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User costs of housing when households face a credit constraint – evidence for Germany

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Abstract

We develop a formula for user costs of housing on the basis of a neoclassical approach to housing investment which does not impose a perfect capital market assumption. We suggest that the definition for the user costs of housing should be extended by an additional term which mirrors the credit constraints a household would be faced with. This extension term consists of the inflation gap between consumer and house price inflation multiplied with an average loan-to-value ratio and the real house prices. The empirical relevance of our finding is confirmed by a VECM. A time series for the user costs of housing is calculated using this extended definition.

Keywords: Housing investments, user costs of housing, cointegration

JEL classification: C32, E13, E22.

Non-technical summary

The housing market plays an important role in an economy for several reasons. Among others, housing investment contributes to the overall aggregate demand. For this reason, we will take a closer look at the determinants of private housing investment. We consider the user costs of housing to be one of the key determinants in this context. This study focuses on Germany because this economy seems to have specific peculiarities.

The paper starts with a derivation of user costs of housing. In contrast to other approaches, we take a credit constraint into account. This credit constraint could be interpreted as the limited ability to raise funds for housing investment. We therefore differentiate between two types of liquid funds. The first one is restricted to the amount of housing serving as security. This kind of loan could be interpreted as a mortgage loan which can be used to finance housing investment up to a certain threshold. The second kind of funds helps fill the financing gap and may contain unsecured loans. We suggest that the interest rate for the mortgage loan is lower than for the unsecured one. As a consequence, the household will, where possible, finance housing through a mortgage loan. This altered derivation of user costs of housing results in an extended definition including an additional term in comparison to the classical one.

In the empirical part of the paper we use econometric techniques to evaluate the additional value of the extended user costs concept. In contrast to the classical definition, the extended user costs can help to reveal a long-run equilibrium relation between housing investment, financial net wealth, disposable income as well as the extended user costs of housing. By estimating an average loan-to-value ratio, we can calculate a time series for the extended user costs, and compare it to the one derived from the standard definition.

Nicht technische Zusammenfassung

Der Häusermarkt nimmt in einer Volkswirtschaft aus mehreren Gründen eine besondere Rolle ein. Unter anderem sind die Investitionen in Immobilien Teil der aggregierte Nachfrage. Im Mittelpunkt der Betrachtungen liegen im Folgenden die Investitionen privater Haushalte in Wohneigentum. Diese werden aus unserer Sicht maßgeblich von den Nutzungskosten des Wohneigentums geprägt. Da die Besonderheiten unterschiedlicher Länder berücksichtigt werden müssen, liegt der Fokus im weiteren Verlauf auf Deutschland.

Der vorliegende Beitrag befasst sich zunächst mit der Ableitung der Nutzungskosten des Wohneigentums. Im Unterschied zu anderen Studien werden die Auswirkungen einer Kreditrestriktion auf diese zentrale Größe untersucht. Diese Restriktion kann dahingehend interpretiert werden, dass Haushalte nur in begrenztem Umfang Immobilienkredite in Anspruch nehmen können. Aus diesem Grund werden zwei Arten von Finanzierungsmöglichkeiten in dem modelltheoretischen Ansatz unterschieden. Zum einen können Haushalte Mittel in Anspruch nehmen, die als Hypothekarkredite verstanden werden können. Deren maximaler Anteil hängt vom Wert des zu finanzierenden und damit als Sicherheit zur Verfügung stehenden Wohneigentums ab. Zum anderen existiert eine Kreditfazilität, die eine hieraus entstehende Finanzierungslücke deckt. Annahmegemäß geht die erste Finanzierungsmöglichkeit mit niedrigeren Finanzierungskosten einher, so dass der Haushalt diese Mittel in größtmöglichem Umfang ausschöpft. Das Modell liefert in diesem Fall eine um einen zusätzlichen Term erweiterte Definition der Nutzungskosten, die unter anderem von dem durchschnittlichen Beleihungswert determiniert wird.

Anschließend wird die empirische Relevanz dieser erweiterten Nutzungskosten für die Investitionen der privaten Haushalte in Wohneigentum analysiert. Dabei zeigt sich, dass eine langfristige Gleichgewichtsbeziehung zwischen den Investitionen in Wohneigentum, dem finanziellen Vermögen, dem verfügbaren Einkommen und den erweiterten Nutzungskosten existiert. Durch die Schätzung einer durchschnittlichen Beleihungsgrenze kann eine Zeitreihe für diese Nutzungskosten berechnet und dem Konzept ohne Kreditrestriktion gegenübergestellt werden.

Contents

List of Figures

List of Tables

User Costs of Housing when Households face a Credit Constraint - Evidence for Germany

1 Introduction

The housing market plays an important role in an economy in several respects. In accordance with the ECB (2003), three key reasons can be mentioned. First, housing is one of the main parts of the private sector's net wealth. Households' behavior may have serious impacts on aggregate demand. In the literature - see Bundesbank (2007) or Campbell and Cocco (2005), for instance - effects of aggregate housing on aggregate consumption are supposed to exist especially when wealth effects are permanent. Strong correlations between the two variables, as are found by Case et al (2001), support these findings. Second, house price bubbles, as have occurred in some countries, play a major role in financial stability and monetary transmission. Third, the housing market with its high transaction costs and non-portable housing-related benefits has an implication for labor mobility, and thus for the supply side of an economy. Moreover, the IMF (2008) postulates that monetary policy should take developments in the housing market explicitly into account, since, due to innovations, the influence of the housing sector on the economy has increased.

We focus on a key concept - the user costs of housing - to gain further insights. The concept of the user costs is crucial for modeling investment behavior. A classical derivation can be found in Jorgenson (1963). Dougherty and Van Order (1982) applied the concept to housing investment decisions and derived a measure of user costs of housing in a neoclassical environment. Nevertheless, this approach can be enlarged by lifting the perfect capital market assumption. Hence, in our approach the household can only partly finance housing investment by a mortgage; the remainder has to be financed by other liquid funds which imply higher expenditures. This change in assumption is reflected by an extended definition of the user costs of housing. The resulting expression consists partly of a term which is equal to the user costs of housing measure derived by Dougherty and Van Order (1982) - it will be denoted below as the classical definition of user costs - but is also enlarged by an addition term. This additional term consists of the real house prices,

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an average loan-to-value-ratio, and an inflation gap defined as the difference between the changes in consumer prices and house prices respectively.

Since explicit account has to be taken of country-specific peculiarities, we focus on Germany.[1] The sample starts in the first quarter of 1980 and ends in the fourth quarter of 2007. Using the Johansen procedure, we find one cointegrating relationship between the variables under consideration, i.e. households' investments in housing, disposable income, net financial wealth, and user costs of housing including the extension term. The estimation of the cointegrating relationship can be interpreted as a long-run equilibrium relationship of housing investment due to a credit constraint. Estimating a full Vector Error Correction Model (VECM), we find that user costs are weakly exogenous. In addition, a likelihood-ratio (LR) test suggests that the extension is present in the user costs expression. An average loan-to-value ratio for German households can be derived from VECM estimates. Using this estimated value, we calculate and show time series for the German user costs of housing.

The remainder of the paper is organized as follows. In Section 2 we set up a theoretical model within a neoclassical framework in order to derive user costs of housing. In Section 3 econometric analyses are carried out in order to evaluate the relevance of our theoretical derivation. Section 4 gives a summary of the key findings and some final conclusions. In Appendix A the dataset for the empirical part is described.

2 Theoretical model

Extending the neoclassical approach of Dougherty and Van Order (1982), a theoretical framework is derived containing a credit constraint relevant to the representative household's decision between non-durable consumption and residential investment. This results in an extended version of the user costs of housing which includes - in addition to the basic expression of user costs of housing - a term depending on the inflation gap between consumer prices and house prices, real house prices, and an average loan-to-value ratio.

The set up of the model

Suppose that the preferences of the representative household are reflected by the instantaneous utility function $u(c_t, h_t)$ with $u' > 0, u'' < 0$ where c_t is the consumption of non-durable goods and h_t is the use of housing services in period t. The use of housing services can be restrained to a quality-adjusted stock of housing. That means that housing services can be seen proportional to the housing stock. The household receives a nominal income flow Y_t and can raise nominal liquid funds through debt expansion $-S_t$. Both can

[1] When comparing, for example, Germany's homeownershiprates or housing investment subsidies (former Article 10e EStG or the *Eigenheimzulage*) - and also the household's overall portfolio behavior - with those of other countries such as France, Italy or the United States, it is possible to note obvious differences perceived in studies published, for instance, in Guiso et al (2002).

be spent on consumption goods C_t, gross housing investment X_t affecting housing stock H_t, or interest payments on debt Z_t. In general, the household faces the budget constraint

$$Y_t - S_t = C_t + X_t + Z_t.$$

The nominal housing stock can be financed either by a mortgage loan M_t or by an unsecured credit B_t. The household has to pay a nominal interest rate $i_{h,t} = i_{r,t} + \pi_{h,t}$ or $i_t = i_{r,t} + \pi_t$ respectively, with a real interest rate $i_{r,t}$. We assume that the consumer price inflation π_t is larger than the house price inflation $\pi_{h,t}$, i.e. $\pi_t > \pi_{h,t}$. A mortgage is covered by housing stock, so that only the share of the nominal housing stock η, with $0 \leq \eta \leq 1$, can be financed by this kind of credit. Since the mortgage is cheaper, the household always takes the maximum available share. Thus we have

$$M_t = \eta H_t \text{ and } B_t = (1 - \eta) H_t.$$

In this context, η can be interpreted as a loan-to-value ratio for real estate mortgages. In analogy with Iacoviello and Minetti (2008), we expect the ratio to be in a range between 60 and 100 percent.

Hence, for the nominal debt expansion we obtain

$$-S_t = M_{t-1} - M_t + B_{t-1} - B_t = H_{t+1} - H_t.$$

According to this, the nominal interest expenditures are given by $Z_t = j_t H_t$ where

$$j_t = [(i_{r,t} + \pi_{h,t})\eta + (i_{r,t} + \pi_t)(1 - \eta)] = i_t - \eta(\pi_t - \pi_{h,t}) \tag{1}$$

is the effective nominal interest rate on household debt as a weighted average of the mortgage rate and the credit rate i_t. An increasing share of mortgage credit implies a decrease in interest expenditures since $\pi_t > \pi_{h,t}$.

In real terms, with a price ratio $q_t = p_{h,t}/p_t$, i.e. the real house prices, we obtain the real housing accumulation, Equation (2), and the real debt expansion, Equation (3):

$$h_{t+1} = (1 - \delta_t) h_t + x_t \tag{2}$$

$$-s_t = h_{t+1}(1 + \pi_{h,t}) - h_t \tag{3}$$

where δ_t is the economic depreciation rate of the housing stock. Economic depreciation consists of technical decay $\tilde{\delta}_t$ as well as capital gains or losses:

$$\delta_t = \tilde{\delta}_t - [\pi_{h,t} - \pi_t].$$

We can express the real budget constraint, i.e. the budget constraint in units of consumer prices as

$$\frac{Y_t}{p_t} - \frac{p_{h,t}}{p_t} s_t = \frac{C_t}{p_t} + \frac{p_{h,t}}{p_t} x_t + j_t \frac{p_{h,t}}{p_{h,t}} \frac{H_t}{p_t}$$

which can be written more compactly as

$$y_t - q_t s_t \quad = \quad c_t + q_t x_t + j_t q_t h_t. \tag{4}$$

The maximization problem of the household
Let us assume that the household maximizes life-time utility represented by a time-separable function, i.e.

$$\max_{c_t, h_{t+1}} \sum_{t=0}^{T} \rho_t^t u(c_t, h_t)$$

with the discount rate $\rho_t = (1 + i_t - \pi_t)^{-1}$ and subject to Equations (2), (3), and (4).

We rewrite the budget constraint as a function of consumer goods and the stock of housing in the current and the next period:

$$\psi(c_t, h_t, h_{t+1}) = y_t - c_t - q_t[x_t + s_t + j_t h_t] = 0.$$

The dynamic Lagrange function

$$L = \sum_{t=0}^{\infty} \rho_t^t u(c_t, h_t) + \lambda \sum_{t=0}^{\infty} \rho_t^t \psi(c_t, h_t, h_{t+1}) \tag{5}$$

yields the following first-order conditions

$$\begin{aligned} \frac{\partial L}{\partial c_t} &= \rho_t^t \frac{\partial u}{\partial c_t} + \lambda \rho_t^t \frac{\partial \psi}{\partial c_t} = 0 \\ \frac{\partial L}{\partial h_{t+1}} &= \rho_t^{t+1} \frac{\partial u}{\partial h_t} + \lambda \rho_t^{t+1} \frac{\partial \psi}{\partial h_t} + \lambda \rho_t^t \frac{\partial \psi}{\partial h_{t+1}} = 0 \end{aligned}$$

which may be written more compactly as

$$u_c + \lambda \psi_{c,t} \quad = \quad 0 \tag{6}$$

$$u_h + \lambda \psi_{h,t} + \lambda \frac{\psi_{h,t+1}}{\rho_t} \quad = \quad 0\,. \tag{7}$$

Optimization implies that consumption of the non-durable goods must be extended up to the point where the marginal rate of utility of consuming goods is equal to the marginal costs of financing consumption. By analogy, consumption of housing services must be extended until the marginal utility of housing services matches the marginal costs of buying an extra unit of housing stock which is the discounted sum of the current and the following period. Combining Equations (6) and (7) leads to

$$\frac{u_h}{u_c} = \frac{\psi_{h,t}}{\psi_{c,t}} + \frac{\psi_{h,t-1}}{\psi_{c,t}\rho_t} \quad . \tag{8}$$

With the partial derivatives of the budget constraint

$$\begin{aligned}\psi_{c,t} &= -1 \\ \psi_{h,t} &= -q_t\left[\frac{\partial x_t}{\partial h_t}+\frac{\partial s_t}{\partial h_t}+j_t\right] = -q_t[j_t+\delta_t] \\ \psi_{h,t+1} &= -q_t\left[\frac{\partial x_t}{\partial h_{t+1}}+\frac{\partial s_t}{\partial h_{t+1}}\right] = -q_t[-\pi_t]\end{aligned}$$

we obtain the following expression for the real user costs of housing:

$$\frac{u_h}{u_c} = \frac{-\,q_t[j_t+\delta_t]}{-1} + \frac{-\,q_t[-\pi_{h,t}]}{-\rho_t} = q_t\left[j_t+\delta_t-\frac{\pi_{h,t}}{\rho_t}\right]. \tag{9}$$

Defining basic and extended versions of the user costs

Using Equation (1) and the approximation $\pi_{h,t}/\rho_t = \pi_{h,t}(1+i_t-\pi_t) \approx \pi_{h,t}$, we can write the equilibrium optimality condition as

$$\frac{u_h}{u_c} = q_t[i_t-\pi_t+\delta_t+(1-\eta)(\pi_t-\pi_{h,t})]. \tag{10}$$

Depending on the share of mortgage loans, i.e. η, user costs of housing ranges between $q_t[i_t-\pi_t+\delta_t]_{\eta=1}$ and $q_t[i_t-\pi_{h,t}+\delta_t]_{\eta=0}$. For $\eta=1$, which means that the full stock of housing can be financed by a mortgage, the user costs of housing collapse to the version presented by Dougherty and Van Order (1982).[2] Therefore, we define the basic user costs UC_t^B relevant to households without a binding credit constraint as

$$UC_t^B = q_t(i_t-\pi_t+\delta_t). \tag{11}$$

In equilibrium, the marginal rate of substitution between consumption of housing services and consumption of the non-durable good is equal to the basic user costs of capital expanded by an extension term. This wedge between the marginal rate of substitution and the basic user costs consists of three factors: The differential between consumer price inflation and house price inflation (inflation gap), the price ratio q, and the average loan-to-value ratio.

We define these extended user costs UC_t as

$$UC_t = (1-\eta)q_t(\pi_t-\pi_{h,t}) + q_t(i_t-\pi_t+\delta_t). \tag{12}$$

[2] For simplicity, the taxation factor included by Dougherty and Van Order (1982) is omitted. For user costs following classical references, see, for example, Jorgenson (1963).

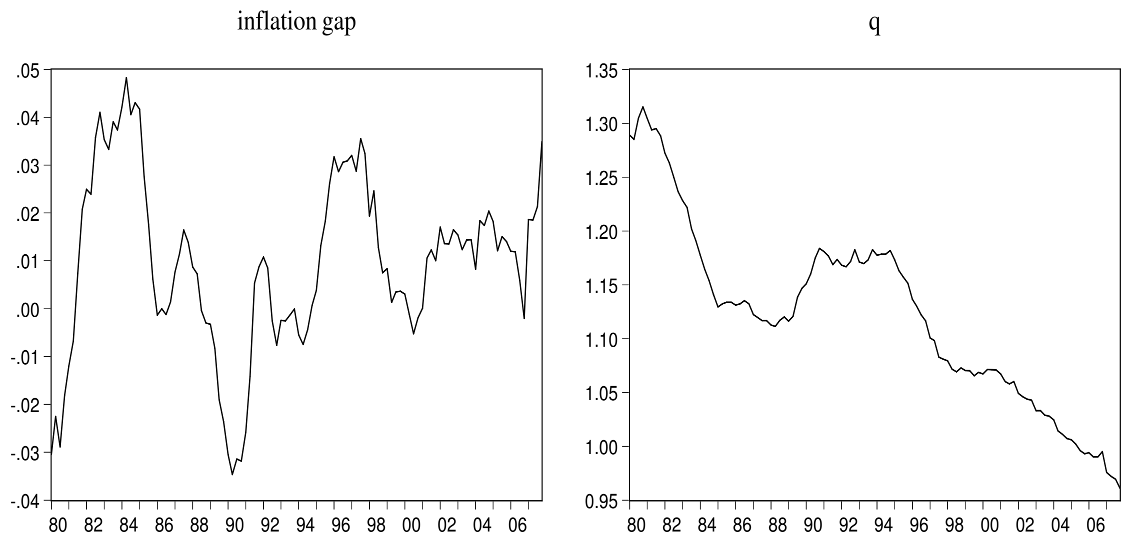
3 Empirical analysis

The theoretical analysis suggests the presence of an extension term in the expression of the user costs of housing that mirrors the credit constraint a household may be faced with. First, we check the general relevance of the extension term by analyzing basic time series properties of the inflation gap between house prices and consumer prices, which is the main time-varying component. Since its mean is shown to be significantly different from zero, the wedge may principally have an effect on housing demand. The second part of this section is therefore devoted to specifying and estimating an econometric model representing residential investment as a function of user costs and other determinants where the impact of the additional term can be tested statistically.

3.1 The relevance of the inflation gap in the user costs of housing

In the theoretical part, two versions of user costs of housing have been described: The basic one UC_t^B and the extended one UC_t; see Equations (11) and (12). The difference between the two expressions is the product of the inflation gap $(\pi_t - \pi_{h,t})$, the real house prices q_t, and the average loan-to-value ratio η. The latter is taken as a constant parameter depending, for instance, on the institutional framework of bank lending to homebuyers. As shown in Figure 1, however, the inflation gap is a rather volatile variable fulfilling the properties of a covariance-stationary series.

Figure 1: Inflation gap $(\pi - \pi_h)$ and real house prices q



Source: Own calculation.

If the inflation gap has a zero mean, i.e. $E(\pi - \pi_h) = 0$, the extended version degenerates to the basic version in the long run. As this case means that the additional term is irrelevant in a long-run perspective even if a credit constraint is binding, it is worth checking in advance whether or not the inflation gap has a non-zero mean. In the sample at hand, mean and median are both 0.9%. In addition, the null hypothesis of zero mean can be rejected at the 1% level. Using Newey-West HAC standard errors and covariance, a t-statistic of 2.70 and a probability of 0.008 are obtained.[3]

The real house prices q_t, as a further component of the extension term, have a negative trend in the sample at hand.

The actual magnitude of the inflation gap's influence on user costs also depends on η. This ratio is expected to be strictly positive since a loan-to-value ratio of zero implies that, irrespective of housing stock pledged as collateral, no loan is available. German banks usually accept a loan-to-value ratio up to 80 percent in standard mortgage contracts.

3.2 A long-run equilibrium relationship for housing demand

We estimate a long-run equilibrium relationship for housing demand. The components of the extended user costs are considered separately. This means that basic user costs and extension term are included as single variables in the model. The key variable in the empirical model is residential investment because the credit constraint is likely to be present when a new dwelling should be financed by mortgages. Under these circumstances, banks usually evaluate the income and wealth position of the household which suggests that the household's disposable income and the value of wealth used as collateral are relevant factors affecting creditworthiness. As a consequence of focusing on residential investment which measures dwellings construction only, the value of assets does not include the building land and other real estate property. Instead, the empirical analysis uses households' financial assets and financial liabilities which are not netted as a precondition.

In sum, we define a vector z_t consisting of six variables. Private residential investment (hi_t), disposable income (di_t), financial assets (fa_t), and liabilities (fl_t) are divided by the number of households and transformed into logs. In addition, the vector include the extension term $q_t(\pi - \pi_h)_t$ and the basic user costs of housing (UC_t^B). In sum, $z_t{}' = \left[\begin{array}{cccccc} hi_t & di_t & fa_t & fl_t & q_t(\pi - \pi_h)_t & UC_t^B \end{array} \right]$. The econometric analysis is carried out for the German economy. The sample starts in the first quarter of 1980 and terminates in the fourth quarter of 2007. Graphical inspection points to a mean shift in some series in the first quarter of 1991 due to Germany's reunification, which is captured by a dummy variable. A detailed description of all time series is found in the Annex. Standard unit root tests indicate that series for hi, di, fa, fl, $q(\pi - \pi_h)$, UC^B can be regarded as I(1)

[3]The sample for our empirical analysis starts in 1980 and ends in 2007. We decided on a sample of 27 years owing to a lack of data as we use expected inflation rates in our empirical analysis derived using the ARIMA approach. See the Annex for details.

processes.[4] These findings are supported by the plots of the series.[5]

Econometric setup

The variables under consideration are modeled jointly, taking them as endogenous in general. Hence, the basic framework is a vector autoregression (VAR). Since the time series are nonstationary, we apply the concept of cointegration and use a vector error correction model (VECM) to reveal the long-run relationships between the variables.[6] The model can be written as

$$\Delta z_t = \Pi z_{t-1} + \sum_{\omega=1}^{\mu-1} \Gamma_\omega \Delta z_{t-\omega} + \kappa D_t + \varepsilon_t$$

where z_t is a set of k given time series variables, μ is the lag order of the underlying VAR, Γ_ω are short-run parameter matrices. Under cointegration, the matrix Π has reduced rank r, $0 < r < k$, and can be written as $\Pi = \alpha\beta'$, where α and β are (k x r) matrices. The residual ε_t is a zero mean white noise process with time-invariant positive definite covariance matrix, κ is a parameter matrix attached to the intercept term and an impulse dummy variable $I(91:1)$ to control for German reunification in the first quarter of 1991; i.e. $D_t = [c, I(91:1)]$. $I(91:1)$ is unity in the first quarter of 1991 and zero otherwise. The matrix β collects the cointegrating vectors of the system. Thus $\beta' z_t \sim$ I(0) can be interpreted as long-run equilibrium relationships.[7]

For specifying the VECM, the lag order μ and the cointegration rank r have to be determined first.

Determining the lag order

We follow the conventional practice of choosing the lag order μ by fitting unrestricted VAR(μ) models in levels for the set of lag orders μ=0,1,2,...,μ_{max}, where μ_{max}=8 in this application. The estimator selected is of the order μ, which minimizes standard information criteria AIC, SC and HQ, following Akaike (1969, 1971) (AIC), Schwarz (1978) (SC), and Hannan and Quinn (1979) (HQ). The results are presented in Table (1).

Unfortunately, the three criteria do not come up with a unique suggestion. Instead, the chosen lag orders range from μ=3 (AIC) to μ=1 (SC). As a further check, we perform residual autocorrelation tests in the VAR(μ), μ=1 to 4. Results are reported in Table (2). The hypotheses of no serial correlation of order $\lambda = 1, 2, ..., 6$ for the VAR models with $\mu = 1, 2$ are mostly rejected at the 5% level. Due to the autocorrelation properties of residuals, we therefore disregard the choices of the SC ($\mu = 1$) and HQ ($\mu = 2$) infor-

[4] The results are reported in the Annex. For an overview of non-stationary time series, see Stock and Watson (1988), for instance.

[5] See Figures 3 and 5.

[6] The concept of cointegration accounts for the observation that I(1) series may be interrelated in a way that linear combinations between them are stationary. The reason for this is that cointegrated series share common (stochastic) trend factors. These processes were introduced by Granger (1981) and Engle and Granger (1987).

[7] For a more detailed discussion of VECMs as well as proofs etc., see, for example, Lütkepohl (2007).

mation criteria. By contrast, the residual autocorrelation properties from the VAR(3) and especially from the VAR(4) model are much better: The absence of serial autocorrelation cannot be rejected at all orders $\lambda = 1, 2, ..., 6$. As the lag orders $\mu = 3$ and $\mu = 4$ (in levels) have adequate autocorrelation properties, we show all further steps for both lag orders, which implies considering VECMs with two and three lags of the variables in first differences in the analysis that follows.

Table 1: VAR lag order selection

Lag	AIC	SC	HQ
0	-22.553	-22.248	-22.429
1	-39.663	-38.442*	-39.169
2	-40.537	-38.402	-39.672*
3	-40.571*	-37.520	-39.335
4	-40.469	-36.502	-38.862
5	-40.355	-35.473	-38.377
6	-40.261	-34.464	-37.913
7	-40.158	-33.445	-37.438
8	-40.255	-32.627	-37.165

* indicates lag order selected by the criterion.

Table 2: VAR(μ) residual serial correlation LM tests

Lag order	$\mu = 1$ (SC)		$\mu = 2$ (HQ)		$\mu = 3$ (AIC)		$\mu = 4$	
λ	LM-Stat.	Prob.	LM-Stat.	Prob.	LM-Stat.	Prob.	LM-Stat.	Prob.
1	110.66	0.00	87.66	0.00	38.39	0.36	41.90	0.23
2	75.57	0.00	64.35	0.00	46.62	0.11	41.83	0.23
3	42.39	0.21	44.97	0.15	42.06	0.23	29.51	0.77
4	41.72	0.24	35.60	0.49	41.99	0.23	38.41	0.36
5	52.99	0.03	47.26	0.10	48.78	0.08	40.22	0.29
6	42.86	0.20	41.17	0.25	34.08	0.56	31.06	0.70

H_0 : no serial correlation at lag order λ.
Probabilities from $\chi^2(36)$.

Determining the cointegration rank

Conditional on $\mu = 3$ and 4, we test for the cointegration rank using the procedure proposed by Johansen (1995). As we do not assume the inclusion of a deterministic trend restricted to the cointegrating space, the maximum number of cointegrating equations to be tested is 4. According to the results of the Johansen test, we conclude that there is exactly one cointegrating relation between the I(1) variables.

Table 3: Test for the cointegration rank

Johansen Trace Test

Cointegration rank r	LR-statistic $\mu = 3$	LR-statistic $\mu = 4$	0.10 critical value	0.05 critical value	0.01 critical value
$r = 0$	107.58**	106.55**	89.48	94.15	103.18
$r \leq 1$	63.58	64.49	64.84	68.52	76.07
$r \leq 2$	35.28	37.33	43.95	47.21	54.46
$r \leq 3$	16.63	20.06	26.79	29.68	35.65
$r \leq 4$	3.88	3.76	13.33	15.41	20.04

Johansen trace test indicates 1 cointegrating equation at the 0.01 level. ** denotes rejection of the hypothesis at the 0.01 level. Critical values are drawn from Osterwald-Lenum (1992). We correct the Johansen LR-statistic to avoid over-rejection of the null hypothesis, as suggested in Banerjee et al (1993).

The resulting reduced rank regression of the VECM(3), without imposing restrictions on the cointegrating space, yields the cointegrating relation[8]

$$\hat{\beta}' z_t = hi_t \underset{(2.187)}{-0.305}\, di_t \underset{(0.929)}{-0.483}\, fa_t \underset{(0.564)}{+0.750}\, fl_t \underset{(2.297)}{+4.585}\, q_t(\pi - \pi_h)_t \underset{(2.282)}{+12.235}\, UC_t^B$$

and for the VECM(4) the relation

$$\hat{\beta}' z_t = hi_t \underset{(1.991)}{-0.476}\, di_t \underset{(0.881)}{-0.564}\, fa_t \underset{(0.546)}{+0.925}\, fl_t \underset{(2.137)}{+3.969}\, q_t(\pi - \pi_h)_t \underset{(2.167)}{+13.371}\, UC_t^B.$$

The vectors of adjustment parameters are given by

$$\hat{\alpha}_{VECM(3)} = \begin{bmatrix} \underset{(0.012)}{-0.009} \\ \underset{(0.003)}{0.006} \\ \underset{(0.004)}{0.012} \\ \underset{(0.003)}{0.019} \\ \underset{(0.002)}{-0.004} \\ \underset{(0.001)}{-0.004} \end{bmatrix} \qquad \hat{\alpha}_{VECM(4)} = \begin{bmatrix} \underset{(0.013)}{-0.014} \\ \underset{(0.003)}{0.010} \\ \underset{(0.004)}{0.014} \\ \underset{(0.002)}{0.021} \\ \underset{(0.002)}{-0.003} \\ \underset{(0.002)}{-0.003} \end{bmatrix} \qquad \begin{matrix} hi_t \\ di_t \\ fa_t \\ fl_t \\ q_t(\pi - \pi_h)_t \\ UC_t^B. \end{matrix}$$

[8]Standard errors are given in parentheses. To the right of the estimated adjustment parameter matrix, we indicate to which left-hand-side variable the corresponding row of $\hat{\alpha}$ belongs. For the procedure computing standard errors for the cointegrating vector, see Boswijk (1995).

In general, we define $\hat{\beta}' z_t = b_0 hi_t + b_1 di_t + b_2 fa_t + b_3 fl_t + b_4 q_t(\pi - \pi_h)_t + b_5 UC_t^B$ and $\hat{\alpha}' = \begin{bmatrix} a_0 & a_1 & a_2 & a_3 & a_4 & a_5 \end{bmatrix}$ accordingly.

Standard errors of estimated coefficients of the cointegrating vector are relatively high in some cases. In particular, this applies to disposable income, financial assets and financial liabilities which are variables included to capture the presence of a credit constraint. On the one hand, the exclusion of this set of variables cannot be rejected on the basis of an LR test as the corresponding statistic is 1.44 for the VECM(3) and 4.04 for the VECM(4), which implies marginal significance levels of 0.258 and 0.697, respectively, taken from asymptotic $\chi^2(3)$ distribution. On the other hand, a test for cointegration in the reduced system does not provide evidence for the presence of cointegration between the remaining variables hi_t, $q_t(\pi - \pi_h)_t$ and UC_t^B; see Table (4) for the results of the corresponding Johansen test. We therefore proceed with the analysis in the full model, taking the sometimes large standard errors as an indication of a great deal of estimation imprecision which might be due to the relatively low degrees of freedom. This problem can be resolved, at least to some extent, by imposing restrictions and thus reducing the set of parameters to be estimated. The theoretical analysis gives us some hints on how to follow these strategies.

Table 4: Test for the cointegration rank II between the variables hi_t, $q_t(\pi - \pi_h)_t$ and UC_t^B

Johansen Trace Test

Cointegration rank r	LR-statistic $\mu = 3$	LR-statistic $\mu = 4$	0.10 critical value	0.05 critical value	0.01 critical value
$r = 0$	25.93	21.46	26.79	29.69	35.65
$r \leq 1$	4.25	4.02	13.33	15.41	20.04

Johansen trace test indicates no cointegrating equation at the 0.10 level. Deterministic assumptions and lag order remained unchanged. Critical values for the Johansen trace test are drawn from Osterwald-Lenum (1992). We correct the Johansen LR-statistic to avoid over-rejection of the null hypothesis, as suggested in Banerjee et al (1993).

Hypothesis tests

Let us now reconsider the full model. Regarding possible restrictions imposed on the cointegrating space, we first check the net wealth condition. Because net financial wealth is computed as the difference between financial assets and liabilities, the estimated coefficient should be equal in absolute value. An LR test of this hypothesis $H_0 : b_2 = -b_3$ is not rejected by the data. Furthermore, we assume that extended user costs are weakly exogenous.[9] An LR test of the hypothesis $H_0 : a_5 = a_6 = 0$ indicates that the restriction is not rejected. The hypothesis $H_0 : b_2 = -b_3; a_5 = a_6 = 0$, i.e. testing for joint restrictions on β and α, is not rejected by an LR test either.

[9] See Johansen (1995) for the definition and implications of weak exogenity.

Table 5: LR Tests for binding restrictions on β and α

Test description		VECM(3)		VECM(4)	
Restriction imposed on β and α	*df*	$\chi^2(df)$	Prob.	$\chi^2(df)$	Prob.
Net wealth condition; $b_2 = -b_3$	1	0.054	0.816	0.119	0.730
Weak exogenity of UC; $a_5 = a_6 = 0$	2	5.004	0.082	3.848	0.146
Joint restriction; $b_2 = -b_3$; $a_5 = a_6 = 0$	3	5.053	0.168	4.215	0.239
No long-run impact of $q(\pi - \pi_h)$; $b_4 = 0$	1	3.910	0.048*	4.963	0.026*
No long-run impact of UC^B; $b_5 = 0$	1	11.972	0.001*	17.779	0.000*
No long-run impact of UC; $b_4 = b_5 = 0$	2	16.935	0.000*	22.353	0.000*

* denotes rejection of the hypothesis at the 0.05 level.
df: degree of freedom.

As the extension term $q(\pi - \pi_h)$ in the definition for the user costs of housing is the new additional element, we test for the relevance of this term within the estimated VECMs. The hypothesis is $H_0 : b_4 = 0$. We also test the hypotheses $H_0 : b_5 = 0$ and $H_0 : b_4 = b_5 = 0$ within our model, i.e. testing the relevance of the basic user costs term UC^B (and the extended user costs UC, respectively) within the VECMs. We can reject all hypotheses of no impact of user costs variables at the 5% level. According to these results, the impact of the extension term on household investment cannot be denied.

Estimating the parameters of the cointegrating space

As mentioned, the vector to be modeled is defined so that $z_t{}' = \left[\begin{array}{cccccc} hi_t & di_t & fa_t & fl_t & q_t(\pi - \pi_h)_t & UC_t^B \end{array}\right]$. The identification scheme for the cointegrating matrix β was described above, which is also true of the zero restrictions imposed on the adjustment parameter matrix α.

The cointegrating relation of the VECM(3) is given by[10]

$$\hat{\beta}' z_t = hi_t \underset{(0.204)}{-0.214}\, di_t \underset{(0.323)}{-0.410}\, fa_t \underset{(0.323)}{+0.410}\, fl_t \underset{(1.188)}{+2.319}\, q_t(\pi - \pi_h)_t \underset{(1.198)}{+4.941}\, UC_t^B$$

and for the VECM(4) by

$$\hat{\beta}' z_t = hi_t \underset{(0.228)}{-0.080}\, di_t \underset{(0.378)}{-0.548}\, fa_t \underset{(0.378)}{+0.548}\, fl_t \underset{(1.330)}{+2.211}\, (\pi - \pi_h)_t \underset{(1.380)}{+6.590}\, UC_t^B.$$

[10] Standard errors are given in parentheses. To the right of the estimated adjustment parameter matrix, we indicate to which left-hand-side variable the corresponding row of $\hat{\alpha}$ belongs. For the procedure computing standard errors for the cointegrating vector, see Boswijk (1995).

The vectors of adjustment parameters are given by

$$\hat{\alpha}_{VECM(3)} = \begin{bmatrix} \underset{(0.019)}{-0.029} \\ \underset{(0.005)}{0.005} \\ \underset{(0.007)}{0.022} \\ \underset{(0.004)}{0.036} \\ 0.000 \\ 0.000 \end{bmatrix} \qquad \hat{\alpha}_{VECM(4)} = \begin{bmatrix} \underset{(0.020)}{-0.032} \\ \underset{(0.005)}{0.013} \\ \underset{(0.007)}{0.025} \\ \underset{(0.004)}{0.037} \\ 0.000 \\ 0.000 \end{bmatrix} \qquad \begin{matrix} hi_t \\ di_t \\ fa_t \\ fl_t \\ q_t(\pi - \pi_h)_t \\ UC_t^B. \end{matrix}$$

Insights from estimated cointegrating vector β
Using $nw_t = fa_t - fl_t$ and rearranging terms with regard to the user cost expression yields the following long-run equilibrium relationships.[11]

	VECM(3)		VECM(4)
	household investments hi_t		household investments hi_t
-	0.21 disposable income di_t	-	0.08 disposable income di_t
-	0.41 net wealth nw_t	-	0.55 net wealth nw_t
+	$4.94 * [0.47 * q_t(\pi - \pi_h)_t + UC_t^B]$	+	$6.59 * [0.34 * q_t(\pi - \pi_h)_t + UC_t^B]$
$\sim$ I(0)		$\sim$ I(0)	

Since the extended user costs are defined in Equation (12) as

$$UC_t = (1 - \eta) * q_t(\pi - \pi_h)_t + UC_t^B$$

the loan-to-value ratio is estimated to be $\hat{\eta} = 0.53$ in the VECM(3) and $\hat{\eta} = 0.66$ in the VECM(4), respectively. The estimate is roughly in line with our prior value in the range between 60% and 100% that is usually required by German banks in housing finance.

Looking at the partial effects of income, wealth and extended user costs, it can be seen that they are consistent with intuition:

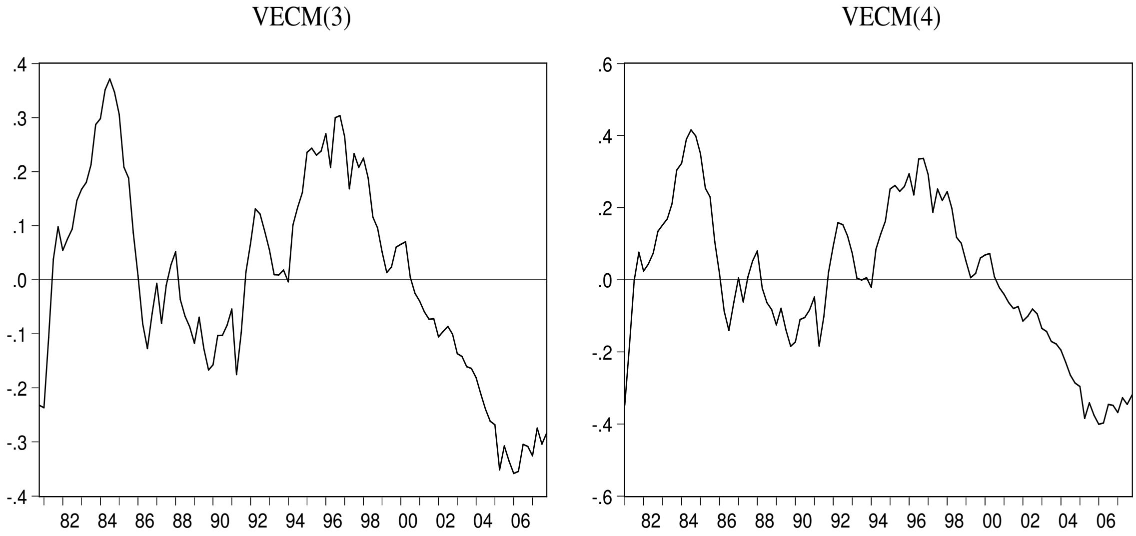
$$\frac{\partial hi}{\partial di} > 0, \; \frac{\partial hi}{\partial nw} > 0, \; \frac{\partial hi}{\partial UC^B} < 0 \text{ and } \frac{\partial hi}{\partial UC} < 0.$$

In Figure 2, the long-run residual series resulting from the estimated cointegrating relations are plotted. Over the last 27 years, investment in housing stock deviates from the long-run equilibrium reflecting the income and wealth conditions from German households. These developments might be explained by changes in the nature and strength of government

[11] See also Johansen (2002) for remarks on the interpretation of the cointegrating vector.

interventions in the housing market. For instance, after German reunification in 1991, there was a boom in some segments, and substantially so in residential construction, which was driven by strong stimuli created by economic policy. The stepwise reduction of the rather expansionary fiscal policy stance in this market segment has led to less investment in housing compared with the equilibrium, especially in view of the fact that the exaggerations in dwellings construction in the first half of the 1990s resulted in an excess supply in many regions, especially in eastern Germany.

Figure 2: Cointegrating relations



Source: Own calculation.

Diagnostic checks - break tests and residual checks

The estimated systems are checked for a possible mean shift of the cointegrating relations in the first quarter of 1991 due to German reunification. Therefore, a shift dummy is included in the cointegration vectors, and a LR test for binding restriction is used to decide whether the dummy is to be included or not. From $\chi^2(1)$ distribution, a value of 0.058 is obtained for the VECM(3), i.e. the probability of this result under the null is 0.810. For the VECM(4) a value of 0.002 is obtained and, thus, the probability under the null is 0.964. The hypotheses of no level shift in the first quarter of 1991 cannot be rejected at a 5% level, i.e. no break in mean has to be included in the VECMs.

To substantiate that the models are well-specified, some diagnostic checks on the VECMs residuals are performed. In the following tables, standard diagnostic checks on residual series are reported. These include serial correlation LM tests, normality tests, and White heteroskedasticity tests.[12]

Table 6: VEC residual serial correlation LM tests

	VECM(3)		VECM(4)	
Lag order	LM-Statistic	Probability	LM-Statistic	Probability
1	59.965	0.007	42.433	0.213
2	38.331	0.364	45.122	0.142
3	37.900	0.383	38.229	0.369
4	45.528	0.133	29.130	0.785
5	39.505	0.316	35.917	0.473
6	32.318	0.644	24.439	0.928

H_0 : no serial correlation at lag order h.
Probabilities from $\chi^2(36)$.

Table 7: VEC residual heteroscedasticity and normality tests

	VECM(3)		VECM(4)	
	$\chi^2(df)$	Probability	$\chi^2(df)$	Probability
Heteroscedasticity test	535.791	0.822	752.840	0.952
Normality tests				
Skewness	5.717	0.456	4.884	0.559
Kurtosis	1.226	0.976	8.537	0.201
Jarque-Bera	6.943	0.861	13.421	0.339

heteroscedasticity test: H_0 : no heteroscedasticity
normality tests: H_0 : residuals are multivariate normal

Serial correlation is absent in the residual series of the VECM(4). For the VECM(3) we cannot reject autocorrelation of residuals. Normality tests for both VECMs show that residuals can be regarded as being drawn from a normal distribution. Heteroskedasticity tests do not indicate problems either. On the basis of the results of the VECM serial correlation tests of residuals, we decide to use the VECM(4) as our preferred model. Section 3.3 therefore refers only to the results from VECM(4).

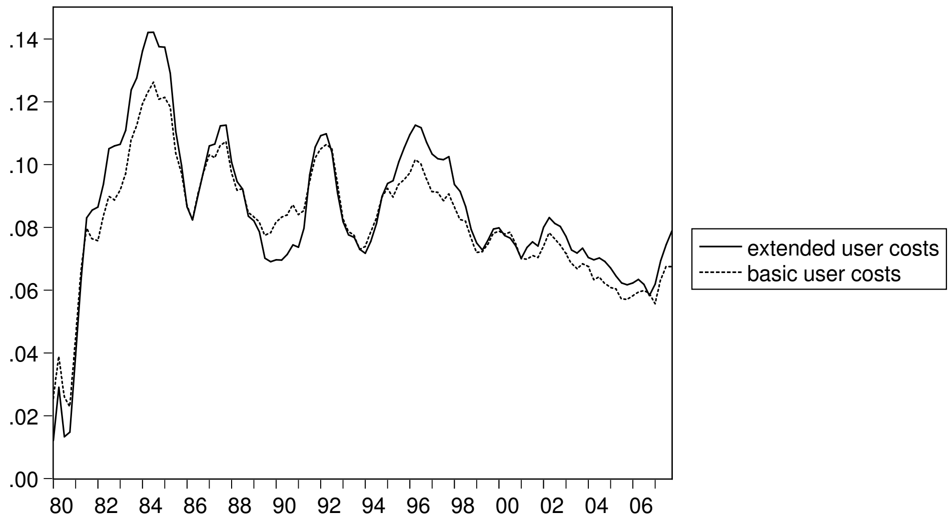
[12]Jarque-Bera residual normality test using a Cholesky orthogonalization, see Lütkepohl (2007) for details. Ordering of variables: $hi_t, di_t, fa_t, fl_t, q_t(\pi - \pi_h)_t, UC_t^B$.

3.3 An extended measure of the user costs of housing

The econometric analysis has provided evidence that variables which are related to the presence of a credit constraint have to be considered in the modeling of residential investment. This includes an extension term in the formula of user costs which is dependent on the inflation and an average loan-to-value ratio. As the ultimate VECM estimate points to $\hat{\eta} = 66\%$, we are now able to compute and analyze the extended measure of user costs which is given by $UC_t = (1 - 0.66) * q_t(\pi_t - \pi_{h,t}) + UC_t^B$.

In Figure 3, a comparison of both series - basic user costs and extended user costs of housing - is shown. All time series included in the user costs definition are described in the Annex. Both measures of user costs behave rather similarly with regard to trend properties, which comes as no surprise against the backdrop that the inflation gap is stationary. However, it substantively affects the cyclical properties of user costs. In particular, the extension term increases the volatility, which is also confirmed by the descriptive statistics shown in Table (8).

Figure 3: Extended and basic user costs of housing



Source: Own calculation.

Table 8: Descriptive statistics for user costs series

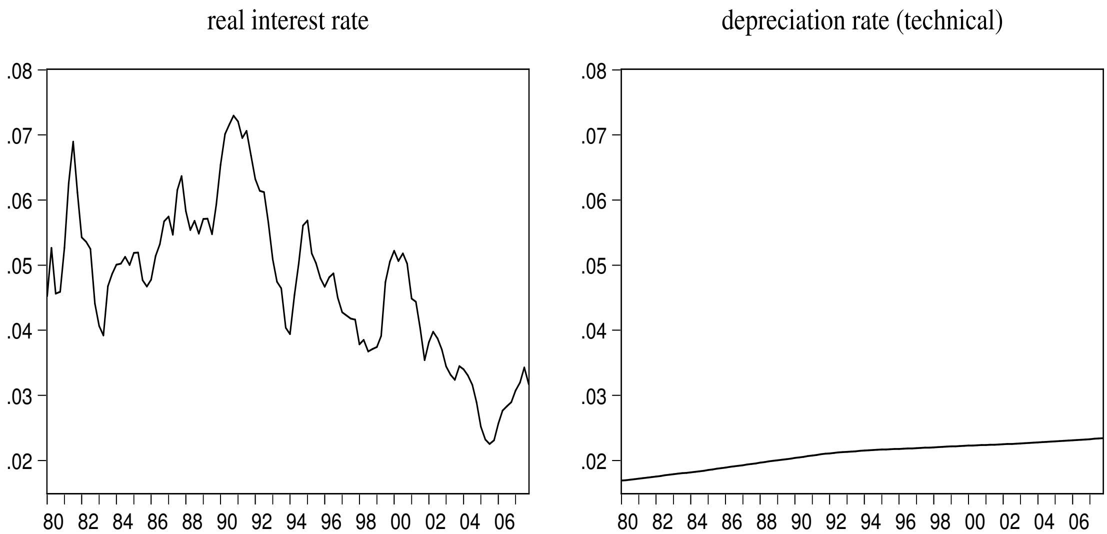
	Extended user costs	Basic user costs
Mean	0.085	0.081
Maximum	0.142	0.126
Minimum	0.012	0.023
Std.dev.	0.023	0.019

In order to obtain more insights into the driving forces of extended user costs, let us further investigate its components

$$UC_t = q_t(i_{r,t} + \tilde{\delta}_t + [\pi_t - \pi_{h,t}]) + (1 - \eta)q_t(\pi_t - \pi_{h,t}) \qquad (13)$$

with the real interest rate $i_{r,t}$ defined as $i_{r,t} = i_t - \pi_t$ and $\tilde{\delta}_t$ as the technical depreciation rate of residential capital (see the Annex for details).

Figure 4: Comparison of time series with impact on user costs



Source: Own calculation (see the Annex for details).

Among its components, the inflation gap and the real interest rate exhibit no clear trending behavior over time and may, in particular, contribute to cyclical effects. Technical depreciation increases steadily, but with a more or less marginal impact owing to its relatively small overall magnitude. The key driver for trending behavior of the basic user costs UC^B is thus the relative price ratio q.

4 Conclusions

Due to the overall importance of the housing market, this paper presents some theoretical and empirical considerations in order to obtain further insights in the investment decision of private households. We modify the basic neoclassical approach of user costs of housing introducing a credit constraint with which an arbitrary household is faced when purchasing an owner-occupied dwelling. This constraint should be important as residential investment is usually financed by credit to a large extent. Compared with the basic neoclassical approach to housing investment, the implementation of this credit constraint leads to an additional term in the first-order condition. The extension could be interpreted as a wedge between the marginal rate of substitution and the basic user costs. The wedge is determined by the inflation gap between consumer prices and house prices multiplied by the real house prices and the loan-to-value-ratio.

The relevance of the theoretical findings are checked in the empirical part of the paper by specifying and estimating a time-series model for housing demand incorporating elements related to the presence of a binding credit constraint. The analysis is based on German data. The sample starts in the first quarter of 1980 and ends in the fourth quarter of 2007.

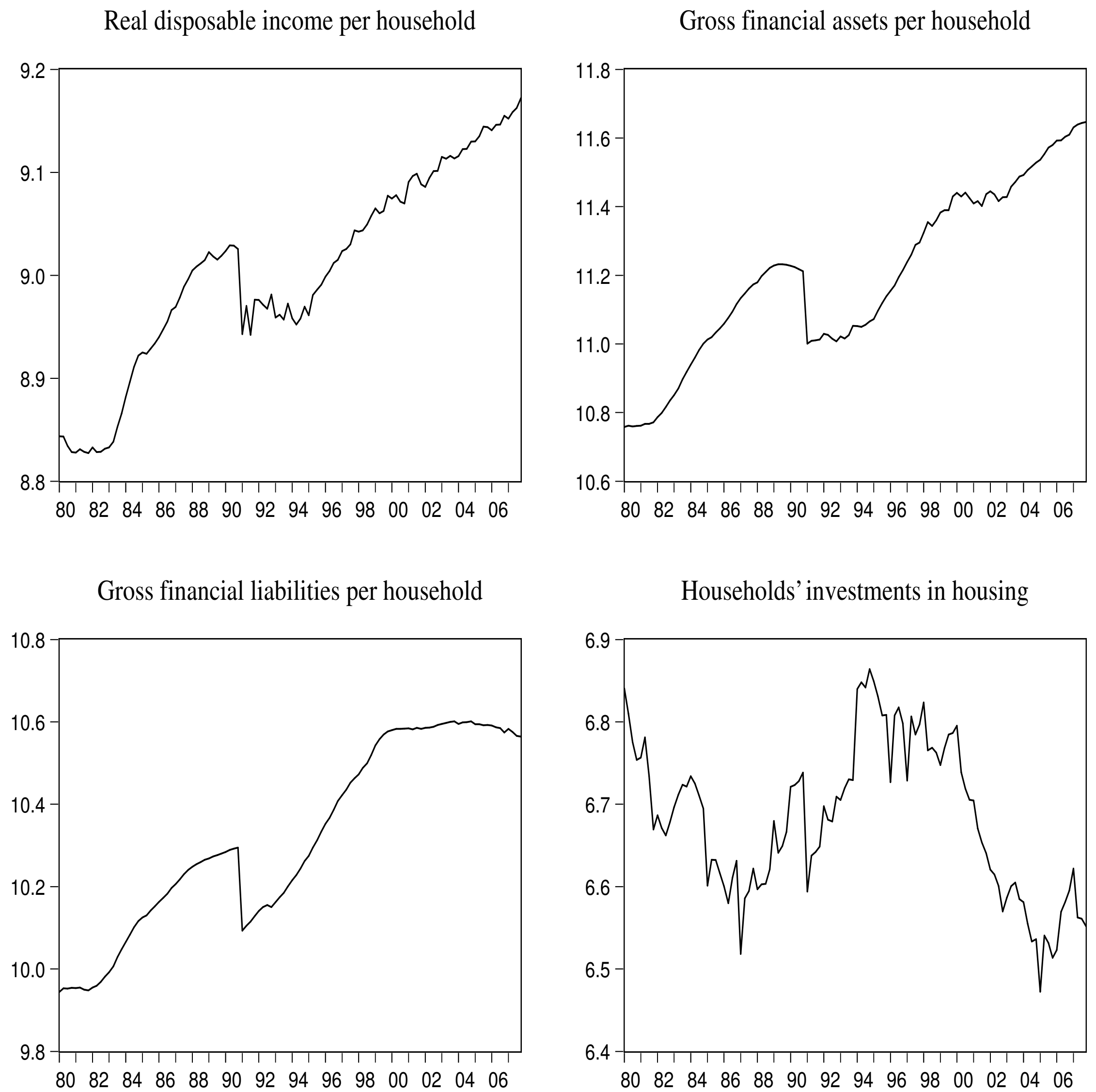
The model comprises household investment in housing, disposable income, financial assets, financial liabilities, the extension term and basic user costs of housing as endogenous variables. As the time series under consideration can be regarded as I(1) processes and we are interested in a long-run equilibrium relationship between these variables, a VECM is used to model household investments in housing. Carrying out cointegration tests indicates one cointegrating relation between variables. Estimating the model also leads to an estimate of the average loan-to-value ratio. Equipped with this, we have computed a time series of extended user costs showing the diminishing importance of the standard user costs. This is due to the fact that the real price of housing has exhibited a negative trend in the sample under review.

We close with brief caveats. Firstly, the analysis has focused on German data exclusively. The more general relevance of the model framework needs to be verified, for instance, by considering other countries. Secondly, the estimation results have to be interpreted cautiously. This is due to measurement issues - in particular, concerning financial assets and financial liabilities as well as inflation expectations.

A Data and unit root tests

A.1 Time series used for variables fa, fl, di and hi

Figure 5: Disposable income, financial assets and liabilities, households' investments in housing



Source: Bundesbank (disposable income and households' investments);
own calculation (financial assets and liabilities).

As discussed in Chapter 3.2, households investments' in housing hi_t depends *inter alia* on (disposable) income di_t and the difference between financial assets fa_t and liabilities fl_t, i.e. net financial wealth nw_t. Therefore, time series for these variables are needed.

Disposable income di_t and households' investments in housing hi_t are taken from the Deutsche Bundesbank. Financial assets fa_t and liabilities fl_t are well-known series from Germany's financial account. We decided to use per household series (see Section 3.2). The transformation was done using number of total households. Series for real disposable income, gross financial assets and gross financial liabilities are price-adjusted with house price index p_h.
These series used in our empirical model are seasonally and working-day adjusted and in real terms (i.e. in 2000 euro). The series are taken in natural logarithm. The sample starts in the first quarter of 1980 and ends in the fourth quarter of 2007. The sample size is $T = 112$. Graphs reported show the per household series used.

A.2 Time series used for calculating user cost series

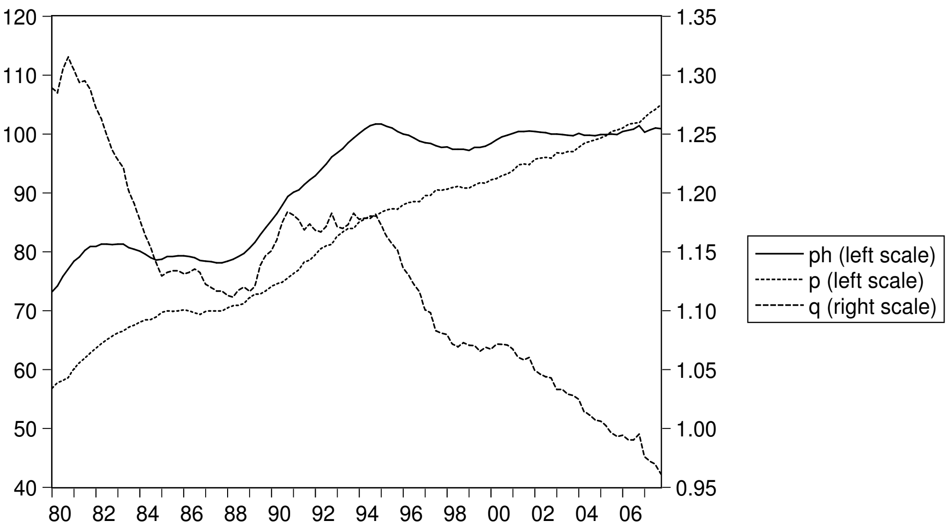
Our extended user costs are defined in Equation (12) as
$UC_t = (1-\eta)q_t(\pi_t - \pi_{h,t}) + q_t(i_t - \pi_t + \delta_t)$, and basic user costs in Equation (11) as $UC_t^B = q_t(i_t - \pi_t + \delta_t)$, i.e. excluding the wedge $(1-\eta)q_t(\pi_t - \pi_{h,t})$. Using $q_t = \frac{p_{h,t}}{p_t}$ and $\delta_t = \tilde{\delta}_t - [\pi_{h,t} - \pi_t]$ we can write our extended version also as

$$UC_t = \frac{p_{h,t}}{p_t}[i_t - \pi_t + \tilde{\delta}_t - (\pi_{h,t} - \pi_t) + (1-\eta)(\pi_t - \pi_{h,t})]. \quad (14)$$

To derive our extended user costs series we need a time series for all variables used in Equation (14). η is estimated within our econometric model and value is set to 66%.

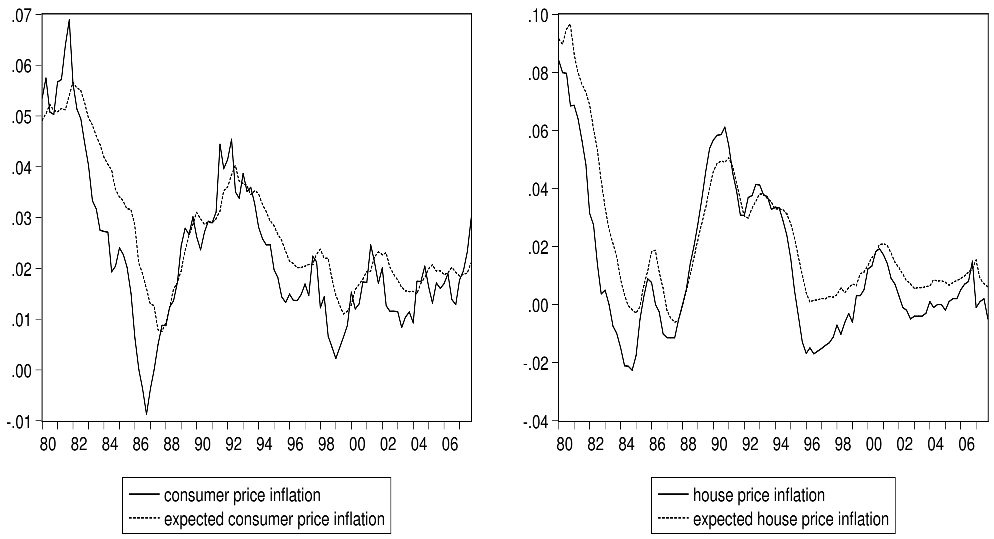
We use a house price index for the variable $p_{h,t}$, a consumer price index for p_t. i_t is represented by a nominal interest rate paid by household series. For $\pi_{h,t}$ and π_t we calculate a series for expected house price inflation rate and expected consumer price inflation rate, respectively. $\tilde{\delta}_t$ is our technical depreciation rate of residential housing. All series used are seasonally and working-day adjusted. The sample starts in the first quarter of 1980 and ends in the fourth quarter of 2007. The sample size is $T = 112$. Below, all series mentioned are plotted and the derivation is briefly discussed, wherever needed.

Figure 6: Consumer price index p, house price index p_h, and ratio q



Source: Bundesbank (p_h and p), own calculation (q).

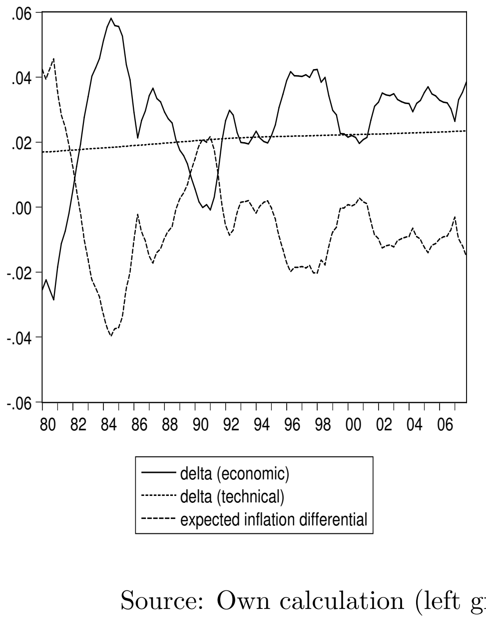
Figure 7: (Expected) house price inflation (π_h), π_h^n, and (expected) consumer price inflation (π), π^n

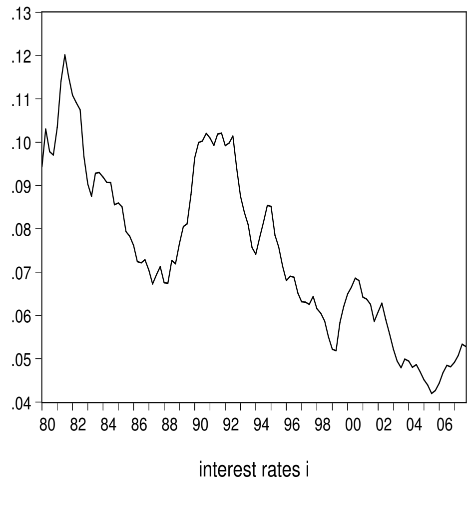


Source: Bundesbank (π^n, π_h^n), own calculation (π, π_h).

In Figure 7, consumer price inflation π_t^n and expected consumer price inflation π_t are plotted. Values for π_t from consensus forecasts are available only from fourth quarter of 1989 onwards, so we do have to calculate our own series. The expectations formation of future consumer price inflation is modeled using the ARIMA approach. We use an ARIMA (5,1,0) model of the type:[13] $\log(p_t) - \log(p_{t-1}) = \theta_0 + \theta_1[\log(p_{t-1}) - \log(p_{t-2})] + \ldots + \theta_5[\log(p_{t-5}) - \log(p_{t-6})] + \varepsilon_t$. The ε_t are independent, identically distributed random variables. Starting with the period from 1970 to 1979, this model is used to forecast the development of consumer price inflation over the next five years. Our starting point (1970Q1) remained fixed. By adding one observation at a time to the end, but keeping the starting point the same, the whole sample is reestimated until 2007Q4, and the forecasts for the following 20 months from each estimation are obtained.[14] Calculating the mean of each estimated series leads to our expected quarterly consumer price inflation series. The year-on-year increase π_t is the sum of the last four expected values. Figure 7 also shows house price inflation $\pi_{h,t}^n$ and expected house price inflation $\pi_{h,t}$. To forecast the development of house price inflation, we use the same approach as before with consumer price inflation. Slightly different is the ARIMA (4,1,0) model we use. It has the type: $\log(p_{h,t}) - \log(p_{h,t-1}) = \theta_0 + \theta_1[\log(p_{h,t-1}) - \log(p_{h,t-2})] + \ldots + \theta_4[\log(p_{h,t-4}) - \log(p_{h,t-5})] + \varepsilon_t$. Also different is our starting period, which is now 1975 to 1979. All other steps of the procedure are executed in the same way.

Figure 8: Left side: Economic and technical depreciation rates of residential housing (δ and $\tilde{\delta}$) and capital gains or losses. Right side: Nominal interest rates paid by households





Source: Own calculation (left graph), Bundesbank (right graph).

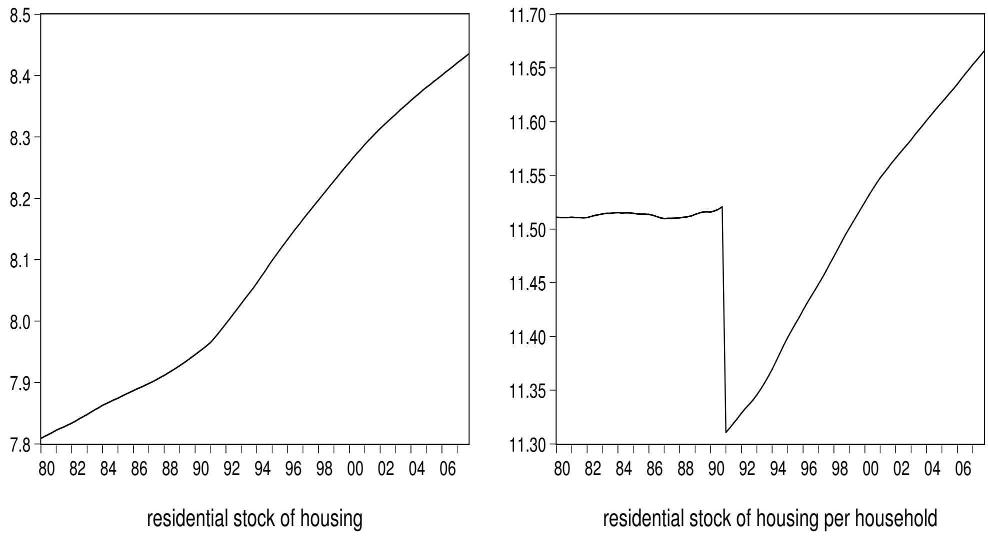
[13]The model was specified by minimizing SC for each sample periods' estimations.

[14]For a similar procedure, see Junttila (2001).

In Figure 8, economic depreciation rate δ_t, technical depreciation rate $\tilde{\delta}_t$, and the difference between expected house price inflation and expected consumer price inflation as a measure for capital gains or losses are plotted. In this context, $\tilde{\delta}_t$ was derived using the value for real depreciation of residential housing drawn from the Deutsche Bundesbank and the series for residential housing stock.

The residential stock of housing in billions of 2000 euro (see Figure 9) was calculated using the available series from the Deutsche Bundesbank between 1991 and 2007. Values between 1980 and 1991 have been derived using cumulative private investments in residential housing drawn from the Deutsche Bundesbank. Resulting series have a yearly frequency. Quarterly values have been derived using a Kalman filter.[15]

Figure 9: Residential stock of housing



Source: Own calculation.

[15]For a discussion of the Kalman filter technique, see, for example, Durbin and Koopman (2001).

A.3 Unit root tests

We performed unit root tests in order to obtain more information on the trending behavior of the time series. Due to German reunification, a statistical break in the first quarter 1991 (T_B) has to be taken into account. This is visible in the series for the variables di_t, fa_t, fl_t. The trending setup for these series includes a constant c and a deterministic trend t. To control for the statistical break, we therefore include a dummy variable $S_M(91:1)$. $S_M(91:1)$ is unity from the first quarter of 1991 onwards, and zero otherwise. For households' investments in housing series hi_t graphical inspection indicates that we may have to include breaks in trend. In 1987, the German government introduced Article 10e EStG subsidies; in 1996 the *Eigenheimzulage* [grant to homebuyers] was introduced; in 2004 the *Eigenheimzulage* was abolished. But it is not possible to attribute the effect of these changes in law to a specific date. This fact, and also because of the short sample, we do not control for these possible structural breaks in 1987, 1996, and 2004. The trending setup for the hi_t series includes a constant c and a deterministic trend t. It is unclear whether the series for the basic user costs of housing UC_t^B, the price ratio q_t, and the inflation gap $(\pi - \pi_h)_t$ appear to be non-stationary or not. After graphical inspection, we decided that a statistical break should not to be included. The trending setup for these both series includes a constant c. In Table (9), results for series used in our VECM are reported for augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests and the test proposed by Kwiatkowski et al (1992) (KPSS).[16] ADF and PP procedures test for a unit root in the series; KPSS assumes stationarity under the null hypothesis. The numbers in brackets indicate the lag length in the ADF procedure and the bandwidth parameter in the PP and KPSS procedures. Lag length was selected by minimizing the Schwarz (1978) criterion (SC) (calculated up to lag length 12), bandwidth parameter was chosen by the automatic procedure suggested by Newey and West (1994). For KPSS we also display values for a shorter bandwidth parameter value of 4 which results from applying the rule of thumb integer $4 * \sqrt[4]{T/100}$, also used by Kwiatkowski et al (1992), for example. Critical values for the ADF and the PP tests, including a structural break, are tabulated in Perron (1989), Table IV.B, which are -4.34, -3.72, -3.44 for series with a break in mean in the given setup with $T_B/T = 0.4$. For the KPSS testing the hypothesis of trend-stationarity, the asymptotic critical values are tabulated in Kurozumi (2002), Table 1b, which are 0.143, 0.103 and 0.086 for series with a break in mean in the given setup. For series without breaks we took the MacKinnon (1996) critical values for the ADF and the PP tests. For series including a constant c, these are -3.49, -2.89 and -2.58. Including a constant c and deterministic trend t the values are -4.05, -3.45, -3.15 in the given setup. For the KPSS testing, the asymptotic critical values for series without breaks are tabulated in Kwiatkowski et al (1992). For series including a constant c, these are 0.739, 0.463 and 0.347. Including a constant c and deterministic trend t, the values are 0.216, 0.146, 0.119. $^{**}, ^{*}, (^{*})$ mean rejection of the null hypothesis at the 1%, 5% and 10% level, respectively.

[16] For details on the ADF and the PP test, see, for instance, Greene (2008) or Hamilton (1994).

Table 9: Unit root tests

Series	Deterministic terms	ADF	PP	KPSS	
hi_t	c, t	$-1.81(1)$	$-2.08(2)$	$0.33(4)^{**}$	$0.18(9)^{**}$
di_t	c, t, $S_M(91:1)$	$-4.53(2)^{**}$	$-4.61(4)^{**}$	$0.30(4)^{**}$	$0.19(8)^{**}$
fa_t	c, t, $S_M(91:1)$	$-5.89(0)^{**}$	$-5.73(6)^{**}$	$0.21(4)^{**}$	$0.13(9)^{*}$
fl_t	c, t, $S_M(91:1)$	$-1.58(0)$	$-2.30(6)$	$0.22(4)^{**}$	$0.14(9)^{*}$
$(\pi - \pi_h)_t$	c	$-3.06(4)^{*}$	$-2.87(5)^{(*)}$	$0.14(4)$	$0.10(8)$
q_t	c	$-1.94(4)$	$-0.89(8)$	$1.82(4)^{**}$	$0.99(9)^{**}$
$q_t(\pi - \pi_h)_t$	c	$-3.18(4)^{*}$	$-2.99(4)^{*}$	$0.12(4)$	$0.09(8)$
UC_t^B	c	$-2.80(1)^{(*)}$	$-3.07(4)^{*}$	$0.56(4)^{*}$	$0.38(8)^{(*)}$

For any trending series except the series for the inflation gap $(\pi - \pi_h)_t$ nonstationarity is confirmed by the KPSS test results. The existence of a unit root cannot be rejected by either the ADF or the PP test for hi_t, fl_t and q_t series. For UC_t^B, di_t and fa_t series we obtain no clear results. ADF and PP test results indicate that we can reject the null hypothesis of a unit root, whereas both KPSS versions reject the stationarity hypothesis. We think it is fair to skip the ADF and PP results and use only the KPSS ones for our decision on stationarity or nonstationarity and, thus, to conclude that these three series contain a unit root. As a working hypothesis for the analysis they will be taken as I(1) series. For the $(\pi - \pi_h)_t$ series, ADF and PP tests indicate that we can reject the existence of a unit root, and the two KPSS versions accept the stationarity hypothesis. For the $q_t(\pi - \pi_h)_t$ series, unit root tests indicate stationarity. But as the tests clearly confirm nonstationarity for the price ratio q_t, which is a component of the expression $q_t(\pi - \pi_h)_t$, we disregard the test results in this case and take the series as I(1).

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