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Seasonality in house prices

Florian Kajuth
Tobias Schmidt

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Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0
Telex within Germany 41227, telex from abroad 414431

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

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Abstract

The contribution of this paper is to offer a rationale for the observed seasonal pattern in house prices. We first document seasonality in house prices for the US and the UK using formal statistical tests and illustrate its quantitative importance. In the second part of the paper we employ a standard model of dynamic optimisation with housing demand and seasonal shocks in non-durables in order to characterise seasonality in house prices as an equilibrium outcome. We provide empirical evidence for seasonality in house prices with our small model using US and UK data.

Keywords: house prices, seasonality, optimal housing consumption

JEL Codes: D91, R21, R31

Non-technical summary

Housing markets and house prices have received considerable attention in the economic literature and popular press during the recent financial crises. The crisis has shown clearly that house prices are volatile and that boom phases of house prices may be followed by bust phases. This volatility is not specific to the financial crises but has been observed previously. Furthermore, it is not specific to the business cycle frequency, rather it is also observed at seasonal frequencies such as months and quarters, albeit quantitatively much less pronounced.

There is one obvious question to ask given the seasonal pattern in house prices: What are the sources of seasonality in house prices? After all, housing is a durable good and is not exposed to a natural source of seasonal fluctuations such as the weather.

The paper addresses this question and starts out by carefully documenting seasonal patterns in house price indicators. We find clear and identifiable seasonal patterns for the repeat-sales FHFA house price index for the US and the Halifax UK house price index, which is quality-adjusted by hedonic regressions.

We furthermore offer a way to endogenize seasonality in house price indexes within a simple model of optimal intertemporal consumption. It turns out that, in the model, seasonality in house prices is an equilibrium phenomenon. The core of the explanation relates non-durables consumption to durables consumption via one of the first-order conditions resulting from an intertemporal utility maximisation exercise. In this way we are able to introduce a plausible source of seasonality into non-durables consumption. This is the main contribution to the existing literature, which so far has relied on much less credible assumptions about the root of seasonality in house prices. We take the model to the data using US and UK time-series in GMM estimation. The data confirm the hypothesis that within a reduced form approach seasonal shocks to non-durables consumption have an effect on house prices both in the UK and the US. Overall the simple benchmark model goes some way in explaining observed seasonality in house prices in the US and the UK. As such it can serve as a useful reference point in more elaborate theoretical models of housing price seasonality.

Nichttechnische Zusammenfassung

In der Folge der Wirtschafts- und Finanzkrise haben Immobilienmärkte und die Preise für Wohnimmobilien sowohl in der wissenschaftlichen Diskussion als auch in der Presse deutlich an Interesse gewonnen. Die Krise hat eindrucksvoll veranschaulicht, dass Immobilienpreise ausgeprägten Schwankungen unterliegen, und dass Boom-Phasen Preisstürze nach sich ziehen können. Solche Preisausschläge treten allerdings nicht nur im Verlauf des Konjunkturzyklus auf, sondern bestehen darüber hinaus auch in unterjähriger Frequenz, d.h. auf Monats- oder Quartalsbasis, wenn auch quantitativ schwächer ausgeprägt. So lässt sich ein deutliches Saisonmuster in Immobilienpreisen nachweisen. Offensichtlich stellt sich die Frage nach dem Ursprung des saisonalen Musters in den Preisen für Wohnimmobilien. Schließlich handelt es sich bei Wohnhäusern um haltbare Güter, die keinen natürlichen saisonalen Schwankungen wie z.B. den Jahreszeiten ausgesetzt sind.

Zunächst wird in diesem Artikel die Existenz saisonaler Schwankungen in den Preisen für Wohnimmobilien und ihre quantitative Bedeutung nachgewiesen. Laut den Ergebnissen enthalten der *repeat-sales* Immobilienpreisindex der Federal Housing Finance Agency (FHFA) für die USA und der Halifax-Indikator für das Vereinte Königreich, die beide qualitätsbereinigt sind, eine erkennbare saisonale Komponente.

Darüber hinaus wird in einem Standardmodell optimaler intertemporaler Konsumentscheidungen die saisonale Komponente in Immobilienpreisen endogenisiert, so dass sie als gleichgewichtiges Phänomen auftritt. Die Optimalitätsbedingungen aus der Nutzenmaximierung fordern neben der üblichen Konsumglättung auch eine Glättung des intertemporalen Konsums von nicht-haltbaren und haltbaren Gütern. Innerhalb des Modells kann so der Konsum nicht-haltbarer Güter als plausible Quelle saisonaler Schwankungen identifiziert und in Verbindung mit den Preisen für Wohnimmobilien gebracht werden. Hierin besteht der Hauptbeitrag zur bestehenden Literatur, die bislang auf vergleichsweise schwer zu begründende Annahmen über die Ursache für Saisonalität in Hauspreisen zurückgegriffen hat.

In einem weiteren Schritt wird das Modell unter Verwendung von Daten für die USA und das Vereinte Königreich mittels der GMM-Methode geschätzt. Die Schätzergebnisse bestätigen die Hypothese, dass saisonale Schwankungen in nicht-haltbaren Gütern Auswirkungen auf die Preise für Wohnimmobilien in den USA und dem Vereinten Königreich haben. Insgesamt lässt sich aus der Analyse schließen, dass ein Standardmodell der intertemporalen Nutzenmaximierung zur Erklärung von Saisonalität in Hauspreisen beiträgt. Weiterhin könnte es als Ausgangspunkt für komplexere Modelle unterjähriger Schwankungen am Immobilienmarkt dienen.

Contents

List of Tables

Seasonality in House Prices[1]

1 Introduction

Housing markets and house prices have received considerable attention in the economic literature and popular press during the recent financial crises. The crisis has shown clearly that house prices are volatile and that boom phases of house prices may be followed by bust phases. This volatility is not specific to the financial crises but has been observed previously.[2] Furthermore, it is not specific to the business cycle frequency, rather it is also observed at seasonal frequencies such as months and quarters, albeit quantitatively much less pronounced. In fact, there appears to be a clear pattern of seasonal house price peaks and troughs across a number of countries.

There are two obvious questions to ask given the seasonal pattern in house prices: What are the sources of seasonality in house prices? After all, housing is a durable good and is not exposed to a natural source of seasonal fluctuations such as the weather. Second, why is the seasonal pattern in house prices not arbitraged away by economic agents taking advantage of predictable opportunities to sell at a higher price and buy at a lower one?

The paper focuses on the first question and starts out by carefully documenting seasonal patterns in house price indicators. To that end it is crucial to use quality-adjusted house price indicators in order to avoid any seasonal pattern introduced by a changing sample and characteristics of houses sold over time. Therefore we restrict our attention to the US and UK indexes, which are quality-adjusted. Specifically we use the repeat-sales FHFA house price index for the US and the Halifax UK house price index, which is quality-adjusted by hedonic regressions. We apply the standard X-12-ARIMA method, which is used by the U.S. Census Bureau, to check for

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[1] Authors' affiliations: Florian Kajuth, Deutsche Bundesbank, Economics Department, Wilhelm-Epstein-Straße 14, D-60431 Frankfurt am Main, Germany, Florian.Kajuth@bundesbank.de, Tel.: +49 69 9566 8879. Tobias Schmidt, Deutsche Bundesbank, Economic Research Centre, Wilhelm-Epstein-Straße 14, D-60431 Frankfurt am Main, Germany, Tobias.Schmidt@bundesbank.de, Tel.: +49 69 9566 3730. We would like to thank Heinz Herrmann, Markus Kirchner, Michael Krause, Ulf von Kalckreuth and seminar participants at the Bundesbank research seminar for comments and suggestions.

[2] See e.g. Muellbauer and Murphy (1997), Ortalo-Magné and Rady (1998;(2001), Stein (1995).

seasonality. The test results indicate a clear identifiable seasonal pattern in both countries. Our results support the findings of earlier studies on seasonality in house prices (see e.g. Ngai and Tenreyro 2009; Case and Shiller, 1989; Hosios and Pesando, 1992). Moreover the differences in prices across seasons are statistically significant and quantitatively non-negligible.

The second part of the paper is dedicated to rationalising the observed seasonal pattern in house prices. Our approach is to see how far we can get with a standard model of optimal consumption. We build on a model of housing and consumption by Iacoviello (2004) and modify it to allow for seasonal shocks to non-durable consumption as in Miron (1986). Given the consumption smoothing motive of the representative consumer the seasonal pattern in non-durables makes desirable some seasonality in the stock of durables. Given that supply of housing is relatively inelastic the seasonal pattern in consumption expenditure on non-durables and housing should feed through to house prices. Generally, the chosen approach is not restricted to modelling seasonality in housing but can in principle be applied to all consumer durables (Miron, 1986). Our objective in this paper is to apply it to the topical problem of seasonality in house prices.

Finally we derive an equation relating house prices to housing demand, interest rates and non-durables consumption. We empirically check for the spill-over of seasonality from non-durables to house prices by estimating the house price equation. This gives an estimate of the impact of seasonality in non-durables on house prices. Our results suggest that there is indeed a statistically significant correlation between the seasonal component in non-durables consumption and house prices. Thus, using a simple model of intertemporal consumption smoothing we are able to rationalize seasonality in house prices as an equilibrium phenomenon. This provides a benchmark model for explaining seasonality in house prices, which can be used as a starting point for more elaborate theories, possibly involving more institutional factors.

A paper closely related to our work is Ngai and Tenreyro (2009). They present a model of seasonality in house prices based on search costs. They argue that in "hot" seasons, i.e. high-price seasons, there is a wider choice of houses for sale, which increases the quality of the match between a prospective buyer and her desired house. Therefore she is willing to pay a higher price. In return, sellers, who are aware of this, are more likely to put up their house for sale because they can ask for a higher price. The source of seasonality in their paper are homeowners that buy and sell according to the school calendar, i.e. who buy and move during summer holidays. Thus, the core of their analysis explains an amplification mechanism of a given (small) seasonal component in house prices.

Our contribution in this paper is to offer a way to endogenize the source of (small) seasonality in house prices in the first place without resorting to institutional explanations or ad hoc assumptions. In this regard, our paper can be seen as a precursor to Ngai and Tenreyro's (2009) model providing a theoretical justification for one of their crucial assumptions. As such our results are fully consistent with their search and matching model of the housing market.

The paper proceeds with a detailed presentation of seasonality in house prices and the specific issues of detecting it in house price indexes. Section 3 discusses potential sources of seasonality in house prices, section 4 presents a simple model of housing demand and derives the core equations on which we build our explanation of seasonality in house prices. Section 5 sets up the estimation equation presents its results. Section 6 concludes.

2 Seasonality in house prices: Myth or reality?

In many countries usually more than one institution publish house prices indexes. These indexes are not harmonized, however, but differ in many respects, for example in the type of buildings they cover (flats, houses, new homes, existing homes, …), in the frequency with which they are published, in the data sources they use (e.g. list prices, transaction prices, appraisals), the point in time prices are recorded or the weighting scheme that is used to produce population totals. These differences are all important aspects that need to be considered when comparing house prices across different countries. What is of particular relevance for our study is to ensure that the house prices are quality-adjusted. If prices are not adjusted, seasonal fluctuations may be driven by the fact that different types of houses are sold in different seasons, e.g. houses with double-glazed windows in winter and those without in summer. The weighting scheme used is also quite important, since it may cause seasonality, e.g. if the weighting is based on the number of sales and this number is seasonal itself. To summarize, a meaningful test of seasonality can only be performed on quality-adjusted indexes that use the total number of houses or total value of the housing stock as the basis for weighting.

The house price index of the US Federal Housing Finance Agency (FHSA) and the Halifax house price index for the UK have these properties and will be analysed below. The US index is quality-adjusted "by construction" since it tracks resale prices of existing homes. In the UK the index is quality-adjusted using hedonic regression methods. According to figure 1 (left panel) house prices in the US as measured by the (non-seasonally adjusted) FHFA repeat-sales house price index follow a steady upward trend until about 2006 when prices decelerated and eventually decreased. In addition, the right panel depicts the seasonal component as derived on the basis of the multiplicative CENSUS-X12 method for seasonal adjustment. Clearly, there is a quarterly seasonal pattern with house prices generally being higher in the second and third quarter compared to their values in the fourth and first quarter of a year.

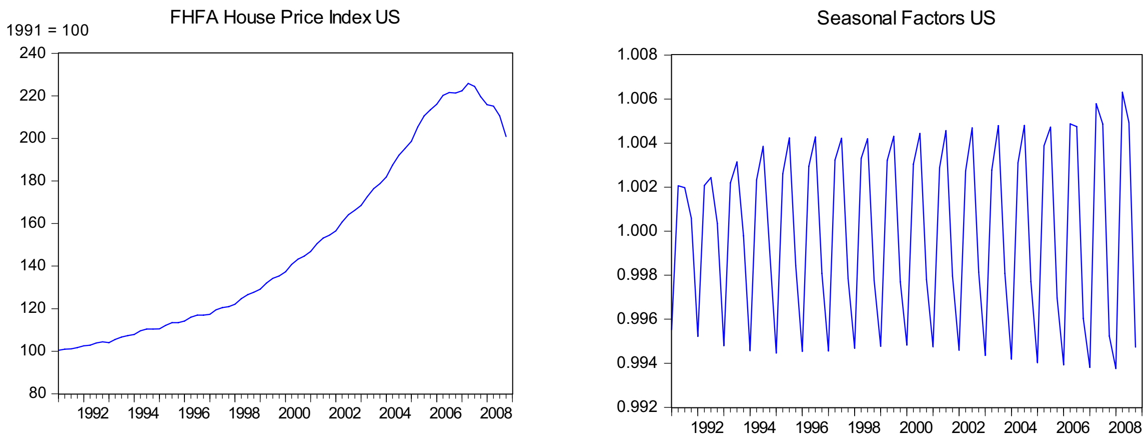

Figure 1: FHFA US House Price Index (non-seasonally adjusted) and its seasonal component

A similar pattern emerges for house prices in the UK as shown in figure 2. House prices in the UK kept increasing over a long horizon until about 2007 and reversed subsequently. However, within the year a clear seasonal pattern is discernible. As in the US, house prices seem to be higher – in seasonal terms – in the second and third quarter than in the fourth and first quarter of a year.

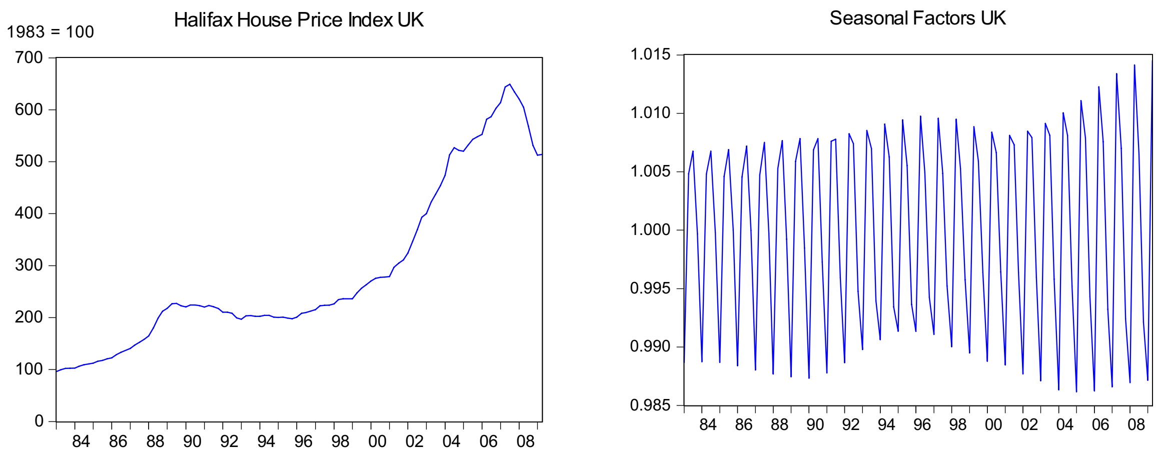

Figure 2: Halifax UK House Price Index (non-seasonally adjusted) and its seasonal component

In order to illustrate that seasonal variation in house prices matters in practical terms figure 3 presents the annualized growth rates of non-seasonally adjusted house prices from the end of the first quarter (seasonal low) to the end of the third quarter (seasonal high) next to the rates of change from the end of the third quarter (seasonal high) to the end of the first quarter (seasonal low) for both the US and the UK. Clearly, house prices increase by much more from the low season to the high season than vice versa. Note that the positive growth rate in the low season is due to the overall trend in house prices in both countries. The horizontal lines are the average growth rates across both types of seasons. On average, house prices in the US grew in a low season by 3.3%, while the growth rate in a high season was 6.7%. For the UK the average rate of change in a low season was 1.5% and 9.2% in a high season. Using standard tests for the equality of means we can show that the mean growth rate in the high price season is in statistical terms significantly different from the average growth rate in the low price season. Finally, we compute the dollar/pound sterling value that a household could save by buying in the low season instead of the high season. Assume a total price of a house of $/£ 300,000 in the low price season. The same house would on average – according to the data used here – cost about $ 10,000 or £ 23,000, respectively, more in the high price season. Even if one considered a cheaper house, the amount that can be saved by slightly altering the timing of purchase seems worth some time and effort to look into the roots and causes of the seasonal pattern in house prices.

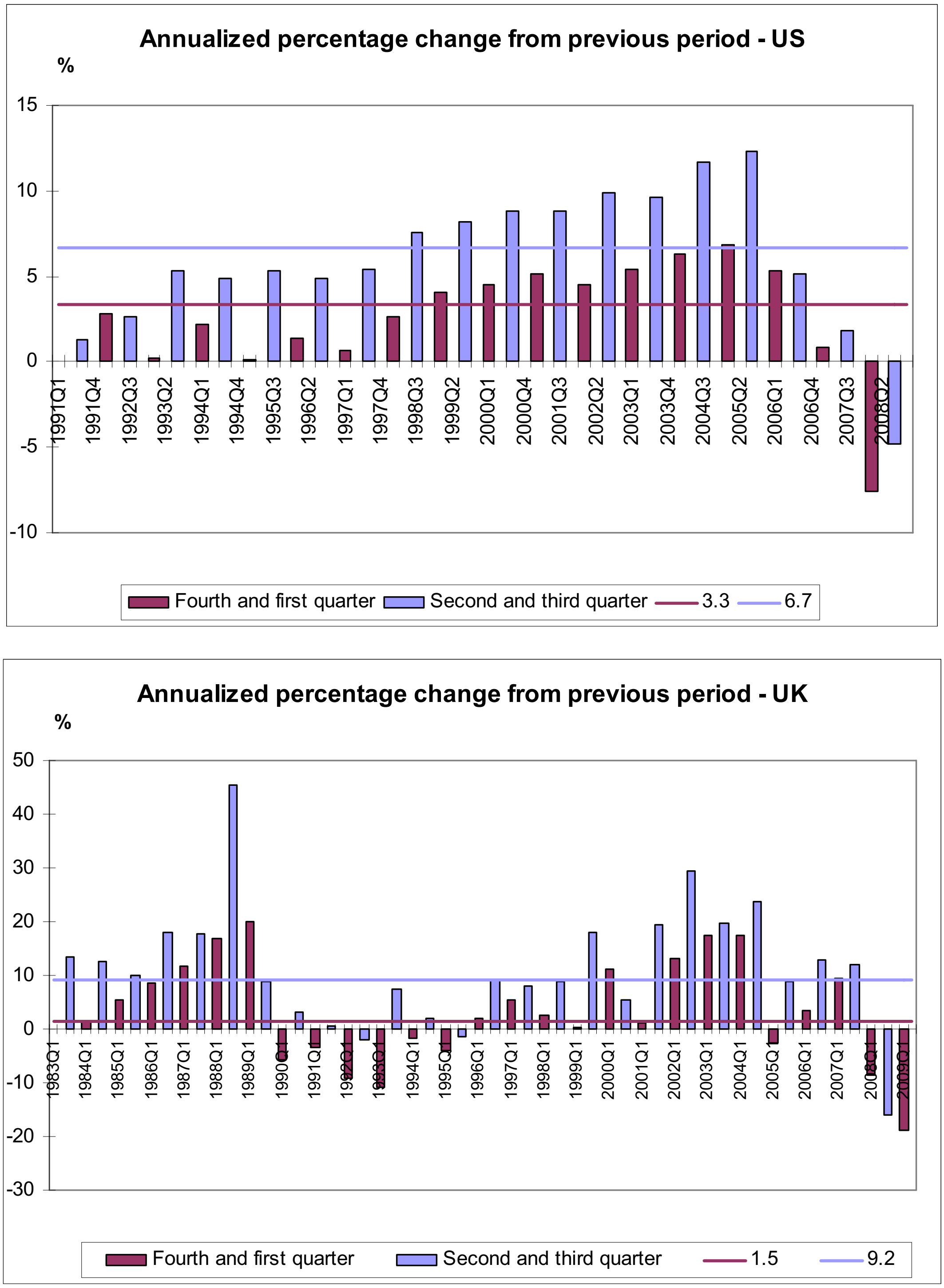

Figure 3: Growth rates of non-seasonally adjusted house prices across high and low seasons for the US and UK. Horizontal lines depict average growth rates in high and low seasons.

To complete the picture we provide some formal tests for seasonality. The most widely used procedure for seasonality adjustment is the X-12-ARIMA procedure developed by the U. S. Census Bureau (see e.g. U. S. Census Bureau (2007)). We use this method in this paper as well since we focus on US and UK data. The Eviews tool implementing the multiplicative X-12-ARIMA method reports a number of different tests for seasonality and accompanying tables and descriptive statistics that allow the users to assess whether seasonality is present or not. In our description of the results we will focus on the three tests most commonly reported and a combination of two of them (cf. Ladiray and Quenneville (2001); Lytras et al. (2007)).

- Parametric F-test for stable seasonality
- Non-parametric Kruskal-Wallis test
- Moving seasonality test base on two-way analysis of variance model
- "M7-Test": Combines the F-test for stable seasonality and the moving seasonality test

Table 1 shows the results for the quarterly nominal house price indexes of the US and UK. Our results indicate that identifiable seasonality is present in both indexes. This result is confirmed by all the tests we conducted and is in line with the findings of Ngai and Tenreyro (2009). The only difference between the two countries seems to be that in the US some degree of moving seasonality can be detected, whereas no moving seasonality is present in the UK index. In addition, we have run tests for seasonality in real house prices using the CPI less shelter and the UK-HICP (without owner-occupied housing) as deflators.[3] Real house prices contain a similar seasonal pattern as their nominal counterparts. In what follows, however, we will concentrate on nominal prices.

[3] Results available upon request from the authors.

Table 1: Results of seasonality tests

Country		UK	USA
F-Test for stable seasonality	F-Test Statistic	121.7	81.3
	Seasonality present at	0.1% level	0.1% level
Kruskal-Wallis-Test	Test-Statistic	77.4	56.9
	Probability of no seasonality	0 %	0 %
Moving seasonality test	Test Statistic (F-value)	1.55	6.49
	Evidence of moving seasonality	no evidence of moving seasonality at 5% level	moving seasonality present
M7-Test	Identifiable seasonality	present	present
	Test Statistic	0.219	0.404
Period		1983Q1-2008Q4	1991Q1-2008Q4
Number of obs		104	72
Frequency		quarterly	quarterly

3 Candidate explanations for seasonality in house prices

The literature proposes a number of determinants for the prices of owner-occupied houses and flats. As a starting point it is useful to examine these with a view to being the source of seasonality in house prices.

According to more technical arguments, an observed seasonal pattern might be the spurious result of the index construction method. Since quality-adjusted house prices indices are often based on hedonic regressions one of the regressors might contain a seasonal component which carries over to the final price index. Then, however, one would have to explain why the effects of individual characteristics of housing such as location, age or features of the building are seasonal. Also, there is evidence of seasonality on house prices in different countries across different index construction methods (cf. Hosios and Pesando, 1992; Case and Shiller, 1989). So it would be necessary to find a common cause of seasonality in prices indices across different approaches.

Another frequent argument trying to explain seasonality in house prices is that, for example, households with children tend to move during summer holidays because their cost of moving would be higher during the school year. Another one is that in the US and UK married couples are more likely to be homeowners, and since marriages tend to take place in spring/summer house prices might exhibit a spike in the "wedding season". There are problems with both arguments, however. First, house prices in some countries show more than one spike during the year casting doubt on the school holiday hypothesis. Second, not all home owners have children. Moreover, it is a priori not clear why weddings should take place in the same months of several years, nor why buying a house should be closely associated with the date of marriage within a year.

An additional explanation is based on the asset pricing approach. Using this approach the house price Q_t should be the sum of discounted future rent payments R_{t+k}, where i_{t+j} is the appropriate per-period interest rate.

$$Q_t = \sum_{k=1}^{\infty} \frac{R_{t+k}}{\prod_{j=1}^{k} \left(1 + i_{t+j-1}\right)} \tag{1}$$

Under this approach seasonality in house prices could be due to seasonality in future rent payments or interest rates. However, rents typically do not contain a pronounced seasonal component. More importantly, even if they did it would have to be implausibly large since future rents are discounted more heavily the further away they are. Moreover, seasonality in house prices due to seasonality in interest rates would then require a model of the dynamics of interest rates.

Finally, the user cost approach to owning a home states that in equilibrium rents R_t should equal the user costs of housing $Q_t u_t$ (Poterba, 1984).

$$R_t = Q_t \cdot u_t \quad with \quad u_t = r_t + \tau_t - \omega_t + \delta_t - g_{t+1} + \gamma_t \tag{2}$$

User costs are given by the house price Q_t multiplied by the sum of a measure of appropriate real interest rate r_t, the tax rate τ_t, rate of subsidies ω_t, the depreciation rate δ_t, the expected growth rate of house prices g_{t+1} and a measure of the risk premium γ_t.

According to the user cost approach, seasonality in one of the determinants could carry over to house prices. However, arguing that the real interest rate, the tax/subsidy/depreciation rate or the risk premium is seasonal would require a model for their seasonality since none of the variables displays a natural seasonal pattern as e.g., introduced by the weather. Moreover, the relationship between user costs and rents is known to be very loose at quarterly frequency.

We propose a novel argument for seasonality in house prices based on a standard model of dynamic optimisation of consumption. The main advantage over the discussed explanations is that our approach is able to provide a natural source of seasonality, in non-durables consumption, which fits in a standard optimising framework.

4 A model of intertemporal consumption smoothing

We start from the simple optimisation problem of the representative household who derives utility from consuming non-housing goods and housing.

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left(u\left(C_t^{NSA}\right) + \mu v\left(H_t\right) \right) \tag{3}$$

where β is the subjective discount rate and C_t^{NSA} non-housing consumption, not seasonally adjusted. μ is the weight on housing consumption, H_t housing stock and $v(.)$ a function that transforms the stock of housing into a flow of housing consumption (see e.g. Iacoviello, 2004). The housing stock evolves according to $H_t=(1-\delta)H_{t-1}$. For simplicity δ is set to zero. The per-period budget constraint is

$$P_t C_t^{NSA} + Q_t\left(H_t - H_{t-1}\right) + B_t = P_t^Y Y_t + \left(1 + i_t\right) B_{t-1} \tag{4}$$

Maximising (3) subject to (4) using $u\left(C_t^{NSA}\right) = \frac{C_t^{1-\alpha}}{1-\alpha}$ and $v\left(H_t\right) = \frac{H_t^{1-\gamma}}{1-\gamma}$ yields the two first-order conditions after some rearrangements.

$$E_t \beta \left(1 + i_t\right) \frac{P_t}{P_{t+1}} u'(C_{t+1}^{NSA}) = u'\left(C_t^{NSA}\right) \tag{5}$$

$$\mu v'(H_t) = E_t \beta u'(C_{t+1}^{NSA}) \left[\frac{Q_t}{P_{t+1}}(1+i_t) - \frac{Q_{t+1}}{P_{t+1}} \right] \tag{6}$$

The first condition is the usual Euler equation for consumption. For the second one, consider a homeowner who reduces her housing stock by one unit. She saves the proceeds which are worth $\frac{Q_t}{P_{t+1}}(1+i_t)$ next period. From these she replaces the housing stock to its original level and consumes the remainder. At the optimum the marginal decline in utility today from giving up one unit of housing has to be equal to the marginal utility from consuming the proceeds net of the costs for replacing the housing stock tomorrow (see Mankiw, 1985).[4]

Finally we introduce seasonality by splitting up non-housing consumption into durables and non-durables with weights 1- τ and τ. The latter is further decomposed into a seasonally adjusted (SA) part and the seasonal factor (SF) with weights *1-σ* and *σ*.

$$\mu v'(H_t) = E_t \left\{ \beta u' \left(\left(C_{t+1}^{D,NSA}\right)^{1-\tau} \left[\left(C_{t+1}^{ND,SA}\right)^{1-\sigma} \left(C_{t+1}^{ND,SF}\right)^{\sigma} \right]^{\tau} \right) \left[\frac{Q_t}{P_{t+1}}(1+i_t) - \frac{Q_{t+1}}{P_{t+1}} \right] \right\} \tag{7}$$

Equation (7) is the core of our small model to explain the origins of seasonality in house prices. The idea is to allow for seasonal shocks in non-durables consumption. This could be justified by seasonal weather conditions or customs. Note that in our model this is the only source of seasonality. It is then argued that via the optimality condition seasonality might spread to house prices as an optimal response *ceteris paribus* to seasonal shocks to non-durables consumption.[5] Consider a seasonal shock to C_{t+1}. To make (7) hold in not-seasonally adjusted terms either of H_t, Q_t, P_t or i_t has to react. The intuition for a rise in Q_t is that since marginal utility of non-durables consumption falls, Q_t must rise to keep the agent from consuming more of H_t. Alternatively, if the supply of housing is relatively inelastic, higher demand for H_t increases Q_t.

[4] Replacing the housing stock to its original level avoids the need to take into account further periods into the future. In addition, we abstract from the issue of lumpy adjustment in the choice of housing.

[5] An implication would be that since seasonality in house prices is an optimal response to seasonal shock in non-durables consumption, it is not arbitraged away.

Note that, of course, we do not suggest that the small amount of seasonality that is observed in non-durables consumption such as e.g. fruit or vegetables is able to explain the entire quite sizeable seasonal pattern in a durable good such as housing. Rather our model offers a theoretical justification for a crucial assumption of search and matching models of the housing market such as Ngai and Tenreyro's (2009), namely some amount of seasonality in house prices in the first place. These models focus on amplification mechanisms that produce large seasonal swings in house prices *assuming* a given small amount of "natural" seasonality in house prices. Our contribution is to endogenize this small amount of seasonality in house prices without resorting to ad hoc assumptions. Therefore our approach is fully consistent with an amplification mechanism à la Ngai and Tenreyro (2009).

5 Empirical model and results

In order to shed light on the partial effects of each variable in response to a seasonal shock linearise (7) to obtain

$$\begin{aligned} q_t &= \frac{d}{\rho} + \frac{\rho-1}{\rho} E_t q_{t+1} - \tilde{i} - \frac{\gamma}{\rho} h_t + \frac{1}{\rho} E_t p_{t+1} \\ &+ \frac{\alpha}{\rho}(1-\tau) c_{t+1}^{D,NSA} + \frac{\alpha}{\rho}\tau(1-\sigma) E_t c_{t+1}^{ND,SA} + \frac{\alpha}{\rho}\tau\sigma E_t c_{t+1}^{ND,SF}{}_t \end{aligned} \tag{8}$$

where lower case letters denote logs of upper case letters.[6] Writing (8) as an estimation equation results in

$$q_t = \varphi_0 + \varphi_1 E_t q_{t+1} - \varphi_2 \tilde{i} - \varphi_3 h_t + \varphi_4 E_t p_{t+1} + \varphi_5 c_{t+1}^{D,NSA} + \varphi_6 E_t c_{t+1}^{ND,SA} + \varphi_7 E_t c_{t+1}^{ND,SF} + \varepsilon_t \tag{9}$$

We estimate this equation using GMM. As instruments we use lags of house prices, interest rate, the housing stock, non-durables prices and non-durables consumption. For lack of any survey data or other data on expected variables for the following

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[6] Furthermore, $\tilde{i}_t = \log(1+i_t)$, $\rho = \frac{1+i_0}{i_0}$, $k = \log i_0 - \frac{1+i_0}{i_0}\tilde{i}_0$, $d = -k - \log\theta - \log\beta + \log\mu$, $b = \log\beta$

quarter we resort to plugging in the lead of the realized variable. This could be interpreted as a model of rational expectations. We estimate (9) on quarterly data for both the US and the UK.[7] Sample sizes are rather small due to data limitations on non-seasonally adjusted data on consumption for the US. There are 53 observations for each country. Since most of the series contain a unit root according to standard ADF-tests, the estimation is done in first differences.[8]

Table 2 presents the results from the estimation. The lag length of the instruments was determined on the basis of the F-tests for explanatory power for the endogenous regressors. Most importantly, for both the US and the UK, the seasonal factor of non-durables consumption has the predicted positive impact on house prices. It is estimated in both cases significantly, with its absolute value being more than three times larger for the US than the UK. This is consistent with the simple model presented in the previous section and lends support to the hypothesis that there might be a spill-over effect from seasonality in non-durables (non-housing) consumption to house prices.

Again we would like to emphasize that the model should be considered as a reduced form approach to modelling the spill-over from seasonality in non-durables consumption to house prices. In particular, we do not explicitly model the search and matching process of purchasing a house. Instead we acknowledge that it is likely to be implicit in the structure of our model and focus on working out the relationship between seasonality in the prices of housing and non-durables consumption. Therefore the coefficients on the seasonal factor of non-durables consumption are likely to partly reflect an inherent amplification mechanism, which is not modelled.

Moreover, for both the US and the UK, some of the remaining coefficients do not have the expected sign although their significance levels are satisfactory throughout. In particular for the UK, the interest rate, the housing stock and the one-period lead of non-housing price carry the "wrong" sign. This might also be due to the reduced form approach employed. The expectations on the signs of the coefficients depend on the exact formulation of a potential amplification mechanism. Therefore more importance should be placed on the significance levels than on the actual values of the coefficients. Finally, the p-values of the J-statistic for overidentifying restrictions are

[7] For a description of the data see appendix.
[8] For consistency, the seasonal factor in non-durables consumption was differenced once too.

very high pointing to sufficiently low correlation between the error terms and the instruments. The results for the US are similar.

Table 2: Estimation results of equation (9)

	US	UK
	Sample period	
	1991Q1 – 2004Q4	1996Q1 - 2008Q4
	Coefficients	
c	0.01***	-0.02**
	(7.4)	(-2.46)
$\Delta E_t q_{t+1}$	1.12***	0.57***
	(24.82)	(6.65)
Δh_t	0.72***	13.32***
	(6.22)	(4.58)
Δi_t	0.03***	0.43***
	(7.77)	(9.97)
$\Delta E_t p_{t+1}$	-1.09***	-1.83***
	(-11.97)	(-4.66)
$\Delta E_t c_{t+1}{}^{D,NSA}$	-0.31***	0.05**
	(-26.38)	(2.54)
$\Delta E_t c_{t+1}{}^{ND,SA}$	-0.20***	0.59*
	(-2.88)	(1.87)
$\Delta E_t c_{t+1}{}^{ND,SF}$	0.31***	0.07*
	(25.55)	(1.82)
Instruments	$q_{t-1}, \ldots, q_{t-5}$	$q_{t-1}, \ldots, q_{t-4}$
	$i_t, \ldots, i_{t-5}$	$i_t, \ldots, i_{t-4}$
	$hp_{t-1}, \ldots, hp_{t-5}$	$hp_{t-1}, \ldots, hp_{t-4}$
	$p_{t-1}, \ldots, p_{t-5}$	$p_{t-1}, \ldots, p_{t-4}$
	$c_{t-1}{}^{ND, SA}, \ldots, c_{t-5}{}^{ND, SA}$	$c_{t-1}{}^{ND, SA}, \ldots, c_{t-5}{}^{ND, SA}$
	$c_{t-1}{}^{D,NSA}, \ldots, c_{t-5}{}^{D,NSA}$	$c_{t-1}{}^{D,NSA}, \ldots, c_{t-5}{}^{D,NSA}$
	F-statistic (p-value)	
$\Delta E_t q_{t+1}$	14.9 (0.00)	2.7 (0.00)
Δh_t	6.4 (0.00)	21.6 (0.00)
Δi_t	2.6 (0.02)	1.9 (0.03)
$\Delta E_t p_{t+1}$	1.4 (0.21)	6.3 (0.00)
$\Delta E_t c_{t+1}{}^{D,NSA}$	10.9 (0.00)	25.9 (0.00)
$\Delta E_t c_{t+1}{}^{ND,SA}$	1.6 (0.16)	0.9 (0.61)
	p-value J-statistic	
	0.90	0.75

Note: ***/**/* denote significance at the 1%/5%/10%-percent level. T-values in parentheses. A constant was included in the first stage regression.

Caveats on the estimation results relate to the correlation between the instruments and the instrumented variable. Indeed, the p-values for the F-test of explanatory power of the instruments for the lead of non-durables consumption is beyond the 10%-threshold. The same holds for the p-value of for the non-housing price variable. Moreover, there might be a problem of weak instruments since the F-statistics of the instruments for the housing stock, the interest rate, and the non-housing price variable and non-durables consumption are lower than ten for the US. For the UK, the power of the instruments for the expected house price, the interest rate, the non-housing price and non-durables consumption might not be sufficient. Another reason for caution might be the time of recording house prices (which is the date of loan approval in the UK, up to six weeks before the actual transaction; see Wood, 2005). Also in both estimations the housing stock is an interpolated variable over a two year period. More accurate measures of the housing stock might improve the results.

Nonetheless, the simple setup of dynamic optimisation goes some way in accounting for seasonality in house prices. As such it can serve as a useful ingredient for more elaborate models of the dynamics on the housing market.

6 Conclusions

In this paper we have documented seasonal patterns in house prices and have offered a way to endogenize these within a simple model of optimal consumption. It turns out that, in the model, seasonality in house prices is an equilibrium phenomenon. As such it provides an important element to be used in more elaborate models of amplification mechanisms in housing markets. The core of the explanation relates non-durables consumption to durables consumption via one of the first-order conditions resulting from an intertemporal utility maximisation exercise. In this way we are able to introduce a plausible source of seasonality into non-durables consumption. This is the main contribution to the existing literature, which so far has relied on much less credible assumptions about the root of seasonality in house prices. We take the model to the data using US and UK time-series in GMM estimation. The data confirm the hypothesis that within a reduced form approach seasonal shocks to non-durables consumption have an effect on house prices both in the UK and the US. Overall, however, while there are certain caveats with regard to measurement and estimation issues, the simple benchmark model goes some way in explaining observed seasonality in house prices in the US and the UK. As such it can serve as a useful reference point in more elaborate theoretical models of housing price seasonality.

7 Appendix

Table 3: Data definitions and sources

	US	UK
Sample period	1991Q1 – 2004Q4	1996Q1 - 2008Q4
House price	FHFA (formerly OFHEO) house price index, non-seasonally adjusted	Halifax house price index, non-seasonally adjusted
Housing stock	Bi-annual data from the American Housing Survey. Interpolated linearly.	UK National Statistics
Interest rate	10year treasury constant maturity yield from the St. Louis Fed	10year nominal yield curve spot rate from the Bank of England
Price non-durables consumption	Bureau of Labour Statistics	UK National Statistics
Non-durables consumption	Bureau of Labour Statistics	UK National Statistics

Non-durables consumption was seasonally adjusted and the seasonally factors extracted using the ARIMA-X12 method used by the U.S. Census Bureau.

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