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Housing market volatility in the OECD area: Evidence from VAR based return decompositions*

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Abstract

Vector-autoregressive models are used to decompose housing returns in 18 OECD countries into cash flow (rent) news and discount rate (return) news. Only for two countries - Germany and Ireland - do changing expectations of future rents play a dominating role in explaining housing return volatility. For the majority of countries news about future returns is the main driver, and both real interest rates and risk premia play an important role in accounting for housing market volatility. Bivariate cross-country correlations and principal components analyses indicate that part of the return movements have a common factor among the majority of countries. However, in a minority of countries (Germany, Japan, and the Netherlands) return movements have been basically unrelated to return movements in other countries.

JEL Classification: C32, G12, R31
Keywords: Housing return volatility, variance decomposition, dynamic Gordon growth model, innovation and news components, VAR model, principal components, OECD countries.

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1 Introduction

In many countries over the last 15-20 years real estate markets have shown a high degree of volatility, with real prices rising over many years up to around 2006 followed by decreasing prices in recent years, see Figure 1. This pattern has been especially pronounced in countries such as Spain, Ireland, Denmark, Italy, the Netherlands, the UK, and the US. Only a few countries, such as Germany and Japan, have experienced price movements different from this overall pattern. Understanding the underlying causes for these price movements is important, not just for real estate economists and analysts, but for economists in general. Housing wealth constitutes an important part of household's total wealth and has a significant effect on household consumption, c.f. Case, Quigley, and Shiller (2012). In addition, many of the problems causing the financial crisis and global recession since 2008 have their origin in the real estate markets, e.g. the US subprime crisis and the overinvestment in housing in many European countries. As a consequence, the European Commission's new early warning system for macroeconomic imbalances (the 'MIP Scoreboard') includes house prices as an indicator, c.f. European Commission (2012).

In this paper we undertake a detailed investigation of what moves housing markets in 18 OECD countries over the period 1970 to 2011. Using the return variance decomposition methodology from Campbell (1991) and Campbell and Ammer (1993) - which has become a standard methodology for analyzing financial market returns[1] - we decompose real estate returns into two factors, one capturing changing expectations ('news') of future rents (proxying for housing service flows), and the other capturing changing expectations of future returns. Since returns can be further decomposed into the risk-free rate and a risk-premium (return in excess of the risk-free rate), real estate excess returns can be decomposed into three components: changing expectations of future rents, changing expectations of future risk-free rates, and changing expectations of future risk-premia. Our aim is to estimate the relative magnitude of these components in explaining the volatility of housing market returns, and to identify cross-country similarities and differences in this respect. We use vector-autoregressions (VAR's) containing returns, rent growth, real interest rates, and additional predictor variables (including the rent-price ratio and macroeconomic variables), to model expectations of future variables, and we pay special attention to the pitfalls and limitations involved in such VAR based variance

[1] See e.g. Campbell and Mei (1993), Ammer and Mei (1996), Patelis (1997), Campbell and Vuolteenaho (2004), Engsted and Tanggaard (2004), Bernanke and Kuttner (2005), Larrain and Yogo (2008), Campbell, Polk, and Vuolteenaho (2010), and Engsted, Pedersen, and Tanggaard (2012a).

decompositions, c.f. Engsted et al. (2012a).

Our paper is related to the recent literature analyzing predictability of real estate returns and rents, e.g. Gallin (2008), Plazzi, Torous, and Valkanov (2010), and Engsted and Pedersen (2012) (see Ghysels, Plazzi, Torous, and Valkanov (2012) for a survey on forecasting real estate prices). Our study is also related to an extensive literature analyzing the role of expectations in house price determination, see e.g. Hamilton and Schwab (1985), Meese and Wallace (1994), Geltner and Mei (1995), and Clayton (1996) for early analyses based on present value models, and Gelain and Lansing (2013) for a recent analysis of the influence of expectations on housing valuation in a model with time-varying risk-aversion and time-varying expected rent growth. Our paper is most directly related to two recent studies (Campbell, Davis, Gallin, and Martin, 2009, and Hiebert and Sydow, 2011) that also conduct VAR based variance decompositions of housing market variables. We will relate our results to the results in those studies.

Our main findings are as follows. First, the return variance decompositions show that for the majority of countries news about future returns is the main determinant of return variability in the 18 OECD countries' housing markets, with news about future rents playing a less important role, although in several of these countries the rent news component is not negligible. Only in two countries, Germany and Ireland, is the rent news component the dominating factor. These results are in contrast to the findings reported by Hiebert and Sydow (2011) where the rent news component explains the bulk of return volatility in eight European countries. Second, when we decompose returns into the risk-free rate and a risk-premium we find that in the majority of those countries - including the US - where return news is the dominating factor, risk-free rate news is either the most important, or equally important as news about future risk-premia. For the US this result is in contrast to Campbell et al.'s (2009) finding that real interest rate variation has not affected housing valuations. Overall, our analysis documents some cross-country differences on what moves housing markets in the OECD area, but in the majority of countries real estate returns seem to be driven mainly by discount rate news with real interest rate variation playing a dominating role. Finally, bivariate cross-country correlations and principal components analyses on the 18 countries' return series indicate that part of the return movements have a common factor among the majority of countries. However, in a minority of countries (Germany, Japan, and the Netherlands) return movements have been basically unrelated to return movements in other countries.

The rest of the paper is organized as follows. Section 2 describes the return variance decomposition and associated VAR methodology for estimating the innovation and news components. Section 3 gives a brief description of the data and reports the empirical results. Finally, section 4 contains some concluding remarks.

2 Methodology

2.1 Decomposing real returns

Denote by $H_{t+1} \equiv (P_{t+1} + R_{t+1})/P_t$ the one-period gross return to housing, where P_{t+1} and R_{t+1} are house price and rent, respectively, at time $t+1$. Applying Campbell and Shiller's (1988) log linearization to H_{t+1} gives the following approximate identity

$$h_{t+1} \approx \Delta r_{t+1} + (r_t - p_t) - \rho\,(r_{t+1} - p_{t+1}) + c, \tag{1}$$

where $h_{t+1} \equiv \log(H_{t+1})$, $r_{t+1} \equiv \log(R_{r+1})$, and $p_{t+1} \equiv \log(P_{t+1})$ denote log return, log rent, and log house price, respectively. ρ is a constant slightly less than one, and c is a linearization constant. The log-linear Campbell-Shiller relation only holds approximately, but Engsted, Pedersen, and Tanggaard (2012b) show that it is highly accurate, so in the rest of the paper we replace $\approx$ with $=$ in (1). (See also footnote 3).

Taking conditional expectations to both sides of (1) and solving recursively forward for $r_t - p_t$ gives

$$r_t - p_t = E_t \sum_{j=0}^{\infty} \rho^j (h_{t+1+j} - \Delta r_{t+1+j}) - \frac{c}{1-\rho} \tag{2}$$

Equation (2) is the housing market equivalent to the well-known - from the finance literature - *dynamic Gordon growth model* for equity valuation where p_t and r_t are log stock prices and log dividends, respectively.

From (1) and (2), Campbell (1991) derives the following expression for unexpected log returns, i.e. log return innovations,

$$h_{t+1} - E_t h_{t+1} = (E_{t+1} - E_t)\sum_{j=0}^{\infty}\rho^j \Delta r_{t+1+j} - (E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j h_{t+1+j}. \tag{3}$$

E_t is the expectations operator, conditional on information at time t. Hence, $(E_{t+1} - E_t)$

represents the change in expectation due to new information that arrives between time t and $t+1$. Campbell denotes this change in expectation 'news'. Equation (3) shows that a positive (negative) return innovation must come from either positive (negative) news about future rent growth or negative (positive) news about future returns. In the literature the first component is often denoted 'cash flow news' while the second component is denoted 'discount rate news'.

Note that since (3) follows from the linearization of the definition of returns, it is a dynamic *identity*. There is no economic theory involved apart from assuming that there are no speculative bubbles (the no-bubble assumption is required because (2) follows from (1) by imposing a transversality condition). The intuition behind (3) is straightforward: For fixed future rent growth a rise in future returns can only come about by a decrease in prices today, i.e. a negative current return. Similarly, for fixed future returns higher future rent growth must imply higher prices today, i.e. a positive current return. Since these relationships also hold *ex ante*, (3) can be thought of as a consistency condition for expectations, c.f. Campbell (1991).

Note also that for $j = 0$ the first term on the right-hand side of (3) is $\Delta r_{t+1} - E_t \Delta r_{t+1}$ which is, strictly speaking, not a 'news' component (as we have defined 'news') but an 'innovation' component, i.e. unexpected one-period rent growth. Thus, in order to separate innovation components from news components, (3) can be restated as

$$h_{t+1} - E_t h_{t+1} = (\Delta r_{t+1} - E_t \Delta r_{t+1}) + (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta r_{t+1+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j h_{t+1+j}. \tag{4}$$

To simplify notation, denote by $v_{h,t+1}$, $v_{r,t+1}$, $\eta_{r,t+1}$, and $\eta_{h,t+1}$ return innovation, rent growth innovation, rent news, and return news, respectively. Then (4) can be written as

$$v_{h,t+1} = v_{r,t+1} + \eta_{r,t+1} - \eta_{h,t+1} \tag{5}$$

To estimate each of the components in (5), a VAR model is formulated containing returns (h_{t+1}), rent growth (Δr_{t+1}), the rent-price ratio ($r_{t+1} - p_{t+1}$), and additional predictor variables that we collect in the vector x_{t+1} (see section 3 for our choice of variables to include in x_{t+1}). Define the vector $Z_t = (h_t, \Delta r_t, r_t - p_t, x_t)'$. Then the first-order VAR model for Z_{t+1} is[2]

$$Z_{t+1} = AZ_{t+1} + \varepsilon_{t+1}, \tag{6}$$

where A is the VAR parameter matrix, and ε_{t+1} is the error vector. From this system, VAR estimates of the innovation and news components in (5) can be obtained. Standard practice in the literature is to compute the return innovation and return news components directly and then back out the rent component $(v_{r,t+1} + \eta_{r,t+1})$ as a residual from (5). We follow a slightly different practice. In order to separate the rent innovation and rent news components, we compute directly $v_{h,t+1}$, $v_{r,t+1}$ and $\eta_{r,t+1}$, and then back out $\eta_{h,t+1}$ as a residual. Engsted et al. (2012a) show that if the VAR information set contains $r_t - p_t$ and is common to the direct computation of either return news or rent news, then the decomposition is independent of whether return news or rent news is backed out residually. Our VAR system fulfills these requirements.

By defining selection vectors, $e1' = (1\ 0\ ...\ 0)$ and $e2' = (0\ 1\ 0\ ...\ 0)$, the components in (5) are computed as[3]:

$$\begin{aligned} v_{h,t+1} &= e1'\varepsilon_{t+1}, \\ v_{r,t+1} &= e2'\varepsilon_{t+1}, \\ \eta_{r,t+1} &= e2'\rho A(I-\rho A)^{-1}\varepsilon_{t+1,} \\ \eta_{h,t+1} &= v_{r,t+1} + \eta_{r,t+1} - v_{h,t+1}. \end{aligned} \tag{7}$$

The magnitude of these components is measured by their variances. From (5) it follows that $Var(v_{h,t+1}) = Var(v_{r,t+1}) + Var(\eta_{r,t+1}) + Var(\eta_{h,t+1}) + 2Cov(v_{r,t+1}, \eta_{r,t+1}) - 2Cov(v_{r,t+1}, \eta_{h,t+1}) - 2Cov(\eta_{r,t+1}, \eta_{h,t+1})$, and the relative importance of the rent innovation, rent news, and return news components, respectively, in explaining the variability of return innovations is given by the variance ratios

[2] The variables in Z_t are measured in deviations from their unconditional means, so the VAR does not contain constant terms.

[3] The components are computed as in (7) with the following slight modifications. To eliminate the influence of the approximation error inherent in the approximate identity (1), we follow Larrain and Yogo (2008) and impose the parameter restrictions implied by (1) onto the VAR system. In addition, instead of computing $v_{h,t+1}$ directly as in the first equation of (7), we compute it as $v_{h,t+1} = (e2' - \rho e3')\varepsilon_{t+1}$, where $e3' = (0\ 0\ 1\ 0\ ...\ 0)$, which follows from how the identity (1) links the VAR errors (see Engsted et al. (2012a) for details).

$$\frac{Var(v_{r,t+1})}{Var(v_{h,t+1})}, \quad \frac{Var(\eta_{r,t+1})}{Var(v_{h,t+1})}, \quad \frac{Var(\eta_{h,t+1})}{Var(v_{h,t+1})}. \tag{8}$$

The contribution from the covariance terms is measured by the covariance ratios

$$\frac{2Cov(v_{r,t+1}, \eta_{r,t+1})}{Var(v_{h,t+1})}, \quad \frac{-2Cov(v_{r,t+1}, \eta_{h,t+1})}{Var(v_{h,t+1})}, \quad \frac{-2Cov(\eta_{r,t+1}, \eta_{h,t+1})}{Var(v_{h,t+1})} \tag{9}$$

The presence of these covariance terms slightly complicates the interpretation of the variance ratios in (8) because they do not sum to one (unless the covariance terms are all zero). However, if a relatively large covariance ratio involves an innovation or news component that also has a relatively large variance ratio, then it is safe to conclude that this component accounts for a relatively large part of the variance of returns.[4]

2.2 Decomposing excess returns

Instead of working with real returns (h_{t+1}) we can - following Campbell and Ammer (1993) - decompose innovations in nominal returns in excess of a risk-free rate ($e_{t+1} \equiv h_{t+1} - i_{t+1}$) into five components: Rent growth innovations, news about future rent growth, risk-free rate innovations, news about future risk-free rates, and news about future excess returns[5]:

$$\begin{aligned} e_{t+1} - E_t e_{t+1} = {} & (\Delta r_{t+1} - E_t \Delta r_{t+1}) + (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta r_{t+1+j} \\ & - (i_{t+1} - E_t i_{t+1}) - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j i_{t+1+j} \\ & - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j e_{t+1+j}. \end{aligned} \tag{10}$$

[4] An alternative would be to orthogonalize the innovation and news components using a Cholesky decomposition. This would eliminate the covariance terms and ensure that the variance ratios sum to one. However, such a decomposition requires a specific ordering of the variables and in the present context it is not obvious what that ordering should be. Thus, we have not pursued this alternative further.

[5] In their decomposition for excess stock returns, Campbell and Ammer (1993) let dividend innovations and risk-free rate innovations be part of the dividend news and risk-free rate news components, respectively. Thus, they work with three components instead of five.

Similar to (5), equation (10) can be written with a simpler notation as

$$v_{e,t+1} = v_{r,t+1} + \eta_{r,t+1} - v_{i,t+1} - \eta_{i,t+1} - \eta_{e,t+1}. \tag{11}$$

The advantage of using the decomposition in (11) is that it allows us to identity how much of expected return variation is due to variation in the expected risk-free rate and how much is due to variation in expected risk-premia. In general, expected return equals the risk-free rate plus a risk-premium. Estimating each of the components in (11) makes it possible to separate news about future risk-free rates from news about future risk-premia in explaining the variability of real estate returns. Identifying the effect of short-term interest rates on housing valuations has been a major concern in the real estate finance literature, see e.g. Campbell et al. (2009).

We estimate the components in (11) by letting the VAR state vector Z_t include excess returns, e_t, instead of raw returns, and by including a short-term interest rate in addition to the other variables, i.e. $Z_t = (e_t, i_t, \Delta r_t, r_t - p_t, x_t)'$. Rent growth innovations ($v_{r,t+1}$), news about future rent growth ($\eta_{r,t+1}$), risk-free rate innovations ($v_{i,t+1}$), and news about future risk-free rates ($\eta_{i,t+1}$), are then computed directly while the excess return news component ($\eta_{e,t+1}$) is backed out as a residual from (11), similar to the equations in (7):

$$\begin{aligned}
v_{e,t+1} &= e1'\varepsilon_{t+1}, \\
v_{i,t+1} &= e2'\varepsilon_{t+1}, \\
v_{r,t+1} &= e3'\varepsilon_{t+1,} \\
\eta_{i,t+1} &= e2'\rho A(I - \rho A)^{-1}\varepsilon_{t+1,} \\
\eta_{r,t+1} &= e3'\rho A(I - \rho A)^{-1}\varepsilon_{t+1,} \\
\eta_{e,t+1} &= v_{r,t+1} + \eta_{r,t+1} - v_{i,t+1} - \eta_{i,t+1} - v_{e,t+1}.
\end{aligned} \tag{12}$$

Here, as before, $e1'$, $e2'$, and $e3'$ are selection vectors that pick out the first, second, and third variable, respectively, from the VAR system. From (11) the variance decomposition is:

$$
\begin{aligned}
Var(v_{e,t+1}) = {} & Var(v_{r,t+1}) + Var(\eta_{r,t+1}) + Var(v_{i,t+1}) + Var(\eta_{i,t+1}) + Var(\eta_{e,t+1}) \\
& + 2Cov(v_{r,t+1}, \eta_{r,t+1}) - 2Cov(v_{r,t+1}, v_{i,t+1}) - 2Cov(v_{r,t+1}, \eta_{i,t+1}) \\
& - 2Cov(v_{r,t+1}, \eta_{e,t+1}) - 2Cov(\eta_{r,t+1}, v_{i,t+1}) - 2Cov(\eta_{r,t+1}, \eta_{i,t+1}) \\
& - 2Cov(\eta_{r,t+1}, \eta_{e,t+1}) + 2Cov(v_{i,t+1}, \eta_{i,t+1}) + 2Cov(v_{i,t+1}, \eta_{e,t+1}) \\
& + 2Cov(\eta_{i,t+1}, \eta_{e,t+1}).
\end{aligned} \tag{13}
$$

The variance and covariance ratios are computed similarly to in (8) and (9).

3 Empirical results

3.1 The OECD data and descriptive statistics

We use official OECD data for 18 countries[6]: Australia, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, the UK, Ireland, Italy, Japan, the Netherlands, Norway, New Zealand, Sweden, and the US. The dataset provided by the OECD contains quarterly observations from 1970Q1 to 2011Q4 for all countries, except Australia (begins 1972Q3), Belgium (begins 1976Q2), Spain (begins 1971Q1), Norway (begins 1979Q1), and Sweden (begins 1980Q1).

The dataset contains seasonally adjusted nominal and real house prices and the rent-price ratio. Based on the nominal and real house prices we back out inflation in each country, and from the house prices and the rent-price ratio we can calculate nominal and real rent growth as well as returns. We have chosen to work with the data at an annual frequency such that parsimonious first-order VAR models adequately describe the data. Using quarterly data would require longer lags which present special problems for VAR based decompositions, c.f. Engsted et al. (2012a). The annual house price is the fourth quarter house price and the annual rent for the corresponding year is the sum of rents throughout the year. Returns are calculated in the usual way $H_{t+1} = (P_{t+1} + R_{t+1})/P_t$, where P_{t+1} and R_{t+1} are the house price and rent in year $t+1$.

In addition to the real estate variables, we include in the VAR models a number of

[6] These data have been used in earlier analyses by OECD, e.g. Girouard, Kennedy, van den Noord and André (2006).

macroeconomic variables: the spread between long and short term interest rates, the growth in real GDP, and the unemployment rate. These variables are obtained from Datastream and are to the extent possible also based on official OECD data.[7]

Table 1 shows descriptive statistics for real returns and rent growth for each country. There are noticeable cross-country differences in both the means and standard deviations of real housing returns and rent growth. The average mean and standard deviation of annual real return across the 18 countries are both 7.9%. Germany stands out with very low and stable returns (mean of 2.9% and standard deviation of 2.6%). Also, Japan has had a low mean return of 3.3% and below average standard devaition of 6.1%. At the other side of the distribution some countries have had annual real returns of 10% or higher (Spain, the UK, Ireland, and New Zealand) and return volatility in these countries has also been above average (around 10%).

With respect to growth in real rents, four countries have had slightly negative growth rates (Canada, Spain, Finland, and Italy), while a number of countries have experienced positive growth of 1% annually or higher (the UK, Japan, the Netherlands, Sweden, and the US). The average annual growth rate in real rents in the 18 countries is 0.6%. There is also a large dispersion in the volatility of rent growth, from around 1.5% standard deviation in Belgium, France, the Netherlands, and the US, to 10% standard deviation in Ireland.

In the following subsections we investigate whether these cross-country differences also show up when we decompose return innovations into innovation and news components associated with rents, interest rates, and risk-premia.

3.2 Decomposing real returns

In this section we decompose real return innovations (v_h) into the three components, rent innovations (v_r), rent news (η_r), and real return news (η_h), using the VAR methodology described in section 2.1. For each country we estimate a first-order VAR model for real returns (h_t), real rent growth (Δr_t), the rent-price ratio ($r_t - p_t$), and a vector of macro-variables (x_t) containing real GDP growth, the spread between long and short term interest rates, and the unemployment rate. These macro-variables turn out to have significant predictive ability for either returns or rent growth (or both) in the majority

[7] In a few cases the OECD data does not cover the whole sample period. In these cases we have spliced the OECD data with alternative variables from other sources. Details are available upon request.

of countries.

Before reporting the decompositions, let us comment on the estimated VAR models. It will be too space consuming to report in detail the VAR parameter estimates for all 18 countries. So instead we summarize the main results as follows (of course, the details are available upon request). First, in the majority of countries lagged returns significantly predict - with a positive coefficient - returns at the 10% significance level or better, and lagged rent growth significantly predicts rent growth with a positive coefficient. This is consistent with e.g. Case and Shiller (1989) and Campbell et al. (2009) who also find strong positive autocorrelation in housing returns and rent growth. Second, in all countries (except Germany and Norway) the rent-price ratio significantly predicts returns with a positive coefficient. This is consistent with the dynamic Gordon growth model, equation (2), and also broadly consistent with the results in Engsted and Pedersen (2012) on the same data. Third, also consistent with the dynamic Gordon growth model, the rent-price ratio either insignificantly predicts rent growth (8 countries) or significantly predicts rent growth with a negative coefficient (9 countries). Only in one case (Belgium) does the ratio significantly predict rent growth with a positive coefficient.[8] Overall, real estate returns and rent growth are strongly predictable by the lagged VAR variables, with R^2 values from 25% to 73% (Australia is the only exception with a return R^2 of 9%), as seen from columns (8) and (9) in Table 2 to which we now turn for details on the return decompositions.[9]

Column (1) in Table 2 shows the variance of return innovations, i.e. the variance of the residuals in the h_{t+1} equation of the VAR. Taking the square-root of this variance and comparing it with the standard deviation of returns in Table 1 reveals that unexpected housing returns are in general much less variable than actual housing returns. This is not surprising given the high R_h^2 values. Columns (2) to (4) in Table 2 show the variance ratios in (8) from section 2.1 and columns (5) to (7) show the covariance ratios in (9). We see that in all countries, except Germany and Ireland, news about future returns accounts for the bulk of return innovation variability: The variance ratio for η_h is larger than the variance ratios for rents (v_r and η_r), and all the largest covariance ratios

[8] For some countries the results for real rent growth predictability by the rent-price ratio are not in full accordance with the results in Engsted and Pedersen (2012). The reasons are that here we include additional predictor variables in addition to the rent-price ratio and we base the predictive tests on standard asymptotic Newey and West (1987) standard errors, whereas in Engsted and Pedersen (2012) only the rent-price ratio is used as predictor and they also base the predictive tests on simulated p-values in a joint hypothesis testing framework, following Cochrane (2008).

[9] In computing the elements in (7) we - for each country - set ρ equal to $(1 + \exp(\overline{r-p}))^{-1}$, where $\overline{r-p}$ is the average log rent-price ratio over the sample. Engsted et al. (2012b) show that this value for ρ minimizes the upper bound for the mean approximation error in (1).

involve η_h. In Germany return news also explains a relatively large part of movements in return innovations, but rent growth innovations and news about future rent growth combined account for most of the movements. Similarly, in Ireland the rent growth components are clearly the dominating factors. In the remaining 16 countries the return news component dominates, although in several of these countries rents have a non-negligible but less important effect. Only in Denmark, the Netherlands, and Norway do the rent components seem to be negligible.

With the exception of Germany and Ireland, these results are in contrast to the results reported by Hiebert and Sydow (2011) for eight European countries. On quarterly data from 1978 to 2009 they find that news about future rents is the main driver of housing market returns. Part of the difference between their results and ours may be explained by slightly different sample periods and their use of quarterly data while we use annual data. However, a more serious explanation for the differences is that Hiebert and Sydow make a decomposition for *excess* returns (return minus the risk-free rate), but they do not compute the risk-free rate innovation and news components, i.e. v_i and η_i in (11). Since their VAR model does not contain the rent-price ratio as a predictive variable, and since they back out the rent news component as a residual from the Campbell-Shiller identity, part of this component contains news about future risk-free rates (c.f. Engsted et al., 2012a) which does not belong to the rent news component but instead belongs to the return news component. If short-term interest rates have a non-negligible effect on house prices, this will inflate the rent news component in Hiebert and Sydow's decompositions. In fact, in the next section we document that the risk-free rate news component is a major determinant of housing return variability in many European countries.[10]

3.3 Decomposing excess returns

Tables 3 and 4 report decompositions for excess returns using the methodology described in section 2.2. Behind these tables lie VAR models for excess returns (e_t), real interest rates (i_t), real rent growth (Δr_t), the rent-price ratio ($r_t - p_t$), and the same vector of macro-variables (x_t) as in section 3.2. Column (1) in Table 3 shows the variance of excess return innovations, $Var(v_e)$, i.e. the left-hand side of equation (11), and columns (2) to

[10] We emphasize that our finding that news about future returns is the main driver of return variability in the majority of countries is not a result of the return news component being backed out as a residual. Since the VAR models contain the rent-price ratio and since the same predictive variables are used to predict both returns and rent growth, exactly the same decomposition would result by instead backing out residually the rent news component, c.f. Engsted et al. (2012a).

(6) show the variance of each of the components on the right-hand side of (11) normalized by $Var(v_e)$. Column (7) reports the sum of all the normalized covariance terms. In Table 4 the individual covariance terms are reported for each country.

The results in Table 3 are consistent with the results in Table 2 in that only for two countries, Germany and Ireland, do rent growth innovations and news explain a substantial part of the movement in housing returns. In the remaining 16 countries news about future returns is the dominating factor. And since we now have decomposed returns into the risk-free rate and a risk-premium, we can assess the relative importance of these two components. Column (4) in Table 3 shows that risk-free rate innovations are not important. The variance ratio for v_i is relatively low for all countries. However, column (5) shows that the risk-free rate *news* component is the largest explanatory factor in six countries (Australia, Belgium, Finland, France, Sweden, and the US). In the remaining countries (except Ireland) news about future risk-premia is the main determinant of return volatility (column (6)), but in these countries the risk-free rate news component is also relatively large.

When we look at the individual covariance terms in Table 4, we see that in general the largest covariances involve the component that in Table 3, columns (2) to (6), gets most weight. For example, in Ireland where the rent innovation term is most important in Table 3, this term is also involved in the highest covariance term in Table 4 (see column (9)). Another example is the US where the risk-free rate news component is the dominating factor in Table 3, and where this component is involved in the highest covariance term in table 4 (see column (1)). Thus, we can safely assess the relative importance of the individual components by focusing on the variance ratios in columns (2) to (6) in Table 3.

The conclusion is that in the vast majority of countries news about future returns is the main determinant of housing market volatility, and in all these countries the risk-free rate component is either the most important or an almost equally important component along with the risk-premium component. For the US this result stands in contrast to the findings in Campbell et al. (2009) where changes in the risk-free rate do not seem to influence housing valuation over the 1975-2007 period. Campbell et al. use a VAR approach to decompose the variance of the *rent-price ratio* into expected future rent growth, risk-free rates, and risk-premia. Instead, our decomposition is for *excess return innovations*; this may explain part of the difference in results. Another possible explanation is that in Campbell et al.'s analysis the rent-price ratio does not appear to be a predictive variable in the VAR model. However, according to the dynamic Gordon growth model in

(2), $r_t - p_t$ is a forward-looking predictor of future rent growth and returns and thereby also a forward-looking predictor of the two components of returns, the risk-free rate and the risk-premium. Thus, we should expect the rent-price ratio to have predictive power for the risk-free rate. Inspection of the estimated VAR model for the US in our analysis reveals that indeed the lagged rent-price ratio predicts the risk-free rate with a t-value of 1.93. This indicates that the expected risk-free rate component may have a too low variance in Campbell et al.'s analysis due to the omission of the rent-price ratio as a predictive variable.[11] Our results for the US are consistent with Himmelberg, Mayer, and Sinai (2005) who attribute much of the movements in house prices to changes in real interest rates.

Following up on this point, it is interesting to observe from Table 4 that the covariance term that in general gets most weight in the decompositions, $2Cov(\eta_e, \eta_i)/Var(v_e)$, i.e. column (1), is consistently negative across countries meaning that the risk-premium news component is negatively correlated with the risk-free rate news component. When news is coming to the housing market that future excess returns will be higher (lower), that tends to be associated with news that future real risk-free rates will be lower (higher). This finding is in accordance with the covariances reported by Campbell et al. (2009) for the US, and it is further evidence in support of the notion that house price booms are associated with low real interest rates. Our results suggest that this is a general phenomenon across countries.

Our general finding that news about future returns is the main driver of housing market volatility is consistent with the model in Favilukis, Ludvigson, and van Nieuwerburgh (2012), in which relaxation of credit constraints and lower transactions costs in the housing market lead to lower risk premia, which may explain part of the general runup in house prices during the 1990s and first half of the 2000s. Our results point to an additional cause for rising prices in this period: lower expected real interest rates.

3.4 Comovement across countries

Above we have documented that in the majority of OECD countries real estate returns seem to be driven mainly by discount rate news. It is naturally of interest to examine whether the cross-country movements in return and its determinants have common fac-

[11] See Engsted et al. (2012a) for a detailed analysis of the importance of the dividend-price ratio as a predictive variable in equity return decompositions. In decomposing housing market variables the rent-price ratio is the equivalent to the equity market dividend-price ratio.

tors. House prices rose and fell simultaneously in many countries in the last 20 years, so it is natural to conjecture that common global factors have played an important role.

Column (1) in Table 5 reports - for each country - the average bivariate correlation of this country's return innovation with the other countries return innovations, where the return innovations come from the 18 country-specific VAR's, i.e. $v_{h,t+1}$. Columns (2) and (3) give the minimum and maximum bivariate correlations for each country. Six countries have an average correlation around 0.25 or higher (Australia, Canada, Finland, France, the UK, and New Zealand). Five countries have an average correlation around 0.20 or slightly below (Belgium, Switzerland, Denmark, Spain, and Sweden). Four countries have an average correlation between 0.10 and 0.14 (Ireland, Italy, Norway, and the US). Finally, three countries have average correlations close to 0 (Germany, Japan, and the Netherlands). These three countries also have maximum bivariate correlation much lower than the maximum correlations in the other countries. Thus, it seems that for the majority of countries there is some degree of comovement in housing returns, while in a minority of countries returns are basically unrelated to movements in other countries.

To further analyze the degree of comovement across countries we do a principal components analysis on the 18 countries' return innovation series. The analysis is conducted on the correlation/normalized covariance matrix of return innovations. The top of Table 5 shows the cumulative explained variance of the first six principal components, i.e. the sum of the largest eigenvalues normalized by the total sum of the eigenvalues. The number 0.27 means that the first principal component explains 27% of the cross-country variation in return innovations. 40% of the cross-country variation is explained by the first two components, so the second component itself accounts for 13%. As seen, the first six principal components together account for 73% of the variation across the 18 countries.

Column (4) in Table 5 reports the eigenvector associated with the largest eigenvalue. All countries except Germany load positively on this factor. Eleven countries have loadings between 0.20 and 0.38. Four countries have loadings between 0.10 and 0.19. Three countries have loadings close to 0. These three countries are the same that have close to 0 bivariate correlation in column (1) (Germany, Japan, and the Netherlands). Thus, the principal components analysis supports the conclusion from the bivarate correlations that house price movements in these three countries do not have common factors with other countries, while for the remaining fifteen countries part of the price movements is common to these countries.

We have also computed cross-country bivariate correlations and principal components on the 'explanatory' innovation and news components, i.e. rent innovation ($v_{r,t+1}$), rent news ($\eta_{r,t+1}$), and return news ($\eta_{h,t+1}$), from the 18 country-specific VAR's. The results (which are not reported so save space, but are available upon request) indicate only weak evidence for common factors in the rent innovation and news components. However, the bivariate correlations and principal components analysis on the return news series give results that by and large are similar to the results for return innovations shown in Table 5. This is as expected since the analyses in sections 3.2 and 3.3 imply that return news is the main driver of return volatility in most of the countries.

Part of the changes in expected returns comes from changes in expected real interest rates, and real interest rates are positively correlated across countries. The other part comes from changes in expected risk-premia, and if these changes are mainly due to changes in credit constraints and transactions costs, as argued by Favilukis et al. (2012), and these changes have occured as a global phenomenon, this may explain our finding of a common factor in return movements in the majority of OECD countries.[12]

4 Concluding remarks

We have documented that changing expectations of future housing returns has been the main driver of housing market volatility in the OECD area in the last 40 years. News about future cash flows (rents) has not been completely negligible, but in the majority of countries cash flow news has played a minor role compared to discount rate news. When decomposing returns into a risk-free rate (real interest rate) component and a risk-premium component, we find that changes in both components contribute to the volatility in returns. We have also documented that for the majority of countries part of the movements in housing returns is due to common global factors.

Common movements in real interest rates and risk-premia across countries are obvious candidates for explaining the common movements in returns. During the 1990s and first half of the 2000s, housing markets in many countries were characterized by easier lending standards and lower mortgage transactions costs, and - together with general financial market liberalizations - this may have decreased risk-premia (c.f. Favilukis et

[12] In describing the results from the principal components analyses we have only focused on the eigenvector associated with the largest eigenvalue. When looking at the eigenvectors associated with the second, third, etc., eigenvalues, no clear picture emerges so we refrain from interpreting these. However, details are available upon request.

al., 2012) thereby contributing to the house price boom up to around 2006. Our results are consistent with this explanation. The decreasing house prices after 2006 in many countries are then naturally explained by higher risk-aversion and tightening of credit constraints following the general economic downturn, especially the global recession beginning in 2008.

Many economists and commentators, e.g. Shiller (2005), have argued that the main reason for the US house price boom up to the mid 2000s was a large speculative bubble in the housing market, i.e. self-fulfilling overoptimistic expectations of continuing price increases with no - or only weak - relation to economic 'fundamentals'. The methodology we have applied in this paper rules out bubbles from the outset, so the presence of a bubble cannot account for our findings. In future work we plan to investigate in more detail the bubble hypothesis, using recently developed econometric tests for bubbles on the OECD data.

References

[1] Ammer, J., and Mei, J. (1996). Measuring international economic linkages with stock market data. *Journal of Finance* 51, 1743-1763.

[2] Bernanke, B.S., and Kuttner, B.N. (2005). What explains the stock market's reaction to Federal Reserve policy? *Journal of Finance* 60, 1221-1257.

[3] Campbell, D., Morris, D., Gallin, J., and Martin, R. (2009). What moves housing markets: A variance decomposition of the rent-price ratio. *Journal of Urban Economics* 66, 90-102.

[4] Campbell, J.Y. (1991). A variance decomposition for stock returns. *Economic Journal* 101, 157-179.

[5] Campbell, J.Y., and Ammer, J. (1993). What moves the stock and bond markets? A variance decomposition for long-term asset returns. *Journal of Finance* 48, 3-37.

[6] Campbell, J.Y., and Mei, J. (1993). Where do betas come from? Asset price dynamics and the sources of systematic risk. *Review of Financial Studies* 6, 567-592.

[7] Campbell, J.Y., and Shiller, R.J. (1988). The dividend-price ratio and expectations of future dividends and discount factors. *Review of Financial Studies* 1, 195-228.

[8] Campbell, J.Y., and Vuolteenaho, T. (2004). Bad beta, good beta. *American Economic Review* 94, 1249-1275.

[9] Campbell, J.Y., Polk, C., and Vuolteenaho, T. (2010). Growth or glamour? Fundamentals and systematic risk in stock returns. *Review of Financial Studies* 23, 305-344.

[10] Case, K.E., and Shiller, R.J. (1989). The efficiency of the market for single-family homes. *American Economic Review* 79, 125-137.

[11] Case, K.E., Quigley, J.M., and Shiller, R.J. (2012). Wealth effects revisited 1975-2012. *Cowles Foundation Discussion Paper no. 1884*. Yale University.

[12] Clayton, J. (1996). Rational expectations, market fundamentals and housing price volatility. *Real Estate Economics* 24, 441-470.

[13] Cochrane, J.H. (2008). The dog that did not bark. A defense of return predictability. *Review of Financial Studies* 21, 1533-1575.

[14] Engsted, T., and Pedersen, T.Q. (2012). Predicting returns and rent growth in the housing market using the rent-to-price ratio: Evidence from OECD countries. *CREATES Working Paper 2012-58*, Aarhus University.

[15] Engsted, T., and Tanggaard, C. (2004). The comovement of US and UK stock markets. *European Financial Management* 10, 593-607.

[16] Engsted, T., Pedersen, T.Q., and Tanggaard, C. (2012a). Pitfalls in VAR based return decompositions: A clarification. *Journal of Banking and Finance* 36, 1255-1265.

[17] Engsted, T., Pedersen, T.Q., and Tanggaard, C. (2012b). The log-linear return approximation, bubbles, and predictability. *Journal of Financial and Quantitative Analysis* 47, 643-665.

[18] European Commission (2012). Alert mechanism report 2013. European Commission. Brussels.

[19] Favilukis, J., Ludvigson, S.C., and van Nieuwerburgh, S. (2012). The macroeconomic effects of housing wealth, housing finance, and limited risk-sharing in general equilibrium. *Working Paper*, New York University.

[20] Gallin, J. (2008). The long-run relationship between house prices and rents. *Real Estate Economics* 36, 635-658.

[21] Gelain, P., and Lansing, K.J. (2013). House prices, expectations, and time-varying fundamentals. *Working Paper*, Federal Reserve Bank of San Francisco.

[22] Geltner, D., and Mei, J. (1995). The present value model with time-varying discount rates: Implications for commercial property valuation and investment decisions. *Journal of Real Estate Finance and Economics* 11, 119-135.

[23] Ghysels, E., Plazzi, A., Torous, W., and Valkanov, R. (2012). Forecasting real estate prices. Forthcoming in: Elliott, G. and A. Timmermann (Eds.), *Handbook of Economic Forecasting* 2.

[24] Girouard, N., Kennedy, M., van den Noord, P., and André, C. (2006). Recent house price developments: The role of fundamentals. OECD Economics Department Working Paper no. 475.

[25] Hamilton, B.W., and Schwab, R.M. (1985). Expected appreciation in urban housing markets. *Journal of Urban Economics* 18, 103-118.

[26] Hiebert, P., and Sydow, M. (2011). What drives returns to euro area housing? Evidence from a dynamic dividend-discount model. *Journal of Urban Economics* 70, 88-98.

[27] Himmelberg, C., Mayer, C., and Sinai, T. (2005). Assessing high house prices: Bubbles, fundamentals and misperceptions. *Journal of Economic Perspectives* 19, 67-92.

[28] Larrain, B., and Yogo, M. (2008). Does firm value move too much to be justified by subsequent changes in cash flow? *Journal of Financial Economics* 87, 200-226.

[29] Meese, R., and Wallace, N. (1994). Testing the present value relation for housing prices: Should I leave my house in San Francisco? *Journal of Urban Economics* 35, 245-266.

[30] Newey, W.K., and West, K.D. (1987). A simple positive semi-definite, heteroscedasticity and autocorrelation consistent covariance matrix. *Econometrica* 55, 703-708.

[31] Patelis, A.D. (1997). Stock return predictability and the role of the monetary sector. *Journal of Finance* 52, 1951-1972.

[32] Plazzi, A., Torous, W., and Valkanov, R. (2010). Expected returns and expected growth in rents of commercial real estate. *Review of Financial Studies* 23, 3469-3519.

[33] Shiller, R.J. (2005). *Irrational Exuberance* (2nd edition). Princeton University Press.

Table 1. Descriptive statistics.

	Real return		Real rent growth	
	Mean	St.Dev.	Mean	St.Dev.
Aus	0.094	0.073	0.007	0.021
Bel	0.080	0.055	0.007	0.015
Can	0.088	0.077	-0.001	0.018
Swi	0.042	0.062	0.007	0.021
Ger	0.029	0.026	0.007	0.021
Den	0.075	0.092	0.006	0.020
Spa	0.116	0.106	-0.003	0.029
Fin	0.073	0.096	-0.003	0.034
Fra	0.080	0.052	0.008	0.016
UK	0.100	0.109	0.017	0.032
Ire	0.143	0.102	0.004	0.103
Ita	0.069	0.114	-0.002	0.044
Jap	0.033	0.061	0.010	0.017
Neth	0.090	0.090	0.012	0.015
Nor	0.092	0.084	0.005	0.018
NZ	0.100	0.094	0.005	0.042
Swe	0.061	0.082	0.017	0.033
USA	0.061	0.040	0.010	0.016
Mean	0.079	0.079	0.006	0.029

Notes: The sample period begins in 1970 for all countries except Australia (1973), Belgium (1977), Spain, (1971), Norway (1979), and Sweden (1980). The sample period ends in 2011 for all countries. Data are annual.

Table 2. Variance decomposition for real estate real returns.

	$Var(v_h)$	$\frac{Var(v_r)}{Var(v_h)}$	$\frac{Var(\eta_r)}{Var(v_h)}$	$\frac{Var(\eta_h)}{Var(v_h)}$	$\frac{2Cov(v_r,\eta_r)}{Var(v_h)}$	$\frac{-2Cov(v_r,\eta_h)}{Var(v_h)}$	$\frac{-2Cov(\eta_r,\eta_h)}{Var(v_h)}$	R_h^2	R_r^2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aus	0.0037	0.048	0.107	0.518	0.058	-0.061	0.331	0.09	0.40
Bel	0.0007	0.177	1.188	3.093	-0.599	0.524	-3.382	0.73	0.34
Can	0.0039	0.064	0.196	0.515	0.015	-0.110	0.321	0.25	0.28
Swi	0.0016	0.142	0.117	0.615	0.079	-0.240	0.287	0.55	0.48
Ger	0.0003	0.646	1.065	1.271	1.155	-1.732	-1.405	0.50	0.51
Den	0.0050	0.048	0.037	0.770	0.031	0.089	0.025	0.34	0.43
Spa	0.0032	0.106	0.249	0.504	0.004	-0.154	0.291	0.64	0.61
Fin	0.0046	0.133	0.076	0.607	-0.001	-0.176	0.361	0.43	0.50
Fra	0.0009	0.201	0.175	1.120	0.091	-0.115	-0.473	0.63	0.30
UK	0.0052	0.138	0.323	1.495	0.043	-0.199	-0.802	0.46	0.29
Ire	0.0035	2.371	1.352	0.949	-2.593	-2.338	1.259	0.60	0.26
Ita	0.0069	0.175	0.163	0.950	-0.204	-0.550	0.467	0.29	0.41
Jap	0.0016	0.100	0.060	0.840	-0.017	0.202	-0.185	0.54	0.47
Neth	0.0025	0.054	0.089	1.438	0.011	-0.012	-0.580	0.64	0.40
Nor	0.0044	0.025	0.028	0.744	0.013	-0.030	0.221	0.31	0.53
NZ	0.0049	0.227	0.315	1.173	0.052	0.070	-0.838	0.33	0.36
Swe	0.0013	0.533	1.032	2.295	-0.717	-0.083	-2.060	0.73	0.27
USA	0.0004	0.407	1.533	3.185	0.361	-1.113	-3.372	0.73	0.38

Notes: For each country we estimate the VAR model (6) with $Z_t = (h_t, \Delta r_t, r_t - p_t, x_t)'$. h_t is real log housing return, Δr_t is real log rent growth, $r_t - p_t$ is the log rent-price ratio, and x_t is a vector containing real GDP growth, the spread between long and short interest rates, and the unemployment rate. The innovation and news terms are computed as in (7). The sample periods are the same as in the note to Table 1.

Table 3. Variance decomposition for real estate excess returns.

	$Var(v_e)$	$\frac{Var(v_r)}{Var(v_e)}$	$\frac{Var(\eta_r)}{Var(v_e)}$	$\frac{Var(v_i)}{Var(v_e)}$	$\frac{Var(\eta_i)}{Var(v_e)}$	$\frac{Var(\eta_e)}{Var(v_e)}$	$\sum \frac{Cov}{Var(v_e)}$	R_e^2	R_r^2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aus	0.0040	0.044	0.107	0.037	0.821	0.568	-0.577	0.15	0.83
Bel	0.0007	0.155	0.942	0.194	7.269	1.949	-9.509	0.81	0.82
Can	0.0039	0.053	0.159	0.035	0.932	1.316	-1.495	0.46	0.85
Swi	0.0017	0.117	0.152	0.076	0.513	0.820	-0.678	0.65	0.88
Ger	0.0003	0.719	1.226	0.447	1.257	2.090	-4.739	0.81	0.76
Den	0.0041	0.058	0.051	0.069	0.582	0.732	-0.492	0.46	0.70
Spa	0.0033	0.101	0.274	0.142	1.016	1.540	-2.073	0.73	0.80
Fin	0.0044	0.130	0.081	0.129	0.924	0.815	-1.079	0.58	0.72
Fra	0.0010	0.146	0.329	0.215	4.148	1.672	-5.510	0.78	0.81
UK	0.0044	0.160	0.187	0.081	0.819	1.516	-1.763	0.56	0.79
Ire	0.0035	2.028	1.192	0.139	1.015	0.953	-4.327	0.73	0.80
Ita	0.0089	0.128	0.111	0.064	0.330	0.935	-0.568	0.50	0.79
Jap	0.0012	0.136	0.064	0.356	1.634	3.057	-4.247	0.71	0.67
Neth	0.0027	0.037	0.118	0.049	0.781	0.874	-0.859	0.68	0.85
Nor	0.0042	0.026	0.028	0.047	0.516	0.546	-0.163	0.47	0.76
NZ	0.0032	0.341	0.447	0.305	1.820	2.065	-3.978	0.59	0.61
Swe	0.0012	0.542	1.130	0.125	9.653	3.327	-13.78	0.81	0.76
USA	0.0005	0.295	0.449	0.462	2.941	1.979	-5.126	0.79	0.72

Notes: For each country we estimate the VAR model (6) with $Z_t = (e_t, i_t, \Delta r_t, r_t - p_t, x_t)'$. e_t is log excess housing return, i_t is the log real interest rate, Δr_t is real log rent growth, $r_t - p_t$ is the log rent-price ratio, and x_t is a vector containing real GDP growth, the spread between long and short interest rates, and the unemployment rate. The innovation and news terms are computed as in (12). The numbers in column (7) is the sum of the covariance terms in (13) where each term is normalized by the variance of excess return innovations. Table 4 reports each individual covariance term. The sample periods are the same as in the note to Table 1.

Table 4. Covariance terms in the variance decomposition for real estate excess returns.

	η_e, η_i (1)	η_e, η_r (2)	η_e, v_i (3)	η_e, v_r (4)	η_i, η_r (5)	η_i, v_i (6)	η_i, v_r (7)	η_r, v_i (8)	η_r, v_r (9)	v_i, v_r (10)
Aus	-0.917	0.317	-0.085	0.057	-0.030	0.153	-0.115	0.013	0.055	-0.025
Bel	-6.282	2.224	0.913	-0.812	-5.208	-1.205	1.122	0.383	-0.399	-0.244
Can	-1.747	0.001	0.076	-0.070	0.359	0.020	-0.040	-0.034	0.005	-0.067
Swi	-0.742	0.564	-0.081	0.022	-0.318	0.259	-0.273	-0.064	0.099	-0.143
Ger	-1.958	0.329	0.687	-1.373	-2.075	0.206	-0.532	-0.678	1.412	-0.756
Den	-0.454	-0.034	-0.263	-0.018	0.020	0.149	0.104	0.009	0.040	-0.046
Spa	-2.129	0.928	0.288	-0.427	-0.627	-0.125	0.289	-0.080	-0.006	-0.183
Fin	-1.129	0.220	-0.194	0.007	0.161	0.202	-0.168	-0.014	-0.031	-0.132
Fra	-4.628	1.384	-0.005	-0.067	-2.201	0.284	0.020	-0.133	0.030	-0.194
UK	-1.110	0.203	-0.197	0.220	-0.576	0.002	-0.407	0.154	0.050	-0.102
Ire	-1.235	0.800	-0.329	-1.104	0.288	0.106	-0.572	-0.252	-2.401	0.372
Ita	-0.558	0.477	0.248	-0.384	-0.157	-0.082	-0.010	0.108	-0.137	-0.071
Jap	-3.482	0.220	-0.875	0.273	-0.506	0.530	0.059	-0.024	-0.070	-0.372
Neth	-0.232	-0.113	0.073	-0.013	-0.524	-0.001	0.031	-0.005	-0.016	-0.056
Nor	-0.262	0.022	-0.093	-0.054	0.181	0.046	0.021	0.002	0.016	-0.041
NZ	-2.135	0.004	-0.913	0.243	-1.252	0.146	-0.123	0.300	0.102	-0.350
Swe	-10.25	3.571	0.540	-0.646	-6.154	-1.027	0.561	0.419	-0.638	-0.149
USA	-3.288	-0.253	-0.380	0.133	-0.864	-0.072	-0.735	0.658	0.086	-0.411

Notes: Each column shows one of the covariance terms in (13) normalized by the excess return innovation variance. For example, column (1) reports $2Cov(\eta_{i,t+1}, \eta_{e,t+1})/Var(v_{e,t+1})$.

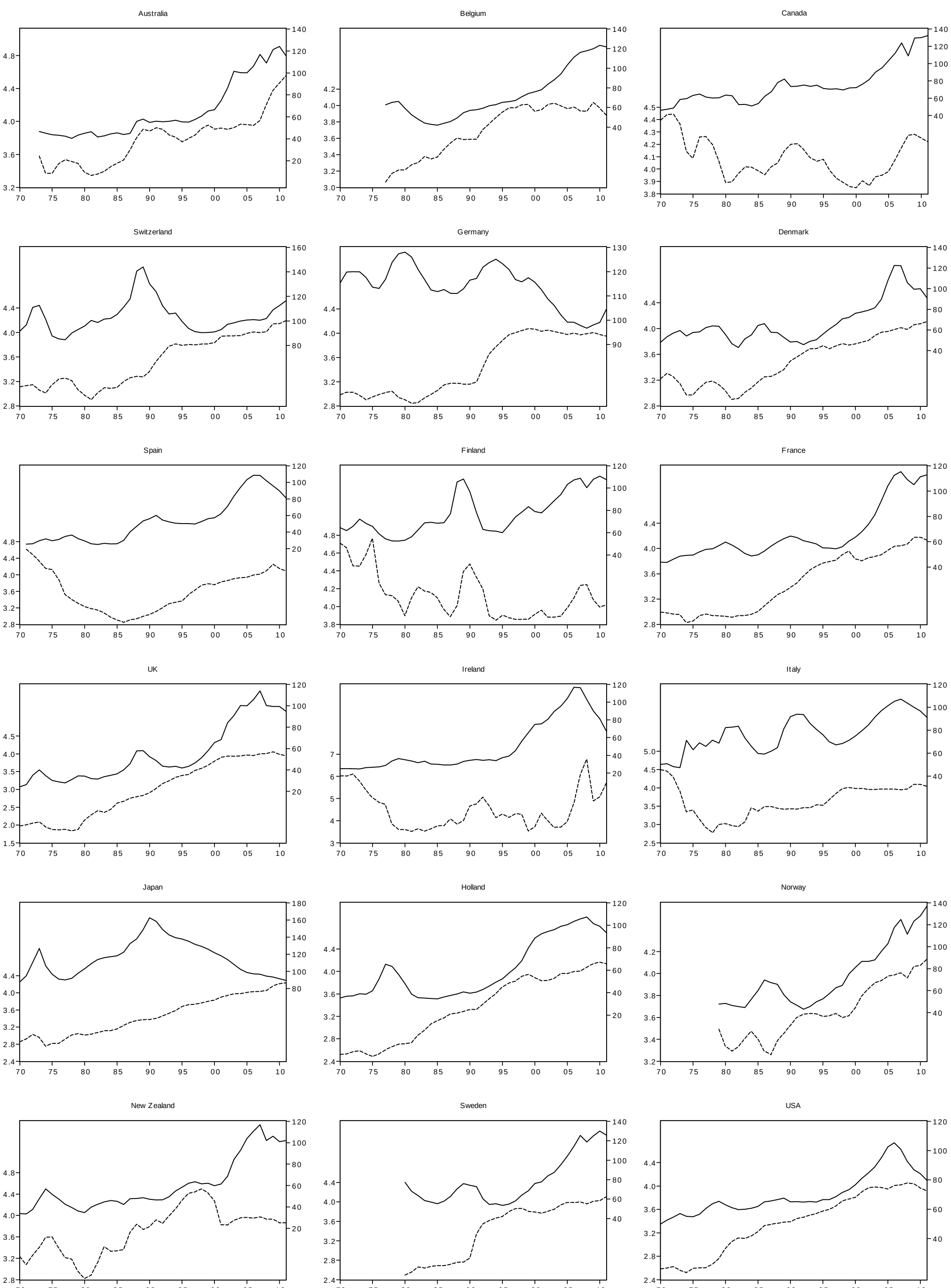
Table 5. Comovement of return innovations across countries.

Cum. expl. var.: (0.27, 0.40, 0.51, 0.60, 0.67, 0.73)

	Avg. corr$(v_h^{(k)}, v_h^{(l)})$	Min corr	Max corr	Eig. vector
	(1)	(2)	(3)	(4)
Aus	0.26	-0.17	0.62	0.33
Bel	0.21	-0.11	0.43	0.23
Can	0.31	-0.08	0.67	0.37
Swi	0.17	-0.14	0.53	0.24
Ger	-0.04	-0.48	0.18	-0.03
Den	0.17	-0.29	0.48	0.20
Spa	0.19	-0.25	0.52	0.23
Fin	0.25	-0.13	0.57	0.31
Fra	0.25	-0.03	0.43	0.27
UK	0.33	-0.06	0.67	0.38
Ire	0.10	-0.22	0.47	0.10
Ita	0.10	-0.35	0.43	0.11
Jap	0.01	-0.45	0.35	0.03
Neth	0.05	-0.45	0.34	0.07
Nor	0.14	-0.35	0.43	0.19
NZ	0.23	-0.03	0.60	0.28
Swe	0.22	-0.09	0.56	0.26
USA	0.13	-0.48	0.48	0.16

Notes: The first three columns report for each country the average, minimum, and maximum correlation of return innovations with the other 17 countries. The last column shows the eigenvector for the largest eigenvalue from a principal components analysis on the correlation matrix of return innovations. The cumulative explained variance is calculated as $\sum_{i=1}^{k} \lambda_i / \sum_{j=1}^{18} \lambda_j$ for $k = 1, ..., 18$, where λ_i denotes the i'th eigenvalue and the eigenvalues are sorted in descending order.

Figure 1. Real house prices and rents in 18 OECD countries.



Notes: The solid line (right axis) gives the (indexed) house price and the dotted line (left axis) gives the (indexed) rent.

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