to innovations in z_j over the total variance of the h-period ahead forecast error of z_i. This measures the relation between unexpected movements in variable z_j today and unexpected movements in z_i in h periods.

Indexed bonds have considerably lower trading volumes than conventional bonds (e.g., Bank of England 1995). This low trading volume for indexed bonds may lead to a slow price response with indexed bonds. Factor models require a contemporaneous impact of inflation news on the prices of indexed bond to detect an impact of inflation. When indexed bonds incorporate changes in inflation very slowly then factor models may suggest a misleading insensitivity of indexed bonds to inflation. However, when inflation affects the prices of indexed bonds then they should sooner or later reflect changes in inflation. The VAR can detect a slow adjustment of indexed bond prices to inflation, because it investigates dynamic interactions between the variables at different time periods.

3 Empirical results

3.1 Data and lag length

Inflation is the annual increase in the UK retail price index. The paper uses the annual growth rate in the volume of UK industrial production to measure economic activity, because GDP figures are only available quarterly. Returns are calculated from the Financial Times indices of all UK indexed and nominal bonds. Table 1 shows

Table 1: Summary statistics

	π	Δy	h^i_M	h^n_M
Mean	3.84	1.29	7.54	9.19
Standard deviation	2.13	2.73	22.36	20.48
		Correlations		
Retail price inflation rate	1			
Industrial production growth	0.07	1		
Returns on indexed bonds	0.04	-0.03	1	
Returns on nominal bonds	0.11	0.00	0.63	1

The table reports summary statistics for UK retail price inflation, π, the growth in the volume of industrial production, Δy, inflation-indexed bond returns, h^i_M, and nominal bond returns, h^n_M. All variables are measured in annual percentages. The monthly sample starts in January 1984 and ends in January 2005.

some summary statistics. The monthly sample starts in January 1984 and ends in January 2005. All variables are continuously compounded and expressed as annual rates. Average returns are larger for conventional bonds, but statistically they are not different from average returns on indexed bonds. The returns on indexed and conventional bonds are highly correlated and have similar standard deviations. The growth in industrial production is not significantly correlated with inflation and the economic variables have low correlations with returns.

Sims's (1980) modified likelihood-ratio test of sequentially deleting the highest lag indicates a VAR with six lags at the 1% significance level.[5] Table 2 shows the decomposition of the forecast error variance for the VAR with six lags and orthogonalised errors. Panel A considers the 60 months ahead forecast and Panel B the contemporaneous impact. Standard errors are based on 1000 bootstrap simulations. Fig. 1 plots the corresponding impulse responses of inflation and industrial production. Fig. 2 shows the impulse responses of indexed and conventional bonds.

[5]The Akaike Information Criterion and Schwarz Bayesian Criterion suggest a lower lag length. A later section assesses the effects of changes in the lag length.

Table 2: Decomposition of the forecast error variances

Shocks	Decomposition of the forecast error variance of			
	inflation rate	IP growth	indexed bonds	nominal bonds
	Panel A: The 60 months ahead forecast			
$\tilde{\pi}$	77.30	12.17	1.17	4.56
	(12.07)	(8.63)	(1.77)	(2.39)
$\Delta\tilde{y}$	1.18	80.04	1.46	0.89
	(6.90)	(10.55)	(1.81)	(1.51)
$\tilde{h}_M^i$	2.18	4.73	87.96	37.17
	(3.95)	(3.83)	(4.21)	(6.21)
$\tilde{h}_M^n$	19.34	3.06	9.41	57.39
	(9.58)	(3.59)	(3.65)	(6.04)
	Panel B: The contemporaneous impact			
$\tilde{\pi}$	100	2.71	0.00	0.13
		(2.39)	(0.62)	(0.89)
$\Delta\tilde{y}$	0	97.29	0.06	0.01
		(2.39)	(0.62)	(0.57)
$\tilde{h}_M^i$	0	0	99.94	39.42
			(0.88)	(6.98)
$\tilde{h}_M^n$	0	0	0	60.44
				(6.89)

The table shows in Panel A the decomposition of the 60 months ahead forecast error variance and in Panel B the decomposition of the contemporaneous impact. The rows report the impact of shocks in the VAR variables on the forecast error variances of the variables. The shocks are orthogonalised and the VAR includes six lags of inflation, π, growth in industrial production, Δy, inflation-indexed bond returns, h_M^i, and nominal bond returns, h_M^n. Figures in parentheses are standard errors from bootstrap simulations.

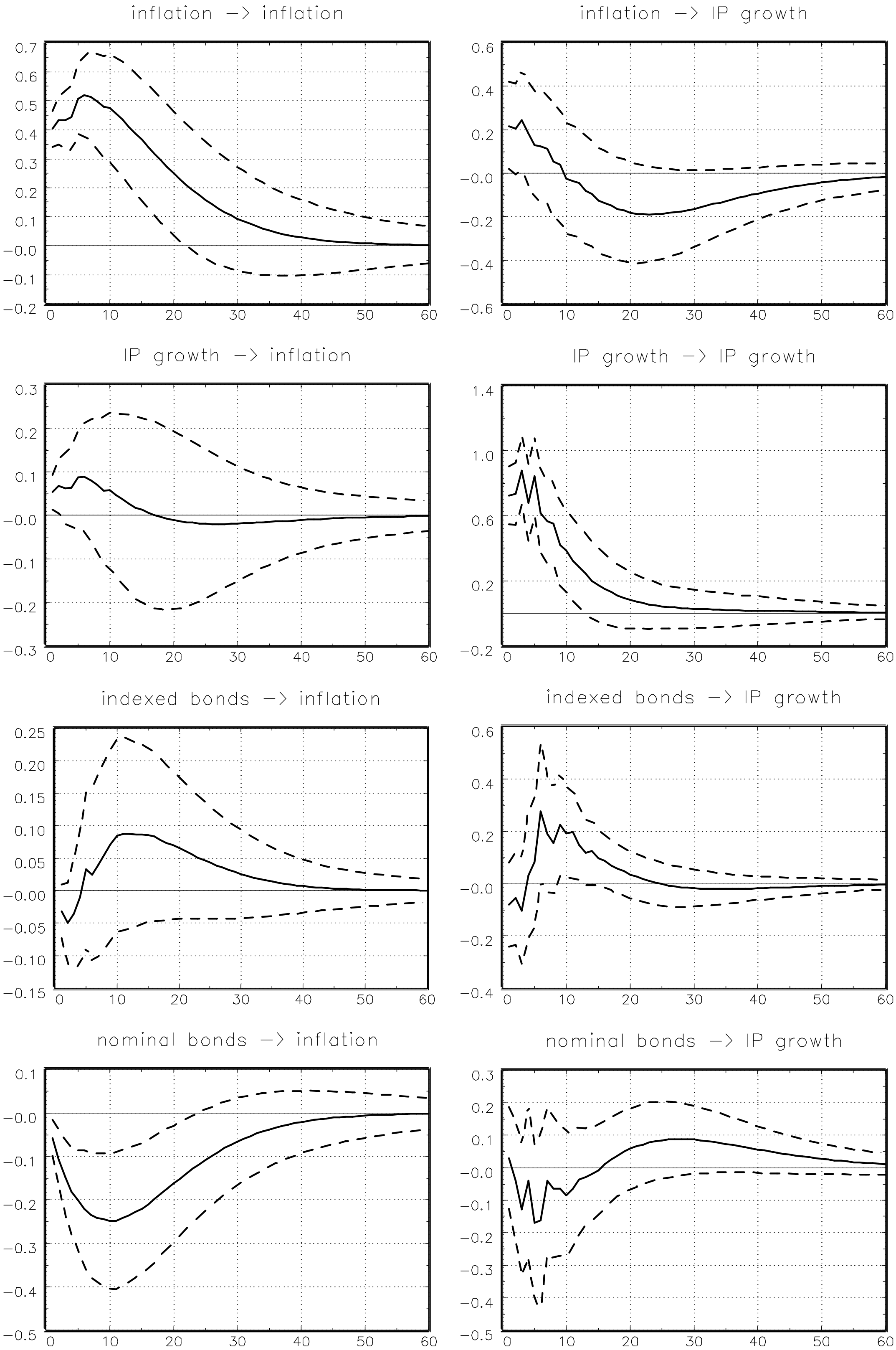

Fig. 1: Impulse responses of inflation and industrial production growth

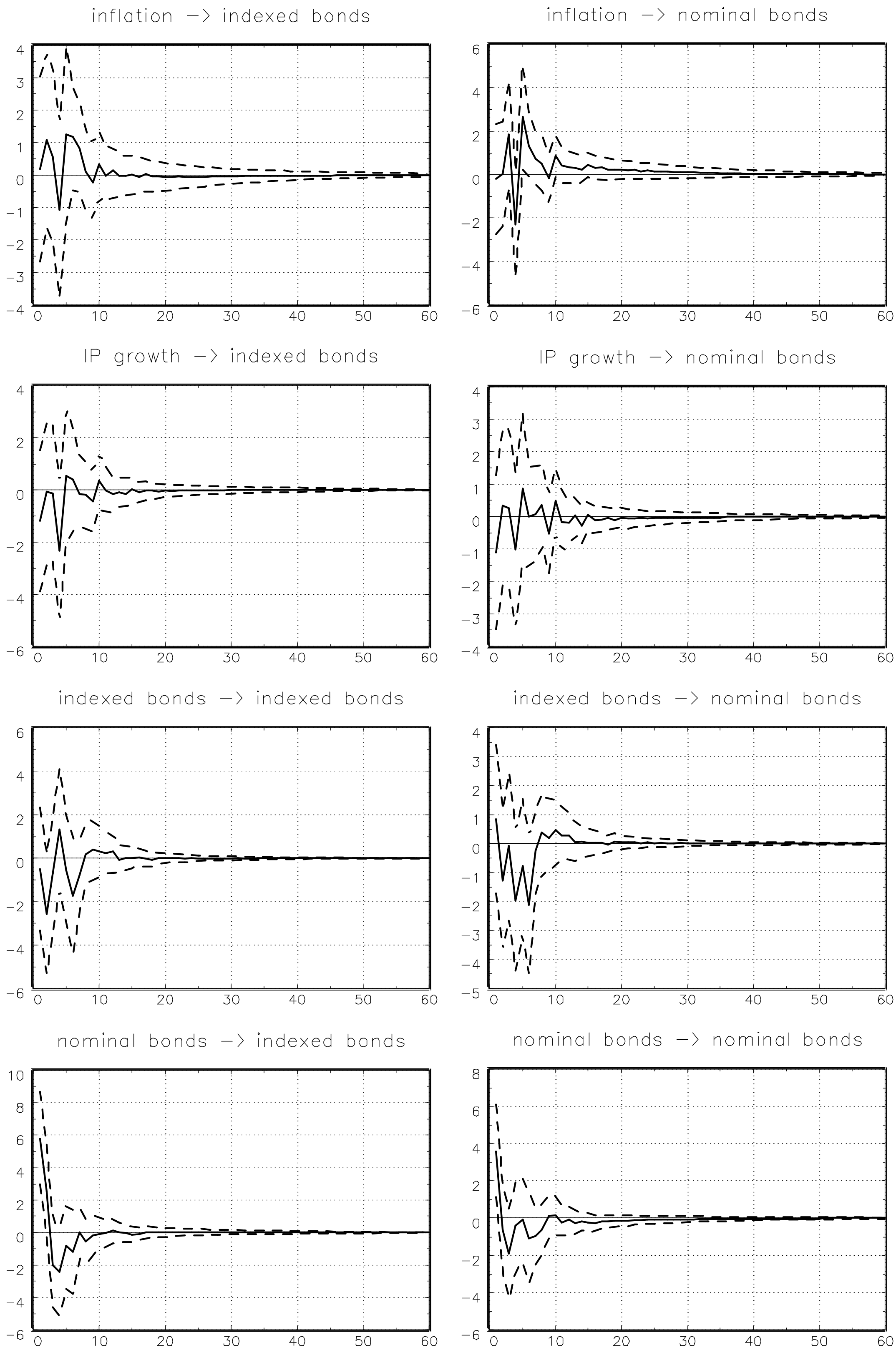

Fig. 2: Impulse responses of indexed and nominal bonds

3.2 Conventional bonds and future inflation

Shocks in the prices of conventional bonds explain a substantial and statistically significant fraction of the forecast error variance of inflation. The impulse response of inflation to a shock in the prices of conventional bonds reveals that unexpected increases in the prices of conventional bonds are associated with downwards revisions of expected future inflation. This suggests that market participants are able to successfully forecast future inflation and that they incorporate revision of inflation expectations into the prices of conventional bonds.

The forward-looking behavior of financial market participants when they trade financial assets can be a rich source of information about the future of the economy. Barr and Campbell (1997) use the yields on UK nominal and inflation-indexed bonds to predict future inflation and Lamont (2001) constructs portfolios that track news in future values of various macroeconomic variables. The impulse response function of inflation reveals that shocks in the prices of conventional bonds signal up to two years ahead movements in inflation. Monetary policy makers can use this information in nominal bond price shocks as an indicator of changes in market expectations about future inflation.

Shocks in the prices of conventional bonds are significantly related to future changes of inflation. From an econometric perspective shocks in the prices of conventional bonds are causal for future inflation. Market participants are forward looking and incorporate expectations about future economic conditions into conventional bond prices. This links the prices of conventional bonds with future inflation. The reason why movements in the prices of conventional bonds signal future inflation are well anticipated movements in inflation. Asset prices adjust to the arrival of news immediately, but the response of economic variables is sluggish. This makes the prices of conventional bonds a leading indicator of future inflation. Although asset prices change before the economy changes it is still the economy that determines asset prices and not vice versa.

3.3 Indexed bonds and future inflation

Unexpected movements in the prices of indexed bonds explain only a small and statistically insignificant fraction of the forecast error variance of inflation. The impulse response of inflation to a shock in the prices of indexed bonds suggests that revisions of inflation expectations have no significant impact on indexed bonds. A negative relation between real interest rates and inflation suggests an inflation exposure of indexed bonds in the opposite direction of conventional bonds. Fig. 1 shows that revisions of inflation expectations lead to price movements of indexed and conventional bonds in opposite directions, but for indexed bonds the impact is statistically insignificant.

The insensitivity of indexed bonds to inflation should not be the result of an inability of investors to forecast inflation, because conventional bonds signal future changes of inflation. It is rather the result of investors disregarding revisions of inflation expectations when they trade indexed bonds. This suggests that investors do not consider inflation a determinant of indexed bond prices. The result that revisions of inflation expectations affect the prices of conventional bonds but not the prices of indexed bonds suggests that indexed bonds are less risky than conventional bonds. When investors are willing to pay a premium for this inflation insensitivity of indexed bonds then the use of indexed instead of conventional bonds should reduce the government's long-run funding costs.

The nominal payments from indexed bonds depend on realized inflation. When inflation is higher than expected the nominal payments from indexed bonds increase. Larger nominal payments increase the tax liability of taxed investors and reduce the after tax payoffs from indexed bonds. Thus, unexpected increases in inflation lead to unexpected decreases in the real return on indexed bonds for tax paying investors. In the UK coupon payments are subject to income tax, but the principal including its inflation uplift are exempt from taxation. In the US also the inflation adjustment of the principal is taxed. Scholtes (2002) argues that indexed bonds are mainly held by institutional investors like pension funds who are exempt from taxation. On the other hand, Campbell and Shiller (1996) point out that tax-paying investors may hold a significant fraction of inflation-indexed bonds. When the marginal investor in indexed bonds is not exempt from taxation then unexpected inflation should affect the prices of indexed bonds. The insensitivity of indexed bonds to inflation suggests that the marginal investor in indexed bonds is exempt from taxation. This is consistent with the view that large parts of indexed bonds are held by tax-exempt pension funds.

3.4 Inflation and industrial production

Inflation shocks are the largest contributor to the forecast error variance of inflation. Inflation and nominal bonds together explain over 95% of the forecast error variance of inflation. A positive inflation shock leads to significant increases in future inflation for up to two years. This persistency in inflation links unexpected inflation with revisions of expected future inflation. Therefore, unexpected inflation should work as a proxy for revisions in inflation expectations in factor models. Panel B of Table 2 shows the contemporaneous impact of a shock in inflation on the prices of conventional and indexed bonds. The contemporaneous impact of unexpected inflation is insignificant for both indexed and conventional bonds. Thus, unlike revisions of inflation expectations, the contemporaneous impact of a shock in inflation suggests neither for indexed nor conventional bonds an impact of inflation. Similarly, the contemporaneous impact of a shock in industrial production is insignificant for both types of bonds.

Shocks in industrial production contribute little to the inflation forecast error variance. Similarly, inflation shocks are insignificant in the decomposition of the forecast error variance of industrial production. The decompositions of the forecast error variances do not suggest a link between inflation and industrial production. The response of inflation to a shock in industrial production is close to zero. The response of industrial production to a shock in inflation indicates after an initial increase a decline in industrial production. This negative impact of inflation on industrial production has a peak approximately two years after the inflation shock. However, statistically the response of industrial production to a shock in inflation is only significant at the 90% level. Overall, the results provide only weak support for a relation between inflation and industrial production.

3.5 Bond price shocks and future industrial production

When inflation is related to industrial production then the relation of returns with industrial production should reflect the relation of returns with inflation. Shocks in the prices of conventional and indexed bonds have no significant impact on the forecast error variance of industrial production. The impulse response of industrial production to a shock in the prices of conventional bonds suggests some statistically insignificant increases in industrial production in two to four years. A shock in the prices of indexed bonds is associated with some increases in industrial production approximately six to twelve months later. Conditional on a link between inflation and industrial production this relation between the prices of indexed bonds and industrial production suggests a relation between indexed bonds and inflation. However, the empirical evidence of a relation between bond price shocks and industrial production is rather weak.

3.6 Signalling future returns

Neither inflation nor industrial production explain a significant fraction of the forecast error variance of indexed and conventional bonds. The impulse responses suggest that economic shocks have no significant impact on future returns. Bond prices appear to incorporate economic news without delay. This supports the notion of informationally efficient capital markets. Shocks in the prices of indexed bonds explain most of the forecast error variance of indexed bonds. Shocks in the prices of conventional bonds significantly explain the remaining variance. Similarly, shocks in conventional bonds explain the bulk of the forecast error variance of conventional bonds and indexed bonds significantly explain the remaining forecast error variance. Fig. 2 shows that a shock in the prices of indexed bonds has no effect on indexed or conventional bonds in future periods. However, a shock in the prices of conventional bonds affects both indexed and conventional bonds in the period after the shock.

The market for conventional bonds is larger and more liquid than the market for indexed bonds. Thus, conventional bonds may incorporate news faster than indexed bonds. This could explain the response of indexed bonds in the period following a shock in the prices of conventional bonds, but not the response of conventional bonds.

The return on indexed bonds appears in the VAR before the return on nominal bonds. This restricts the contemporaneous impact of a shock in the prices of nominal bonds on indexed bonds to zero. Panel B of Table 2 shows that the contemporaneous impact of a shock in indexed bonds on conventional bonds is highly significant. When the ordering of indexed and conventional bonds in the VAR is reversed the significant impact of a nominal bond price shock in the period after the shock still persists.[6] This statistically significant price impact of a shock in conventional bonds in the period after the shock makes returns predictable. Rational asset pricing models attribute the predictability of returns to predictable variations in the risk compensation. This suggests that the risk compensations of indexed and conventional bonds are time-varying and predictable.

3.7 Robustness

The following assesses the robustness of the results to changes in the specification of the VAR model. An augmented VAR model additionally includes variables that are known to predict future returns (e.g., Campbell 2000, Reschreiter 2004). These additional variables are the return on the equity market, the equity market dividend yield, the difference between the yield on long-dated government bonds and the T-Bill rate, the one-month T-Bill rate, and the difference between the yield on corporate bonds and long-dated government bonds. These return predictors may affect the formation of return expectations and therefore the unexpected movements in the prices of indexed and conventional bonds.

Table 3 shows the contribution of inflation-indexed and conventional bond price shocks to the forecast error variance of inflation for different lag lengths. Panel A considers the basic four variable VAR and Panel B shows the augmented VAR model. The augmented VAR model measures returns in excess of the short rate. This is consistent with the inclusion of return predictors, because excess returns are a measure of risk compensation. The augmented model also uses a different measure for economic

[6]Nominal bonds explain a large share of the forecast error variance of indexed bonds when the ordering of the bonds is reversed.

Table 3: Contribution to the inflation forecast error variance

	k						
Shocks	1	2	3	4	6	9	12
			Panel A: Basic model				
$\tilde{h}^i_M$	1.66	1.86	1.44	0.12	2.18	1.44	3.11
	(1.67)	(2.24)	(2.54)	(1.77)	(3.95)	(4.98)	(6.33)
$\tilde{h}^n_M$	3.44	4.98	7.06	10.20	19.34	34.93	35.49
	(2.46)	(3.44)	(4.83)	(6.41)	(9.58)	(13.94)	(13.81)
			Panel B: Augmented model				
$\tilde{x}^i_M$	5.41	5.18	6.37	2.52	1.31	2.19	4.10
	(4.19)	(4.27)	(5.45)	(4.17)	(3.49)	(4.34)	(5.22)
$\tilde{x}^n_M$	27.46	27.05	27.55	19.81	20.37	27.78	18.27
	(12.66)	(11.18)	(10.29)	(9.43)	(8.52)	(9.56)	(9.19)

The table reports the contribution of bond price shocks to the forecast error variance of inflation for different lag lengths, k, and two different model specifications. The basic model (Panel A) uses the error orthogonalisation of Sims and includes inflation, the growth in industrial production, the return on inflation-indexed bonds, h^i_M, and the return on nominal bonds, h^n_M. The augmented model (Panel B) uses the error transformation of Koop, Pesaran, and Potter (1996) and includes inflation, the growth rate in the volume of retail sales, the excess return on indexed bonds, x^i_M, the excess return on nominal bonds, x^n_M, the excess return on equities, the dividend yield, the term-structure the yield spread, the short-rate and the default spread. Figures in parentheses are standard errors from bootstrap simulations.

activity. The growth in the volume of retail sales replaces the growth rate of industrial production.[7] Finally, in the augmented model the shocks are based on the error transformation of Koop, Pesaran, and Potter (1996) and no longer orthogonalised.

The basic and augmented model yield similar results. Conventional bonds signal future inflation but indexed bonds contain no information about future inflation. For the basic model the choice of lag length has a bigger influence on the results. The decomposition of the forecast error variance only stabilizes when the lag length is quite long. This suggests that a short lag length misses out some important information. With the augmented model the choice of lag length has little influence. The augmented model contains more variables and as a result of this a short lag length appears to be sufficient to capture all relevant information.

4 Conclusions

This paper models shocks in the prices of UK inflation-indexed and conventional government bonds and subsequent movements in economic conditions with a reduced-form VAR model. Shocks in the prices of conventional bonds signal up to two years ahead changes in inflation. Unexpected increases in the prices of conventional bonds are associated with downwards revisions of inflation expectations. This provides monetary policy makers with an indication of changes in market expectations of future inflation. Indexed bonds contain no information about future inflation. This suggests that investors price future inflation into conventional bonds, but at the same time disregard inflation when they price inflation-indexed bonds. This insensitivity of indexed bonds to inflation is consistent with the view that investors should not require a compensation for inflation risk with indexed bonds. It also suggests that the marginal investor in indexed bonds is exempt from taxation. This is consistent with the view that large parts of indexed bonds are held by tax-exempt pension funds.

[7] Descriptive statistics for the variables in the augmented VAR model are available on request.

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