Macroeconomic Determinants of International Housing Markets

Abstract

This paper examines the long-term impact and short-term dynamics of macroeconomic variables on international housing prices. Since adequate housing market data are generally not available and usually of low frequency, a panel cointegration analysis consisting of 15 countries over a period of thirty years is applied. Pooling the observations allows us to overcome the data restrictions which researchers face when testing long-term relationships among single real estate time series. This study does not only confirm results from previous studies but also allows for a comparison of single country estimations in an integrated equilibrium framework. The empirical results indicate positive effects on house prices arising from an increase in economic activity, construction costs, and the short-term interest rate and negative effects stemming from an increase in the long-term interest rate. Deviations from the long-term equilibrium result in a dynamic adjustment process that can take several years.

Keywords: *Housing market*, *macroeconomy*, *panel cointegration*, *FMOLS*, *DOLS*

JEL-Classification: *C*33, *G*15

1. Introduction

In the past, long-run equilibrium models of housing markets and the macroeconomy have been restricted to countries that offer a high availability of long time series of housing market data. The reason for this is that cointegration techniques such as the Engle-Granger or the Johansen approach require a sufficiently large time period in order to test on long-run relationships. Accordingly, such studies so far have been restricted to the US (Catte 2004, Case 2000), the UK (Meen 1996, Bowen 1994) and a few other countries.[1] To overcome this restriction this study uses macroeconomic and housing market data from 15 OECD countries and applies the panel cointegration approach proposed by Pedroni (1999, 2000, 2004). This method makes use not only of the T observations of a time series of a single country but pools the observable data over all N countries so that in effect $N \cdot T$ real observations are available for estimation. This results in a higher robustness of the estimation process since the effects of large sample asymptotics are more likely to apply in this environment. The main advantage however lies in the existence of an international housing market result which can be obtained by weighting the individual country estimations. Finally, in recent literature variables of panel data were found to be cointegrated even where there was no cointegration between them in individual time series. Hence, this study does not only confirm results from earlier studies but also highlights the differences between countries in an integrated long-run equilibrium framework.

The study is organized as follows: the next section discusses a theoretical long-run equilibrium model of the housing market which is used as a theoretical foundation for the empirical investigation. Section three applies the panel cointegration technique for non-stationary panel data which is used to test and estimate long-term equilibrium relationships between the housing market and macroeconomic variables. Furthermore, an error correction

[1] For a recent and comprehensive literature overview see Leung (2004).

model is estimated to describe the adjustment process to this long-term equilibrium. Some conclusions are drawn in section four.

2. Macroeconomic Effects and their propagation mechanism on the Housing Market

In contrast to other capital market assets, real estate prices do not change immediately after economic news has been released and generally exhibit low price fluctuation. Residential housing prices in particular show strong downward price stickiness since house owners have high reservation prices or simply resist to sell their house under a certain price during recessions. Price inertia, however, also influences the behaviour of housing prices during economic booms since exuberant expectations of house owners facilitate the formation of housing bubbles.[2] The propagation of macroeconomic shocks on US house prices have been discussed in the literature, e.g. Catte (2004) and Case (2000). Macroeconomic shocks such as unexpected changes in the money supply, industrial production or changes in the interest rate effect house prices with a lag depending on the speed of the propagation mechanism. The speed of propagation is determined by the efficiency of the institutional framework such as zoning regulations, the speed of administrative processes, credit supply, transaction costs or the mortgage market. If for example changes in the interest rates propagate quickly into changes of mortgage market interest rates, then an increase in the money supply affects the housing market more quickly compared to a situation where most mortgage rates are fixed and the mortgage market in general is inefficient. The credit supply for housing financing can also vary between countries depending on the real estate valuation methods. If the valuation method reacts sensitively to changes in real estate

[2] Furthermore, price information in the real estate market is often limited and inaccurate as real estate is sold only infrequently and information about prices is often specific to the respective local market. For this reason, price forecasts are usually simple extrapolations from the past. This leads to endogeneous dynamics of real estate prices and thus facilitates the formation of housing bubbles. The contribution of those endogeneous dynamics can be substantial and varies between 70 % and 40 % depending on the country under consideration (Zuh 2003).

prices and if the loan-to-value (LTV) ratio[3] is high, rising house prices increase the credit supply more strongly and vice versa, decreasing house prices lead to a shortage in the credit supply. A higher credit supply in turn increases the importance of interest rate changes as more firms and households rely on debt financing. Lower transaction costs on the other hand lead to more transactions and thus to a faster response of house prices in face of a macroeconomic shock. Furthermore, housing supply inelasticities lead to a stronger weight on price reactions relative to supply reactions.

However, there might also be a feedback reaction from housing prices to the macroeconomy. Rising house prices make homeowners feel richer.[4] The value of their houses increases, and thus, the size of the collateral that people can borrow on. For liquidity constrained households, an increase in house price may be the only opportunity to borrow at all. This wealth effect then increases consumption. A decline in house prices leads to a negative effect on consumption since decreasing house prices lead to more mortgage defaults and thus reduce the supply of bank credit as banks loose part of their bank capital (Parker 2000). Here, the mortgage market also plays an important role for the propagation of real house prices to the macroeconomy. Higher mortgage debt means a higher leverage through which changes in the interest rate can affect consumer spending. The effect of house prices on consumption is especially strong in the US as shown in Case (2000), where two thirds of all occupants are also owner-occupants so that the wealth effect has a strong impact on consumer spending.[5] Real

---

[3] Loan-to-value (LTV) is defined as ratio of the value of the loan to the value of the collateral.

[4] For instance, in the United States, about two thirds of the population are house owners. The increase in house prices is of course disadvantageous for the other one third of the population who rent houses as rents increase as well.

[5] Case et al. (2005) show that the consumption effect of housing wealth is even larger than the effect stemming from financial wealth.

house prices even have a stronger effect on consumption than stock market prices which might be due to the fact that house ownership is more evenly distributed across households than stock market wealth. Stock market wealth is mainly held by rich households and since the propensity to consume declines with increasing wealth, an increase in house prices has a stronger effect on consumption than an increase in stock prices.[6]

Global macroeconomic effects on real estate prices have been discussed in Case (2000). Real estate markets appear to show high correlations internationally even though they are not substitutes since they are bound to a specific place. However, fundamentals like GDP which drive real estate markets are internationally correlated.[7] The strength of those global factors depend on the openness of the country and GDP correlations were found to range on average between 0.33 and 0.44 (Case 2000).[8]

The slow propagation of macroeconomic effects on the one hand and endogenous feedback effects on the other hand ask for a long-run equilibrium analysis and a model of short-run dynamics to model deviations from this long-run equilibrium.

In order to provide a theoretically based motivation for our choice of variables in the empirical part of this study we briefly present a simple supply and demand model. In this context, we build on the theoretical equilibrium model of DiPasquale and Wheaton (1996). Central to this model in Figure 1 is the distinction between the asset and the property market as well as their interaction:[9]

---

[6] Some economists, however, do not believe in the existence of such wealth effects, see e.g. Glaeser (2000).

[7] The real estate crash of office prices in the early 1990s e.g. was felt by nearly every country around the world.

[8] Other, non-macroeconomic effects have been studied as well. See e.g. Parker (2000) for the effect of population growth on house prices and Cocco (2005) for real estate in the portfolio context.

[9] For a more detailed discussion the reader is referred to DiPasquale and Wheaton (1996).

One the one side is the asset market which determines the price of real estate and leads to an equilibrium of the demand to *own* houses, and the supply of houses. The supply of houses depends on house prices relative to the construction costs of building a new house. Since one important aspect of real estate is its short-term inelasticity of supply, a sudden increase in demand will increase prices. For given construction costs, this increase in the price acts as an incentive for investors to build new houses until the price decreases to its long-term relation of replacement costs and the costs of land, at which point the investor has no incentive to build more houses. The demand to own houses depends negatively on house prices but positively on the rental income that houses earn as an asset.

On the other side is the property market which equates demand and supply of real estate and housing *use* or *space*. Individuals, whether owners or tenants , require space for living. For a tenant, space is part of overall consumption spending and the demand for space, i.e. the use of real estate, depends on the rent relative to the price of other consumer goods and on economic factors like disposable income. For a house owner, the rents are the annualized opportunity costs of using the space instead of renting it to other individuals. The supply of real estate space is given by the asset market. The rent is determined by the property market where demand for space equals supply of space. For a given inelastic supply, an increase in economic activity, e.g. an increase in household's disposable income or a higher level of production, lead to higher rents.

<< Figure 1 about here >>

Within this framework we implement the following long-run model of supply and demand:

(1) $$D_t = \alpha + \beta' x_t^D + \delta' z_t^D + \varepsilon_t$$

x_t^D is a vector of macroeconomic variables affecting demand and z_t^D is a vector of country-specific factors affecting housing demand on the micro level such as mortgage market characteristics, tax regulations, and depreciation laws. Since we focus in this study on the macroeconomic impacts on housing markets the vector z_t^D is incorporated in the error term and equation (1) can be written as[10]

$$(2) \qquad D_t = \alpha - \beta_1 hp_t + \beta_2 EA_t - \beta_3 long_t - \beta_4 short + \tilde{\varepsilon}_t$$

In equation (2), higher house prices hp_t decrease demand for house ownership while higher economic activity EA_t measured e.g. by real industrial production or real money supply have a positive effect on demand.[11] Higher long-term interest rates make fixed income assets more attractive relative to housing investments and thus lead to a capital switching that lowers demand for house ownership. Finally, an increase in the short-term interest rate affecting mortgage-rates has a negative impact on demand. In a similar fashion housing supply is given by

$$(3) \qquad S_t = \eta + \gamma' x_t^S + \lambda' z_t^S + \nu_t$$

which incorporates the micro factors such as governmental building provisions in the error term. The supply equation can be expressed in more detail as

$$(4) \qquad S_t = \eta + \gamma_1 hp_t - \gamma_2 short_t - \gamma_3 constr_t + \tilde{\nu}_t$$

In equation (4) higher house prices act as incentives for investors to increase the supply of houses while higher short-term rates increase financing costs for house builders leading to a decrease of supply. We also expect construction costs $constr_t$ to have a negative impact on

[10] Although we consider the micro factors to be relevant they cannot be taken into account in a panel of 15 countries since they vary greatly between countries.

[11] The current subprime bubble may be regarded as evidence that increasing house prices my actually *increase* demand for house ownership. This model, however, is concerned about the macroeconomic impacts on the long-run equilibrium relationship which, by definition, does not include bubbles.

housing supply. The equilibrium relationship is established by equating supply and demand. Solving for house prices and taking the panel structure into account we receive:

$$hp_{it} = \alpha_i^* + \beta_{2i}^* EA_{it} + \gamma_{2i}^* short_{it} + \gamma_{3i}^* constr_{it} - \beta_{3i}^* long_{it} + \varepsilon_{it}^* \quad (5)$$

with $\alpha_i^* = \frac{\alpha_i - \eta_i}{\gamma_{1i} - \beta_{1i}}$, $\gamma_{2i}^* = \frac{\gamma_{2i} - \beta_{4i}}{\gamma_{1i} - \beta_{1i}}$, $\gamma_{3i}^* = \frac{\gamma_{3i}}{\gamma_{1i} - \beta_{1i}}$, $\varepsilon_{it}^* = \tilde{\varepsilon}_{it} - \tilde{\nu}_{it}$, and $\beta_{ji}^* = \frac{\beta_{ji}}{\gamma_{1i} - \beta_{1i}}$, for j = 2,3.

Note that the total effect of the short-term interest rates on house prices γ_2^* is ambiguous and depends on the relative strength of γ_2 versus β_4.

In the context of this theoretical model we expect a positive sign for β_2^* (see upper panel of Figure 1): An increase in economic activity e.g. through an increase in employment, real money supply or an increase in real consumption increases the demand for space and shifts the demand curve in the first quadrant to the right. Since the housing stock cannot change in the short-run, rents increase leading to higher house prices in the asset market.

An increase in the long-term interest rate (β_3^*) does not change the demand for housing space directly but changes the demand to own houses. A higher long-term interest rate increases the return of other fixed income assets such as bonds relative to the return of real estate, thus shifting the demand from real estate into other assets. This change in demand is shown in the central panel of Figure 1 as an increase in the slope of the capitalization rate which is the ratio of rents to house prices.[12] The higher capitalization rate is reflected in lower real estate prices which in turn decreases construction and thus translates into a lower housing stock. The lower housing stock increases rents so that the new box is higher and more quadratic than the previous one.

[12] The capitalization rate is defined as *cap = (NOI - debt)/sales prices*, with NOI as the net operating income (gross income minus operating expenses) and *debt* as the debt service payments. This earnings-price ratio is often considered relative to the earnings-price ratio of other investments.

The third effect, which is likely to have an impact on the supply schedule of new construction is a change in the short-term interest rate or in the construction costs. Higher short-term interest rates and generally all factors that increase the costs of construction such as an increase in the price of construction materials or stricter building regulations increase the financing costs of construction. This effect is shown in the bottom panel of Figure 1 as a shift of the construction line to the left. The higher construction costs lead to a decrease in construction and thus to a lower level of the housing stock. The lower housing stock also means less housing space which increases rents. Higher rents then generate higher house prices in the asset market. As evident, the location of the new box is higher and more to the left relative to the previous box. Rents and house prices are higher but construction and the housing stock are lower than without the increase in the short-term interest rate. The exact position of the box depends on the elasticities of the individual curves.

In reality, the effects described above often occur at the same time, e.g. an increase in economic activity also increases the short-term interest rate making the theoretical outcome more complicated. Furthermore, the model is a static equilibrium model, whereas the propagation of the various effects would also be interesting to investigate. In the next section we apply a panel cointegration approach with the associated error correction model for modeling long-run equilibria and the corresponding short-run dynamics.

4. Long-Term Equilibrium Relationships between Housing Markets and the Macroeconomy

Cointegration analysis for non-stationary panel data is conducted in three steps: First, we test the variables for stationarity using panel unit-root tests. Afterwards, we apply panel cointegration tests to detect the long-term equilibrium relationships, and finally we estimate the short-term dynamics.[13] For the following estimation, house prices for fifteen countries ranging from 1975Q1 to 2007Q2 are used. The 15 countries are Australia, Belgium, Canada, Denmark, Finland, France, Ireland, Italy, Netherlands, New Zealand, Norway, Spain, Sweden, the UK, and the USA.[14] Figure 2 shows the development of the log real house prices since 1975.[15]

<< Figure 2 about here >>

4.1 Panel Unit Root Tests

Early work on non-stationary panel data include Quah (1994) or Levin and Lin (1993) who study unit root tests under the null hypothesis of non-stationarity assuming homogeneous parameters of the lagged endogenous variable. Im, Pesaran and Shin (1997) and Maddala and Wu (1999) propose unit root tests which also allow for heterogeneous autoregressive roots. The Levin and Lin (LL) test, the Im, Pesaran and Shin (IPS) test and the Fisher Phillips-Perron (Fisher-PP) test have been the most popular in the literature (see Maddala and Wu 1999). The main drawback of the LL test is that the autoregressive root ρ is assumed to be the same for all i:

$H0: \rho_1 = \rho_2 = ... = \rho_N = \rho = 0$ against the alternative hypothesis

$H1: \rho_1 = \rho_2 = ... = \rho_N = \rho < 0$

Although the LL test allows for heterogeneity in the variance and serial correlation structure of the error terms, the restriction of homogeneous slope parameters is clearly too strong and the alternative hypothesis is thus of no practical interest. The IPS test in contrast is a generalization of the LL test that combines the test statistics of the individual unit root tests for

---

[13] Cointegration methodology for testing long-term equilibrium relationships between single time series have been developed by Engle and Granger (1987) for the univariate case and by Johansen and Juselius (1990) for the multivariate case.

[14] Germany and Japan were excluded from the data set due to inaccurate housing price data.

[15] Although we are aware of the potential impact of the housing bubble on our analysis, we decided to include the recent years in order to include recent relevant information and to increase the total number of observations.

each cross-section unit. The IPS test has the advantage of heterogeneous slope parameters by applying a group-mean Lagrange multiplier (LM) statistic. Under the IPS test the alternative hypothesis accordingly becomes:

$H1: \rho_i < 0$ for $I = 1, 2, \ldots, N_1$ and $\rho_i = 0$ for $N_1+1, N_2+2, \ldots, N$

so that slope parameters ρ_i are allowed to differ across group members and not all N members need to be cointegrated. Another test, which can also be applied to unbalanced panels is the Fisher Phillips-Perron (PP) test proposed by Maddala and Wu (1999) and Choi (2001). In contrast to the IPS test which is a parametric and asymptotic test, the PP test is a nonparametric and exact test. The PP test combines the p-values π_i of each individual unit root test and follows a Chi-square distribution with $2N$ degrees of freedom:

(6) $$\lambda = -2\sum_{i=1}^{N} \ln \pi_i \sim \chi^2(2N)$$

A modification of the Fisher PP test by Choi (2001) results in a normally distributed test statistic:

(7) $$Z = \frac{1}{\sqrt{N_i}} \sum_{i=1}^{N} \Phi^{-1}(\pi_i) \sim N(0,1)$$

with Φ^{-1} as the inverse of the standard normal cumulative distribution function.

Monte-Carlo studies of Maddala and Wu (1999) show that the PP test has a higher power than the IPS test and will be used in the following estimation. Table 1 shows the Fisher-PP and Choi-PP test statistics. All variables except for the long-term interest rate have been deflated with the consumer price index. Where necessary, the series have been seasonally adjusted using the Census X12 procedure. As can be seen from Table 1 all variables are non-stationary in levels and stationary in first differences even though for industrial production, construction costs, and the interest rates the evidence of a unit root is rather weak. The fact that almost all variables seem to be stationary when considering both individual intercepts and individual trends seems puzzling. When tested individually, the variables are non-stationary. Furthermore, Pedroni (2000) suggests omitting the individual trends and only to include individual intercepts. After concluding that the variables are integrated of order 1, $I(1)$ in levels but $I(0)$ in differences, the next step is to test if a cointegration relationship between the variables exists.

<< Table 1 about here >>

4.2. Panel Cointegration Test

If the macroeconomic and housing market variables are $I(1)$ but a linear relationship between those variables is $I(0)$, the variables are cointegrated. In order to test for cointegration, a cointegration test for heterogeneous panels with multiple regressors developed by Pedroni (2000) is applied. This test has the null hypothesis of no cointegration and also allows for unbalanced panels. In this test the regression residuals are computed from the following regression:

$$y_{i,t} = \alpha_i + \delta_i t + \rho_{1i} \cdot x_{1i,t} + \rho_{2i} \cdot x_{2i,t} + ... + \rho_{Mi} \cdot x_{Mi,t} + e_{i,t} \qquad (8)$$

for $t = 1,\dots, T$; $I = 1,\dots, N$; $m = 1,\dots, M$

with individual fixed effects α_i and individual time trend $\delta_i t$, although such individual time trends are often omitted. In some cases common time dummies can also be included.[16] In this equation, m regressors $x_{mi,t}$ are allowed and the slope coefficients ρ_{mi} and thus the cointegration vectors are heterogeneous for all i. The residuals $e_{i,t}$ from equation (8) are then tested on unit roots:

$$\hat{e}_{i,t} = \rho_i \hat{e}_{i,t-1} + \varepsilon_{i,t} \qquad (9)$$

[16] In the following analysis time dummies have not been subtracted since common time effects are almost certainly macroeconomic and thus directly controlled for in the model.

Including fixed effects and time trends changes the asymptotic distribution and increases the critical values of the unit root statistic. This is because in the presence of a unit root, the sample average of a variable with a stochastic trend $\bar{y}_i = \frac{1}{T}\sum_{t=1}^{T} y_{i,t}$ does not converge to the population mean with increasing *T*.[17] In Pedroni (1999) seven test statistics are proposed. For our purpose we decided to use the multivariate extensions of the Phillips-Perron Roh (PPr) and Phillips-Perron t (PPt) statistic which are both nonparametric and do not require the slope coefficients of the regression residuals to be homogeneous for all i in the case of the alternative hypothesis of cointegration. Pedroni (2000, 2004) shows that under general requirements the test statistics follow a normal distribution as T and N grow large. We test two models, both include supply and demand variables but focus on different aspects of the theoretical model.[18] The smaller model (**model I**) tests on cointegration between house prices, industrial production as well as short-run and long-run interest rates. This model therefore concentrates on the relationships of the two interest rates. The second model (**model II**) confirms the effects of economic activity by including money supply and employment as economic activity variables but also includes the long-run interest rate and construction costs. Table 2 shows the cointegration test results from the PPr and PPt test.

<<Table 2 about here >>

All values are larger than 1.65 so that the null hypothesis of no cointegration is rejected and house prices are cointegrated with the industrial production, money supply, employment, the short-term and the long-term interest rate, and construction costs.

---

[17] In fact, it can be shown that the sample mean diverges at a rate $\sqrt{T}$.

[18] Our experience was that the regression estimations below produce bad results for more than 4 variables. Multicollinearity, which is strong e.g. between economic activity variables such as industrial production and money supply may be a reason.

4.3 Cointegration Vector Estimates

Estimating long run relationships in panel data requires considering correlation in the time series and endogeneity of the variables. Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimators which augment the conventional OLS parameter to take serial correlation and endogeneity of the variables into account have been introduced by Phillips and Moon (1999) and Pedroni (2000, 2004). The well-known panel OLS estimator of β is:

(10) $$\hat{\beta}_{OLS} = \frac{\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{i,t}-\overline{x}_i\right)\left(y_{i,t}-\overline{y}_i\right)\right]}{\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{i,t}-\overline{x}_i\right)\left(x_{i,t}-\overline{x}_i\right)'\right]}$$

with $\overline{x}_i$ as the average $T^{-1}\sum_{t=1}^{T} x_{i,t}$ of the regressor and $\overline{y}_i$ as the average $T^{-1}\sum_{t=1}^{T} y_{i,t}$ of the regressand. The FMOLS estimator can then be expressed as:[19]

(11) $$\hat{\beta}_{FMOLS} = \frac{\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\left(x_{i,t}-\overline{x}_i\right)s_{i,t}^{*}-T\Theta_{xy}\right)\right]}{\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{i,t}-\overline{x}_i\right)\left(x_{i,t}-\overline{x}_i\right)'\right]}$$

with $s_{i,t}^{*}=\left(s_{i,t}-\overline{s}_i\right)-\frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}}\Delta x_{it}$ and $\Theta_{xy}\equiv\hat{\Gamma}_{21i}+\hat{\Omega}_{21i}^{0}-\frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}}\left(\hat{\Gamma}_{22i}+\hat{\Omega}_{22i}^{0}\right)$. The variables Ω_{lji}^{0} and Γ_{lji} are the contemporaneous covariance and the weighted sum of the autocovariances of the long-run covariance matrix Ω, respectively.

[19] For the exact mathematical drivation the reader is referred to Pedroni (2000, 2004).

The DOLS estimator first augments the regression equation by adding leads and lags of the differences of the regressors: $hp_{it} = \alpha^* + \beta^{*\prime} x_{it} + \sum_{k=-K_i}^{K_i} \vartheta_{ik} \Delta x_{it-k} + \varepsilon_{it}^*$. The DOLS estimator is then constructed as:

(12) $$\hat{\beta}_{DOLS} = \frac{\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\left(x_{i,t} - \bar{x}_i\right)\tilde{s}_{i,t}\right)\right]}{\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{i,t} - \bar{x}_i\right)\left(x_{i,t} - \bar{x}_i\right)'\right]}.$$

Both estimators can now be interpreted like a normal panel OLS estimator. If all variables are in logs, $\hat{\beta}_{FMOLS}$ and $\hat{\beta}_{DOLS}$ show the average long-term percentage change of the regressand for a one percentage change in the regressor. The FMOLS estimates of model I for each of the fifteen countries and for the whole panel are shown in table 3.

<< Tabel 3 about here >>

The coefficients for the whole group all show the expected sign and are highly significant. Industrial production has a positive impact on house prices through higher demand whereas higher long-term interest rates lead to capital switching into fixed income assets and thus reduce demand for houses and decrease house prices. For example, an increase in long-term interest rates by 1 % decreases house prices on averages by 0.29 %. The overall effects of the short-term interest rate are positive, suggesting that γ_2 is larger than β_4, i.e. the cost effect for the house builder weighs more than the mortgage effect for the house owner. Note however that many parameters are imprecisely estimated and that the US and Italy have in fact negative coefficients. This is plausible, since adjustable rate mortgages are the preferred type in the US and Italy (see Paiella and Pozzolo 2007). The results are generally confirmed when comparing them with the DOLS estimated in Table 4 although the interest rate effects are now larger and the impact of industrial production appears to be very low. The panel group results for the DOLS estimates are not the averages of the individual results as in the case of the FMOLS method but are weighted by the precision of its estimate, thus giving more weight to the more stable estimates.

<< Table 4 about here >>

In Table 5, economic activity measured by money supply and employment have much higher effects on housing prices compared to model I. Instead of the monetary costs from increasing short-term interest rates we now model the costs of labor and material by the construction cost index.

<< Table 5 about here >>

As expected, an increase in construction costs leads to an increase in house prices as the supply of houses decreases. The effects of the long-term interest rate are somewhat lower than in model I. This can also be seen in Table 6 which shows the DOLS results of model II. Except for the interest rate effect of -0.36 which is larger in absolute terms than the FMOLS estimates of -0.05, all other parameters are estimated somewhat lower than in the FMOLS equation.

<< Table 6 about here >>

Despite the differences in parameter values between methods, model specifications, and individual countries the overall performance is satisfying and the theoretical model is strongly supported by all four models.

4.4 Error Correction Model

After having analyzed the long run impact of the macroeconomic variables on the housing market, one could ask how long it would take for the housing market to reach the equilibrium position once it has deviated from equilibrium due to an exogeneous shock to the economy. For this reason, an Error Correction Model (ECM) which models the adjustment process to equilibrium has been estimated. The deviations from the equilibrium can be expressed as:

(13) $$ecm^1_{it} = hp_{it} - \beta_1 rip_{it} - \beta_2 short_{it} - \beta_3 long_{it}$$ **(model I)**

(13)' $$ecm^2_{it} = hp_{it} - \delta_1 rmoney_{it} - \delta_2 employ_{it} - \delta_3 constr_{it} - \delta_4 long_{it}$$ **(model II)**

Where the β_i and the δ_i are the corresponding FMOLS and DOLS parameter estimates of model I and model II, respectively. If the variables are in equilibrium, the error correction term ecm^j_{it} is zero. If the variables deviate from equilibrium, for example if the house prices hp_{it} are too high relative to their equilibrium position, then the error term is positive. In this situation, hp_{it} will decrease in the following periods until the equilibrium is reached. This adjustment process can be estimated by including the lagged error term in a panel regression with random effects.[20] Since the panel regression has to be estimated with stationary variables, all variables except the error term are included as *dlogs*:

(14) $$\Delta \log hp_{it} = \hat{\alpha}_{0i} + \sum_{j=1}^{K} \hat{\alpha}_{1ij} \Delta \log hp_{it-j} + \sum_{n=0}^{N} \hat{\alpha}_{2in} \Delta \log prod_{it-n} + \sum_{s=0}^{S} \hat{\alpha}_{3is} \Delta \log (1 + short)_{it-s} + \sum_{m=0}^{M} \hat{\alpha}_{4im} \Delta \log (1 + long)_{it-m} + \hat{\alpha}_{5i} ecm^1_{it-1} + \varepsilon_t$$ **(model I)**

(14)' $$\Delta \log hp_{it} = \hat{\gamma}_{0i} + \sum_{j=1}^{K} \hat{\gamma}_{1ij} \Delta \log hp_{it-j} + \sum_{n=0}^{N} \hat{\gamma}_{2in} \Delta \log rmoney_{it-n} + \sum_{s=0}^{S} \hat{\gamma}_{3is} \Delta \log employ_{it-s} + \sum_{m=0}^{M} \hat{\gamma}_{4im} constr_{it-m} + \sum_{p=0}^{P} \hat{\gamma}_{5ip} \log (1 + long)_{it-p} + \hat{\alpha}_{5i} ecm^2_{it-1} + e_t$$ **(model II)**

Lagged house prices hp_{it} can also be included on the right hand side of the equation. The error term has to be included with lag 1 since the deviation from equilibrium in the period *t*-1

[20] Individual effects α_i represent country specific regulatory variables and mortgage market characteristics which can be regarded as being uncorrelated with the macroeconomic variables. Therefore, we use random effects rather than fixed effects although for large *T* (130 in our case) both estimators give similar results. See Hsiao (2003).

starts the adjustment process in period *t*. The other exogeneous variables can be included in any combination of different lag settings. Table 7 shows the error correction model for both models and both estimation procedures.

<< Table 7 about here >>

As can be seen, the error correction term has the right sign and is highly significant. If house prices are too high reflected by a positive error term, the negative coefficient reduces house prices in the following periods until they are in equilibrium. The value of the error term, however, ranges only between -0.011 and -0.043 indicating that deviations from equilibrium are quite persistent. Calculating the approximate adjustment time by $1/ecm(-1)$ this corresponds to a range of 23 to 6 years. The long adjustment periods are probably due to the general downward price stickiness and differences among countries may arise due to differences in micro factors. Considering that the time period from the planning and permission stage until completion can take quite a few years, 6 years seem to be reasonable whereas adjustment periods of more than 9 years are not. Most of the coefficients of the other variables are also significant and have the expected sign.

5. Conclusion

This study examines the impact of the macroeconomy on house prices. Housing market data is often not easily available or covers only short time periods. By using a panel of 15 countries over a period of over 30 years allows for the robust estimation of long-term macroeconomic impacts.

In this context standard theoretical equilibrium models are clearly supported by the empirical results and suggest that macroeconomic variables do have a significant impact on house prices. In particular, economic activity variables such as employment, industrial production, and money supply increase the demand for houses and thus house prices. An increase in the short-term interest rate also affects house prices positively by increasing financing costs and thus reducing housing construction, leading to an increase in rents and thus in house prices. An increase in the long-term interest rate makes other fixed income assets more attractive relative to residential property investment, reducing the demand for this kind of investment which in turn lowers house prices.

Although the results are similar over different estimation equations and methods there is also a high degree of variation in the findings for individual countries. This can be generally traced back to differences that exist on the micro level such as different regulatory settings and mortgage market characteristics. Short-run deviations from the long-run equilibrium result in several years of adjustment until all variables are back in equilibrium.

References

Bowen, A. (1994), “Housing and the Macroeconomy in the United Kingdom”, *Housing Policy Debate*, 5(3), 241-251.

Case, K.E. (2000), “Real Estate and the Macroeconomy”, Brookings Papers on Economic Activity, Wellesley College.

Case, K.E., Quigley, J.M., and Shiller, R.J. (2000), “Comparing Wealth Effects: The Stock Market versus the Housing Market.”, *Advances in Macroeconomics*, 5(1), 1-32.

Catte. P., N. Girouard, R. Price, and C. Andre (2004), “Housing Markets, Wealth and the Business Cycle”, OECD Working Paper, No. 394.

Cocco, J.F. (2005), “Portfolio Choice in the Presence of Housing”, *The Review of Financial Studies*, 18(2), 535-567.

Choi, I. (2001), “Unit Root Tests for Panel Data”, *Journal of International Money and Finance*, 20, 294-272.

DiPasquale, D., and W.C. Wheaton (1996), “Urban Economics and Real Estate Markets“, Prentice Hall, Englewood Cliffs, New York.

Engle, R.F., and C.W.J. Granger (1987), “Co-Integration and Error-Correction: “Representation, Estimation and Testing”, *Econometrica*, 55, pp. 251-276.

Glaeser, L.E. (2000), Comments and Discussion on: Case, K.E. (2000), “Real Estate and the Macroeconomy”, Brookings Papers on Economic Activity, Wellesley College.

Hsiao, C. (2003), “Analysis of Panel Data”, 2nd ed., Cambridge University Press, Cambridge.

Im, K., H. Pesaran, and Y. Shin (1997), “Testing for Unit Roots in Heterogeneous Panels”, Discussion Paper, University of Cambridge, June.

Johansen, S., and K. Juselius (1990), "Maximum Likelihood Estimation and Inference: On Cointegration- with Applications to the Demand for Money", *Oxford Bulletin of Economics and Statistics*, 52, 162-210.

Leung, C. (2004), "Macroeconomics and Housing: a Review of the Literature", *Journal of Housing Economics*, 13, 249-267.

Levin, A., and C. Lin (1993), "Unit Root Tests in Panel Data: Asymptotic and Finite-SampleProperties", University of California, San Diego Discussion Paper, December.

Maddala, G..S., and S. Wu (1999), "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test", *Oxford Bulletin of Economics and Statistics*, 22, 631–652.

Meen, G. (1996), "Ten Propositions in UK Housing Macroeconomics: An Overview of the 1980s and Early 1990s", *Urban Studies*, 33(3), 425–444.

Paiella, M., and A.P. Pozzolo (2007), "Choosing between Fixed and Adjustable Rate Mortgages", Unpublished Working Paper at http://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID976346_code193151.pdf?abstractid=976346&mirid=3.

Parker, J.A. (2000), Comments and Discussion on: Case, K.E. (2000), "Real Estate and the Macroeconomy", *Brookings Papers on Economic Activity*, Wellesley College

Pedroni, P. (1999), "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors", *Oxford Bulletin of Economics and Statistics*, 22, 653-670.

Pedroni, P. (2000),"Fully Modified OLS for Heterogeneous Cointegrated Panels", *Advances in Econometrics*, 15, 93-130.

Pedroni, P. (2004), “Panel Cointegration; Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with an Application to the PPP Hypothesis”, *Econometric Theory*, 20, 325-597.

Phillips, P.C.B., and H. Moon (1999), “Linear Regression Limit Theory for Nonstationary Panel Data”, *Econometrica*, 67, 1057-1111.

Quah, D. (1994), “Exploiting Cross-Section Variation for Unit Root Inference in Dynamic Data”, *Economics Letters*, 44, 9-19.

Zuh, H. (2003), “The Importance of Property Markets for Monetary Policy and Financial Stability”, BIS Working Paper 21.

Figure 1: The Impact of Macroeconomic Variables on Real House Prices.

Notes: The upper panel shows an increase in economic activity, the central panel shows the effects of an increase in long-term interest rates. The lower panel shows the effects of an increase in short-term interest rates and general construction costs.

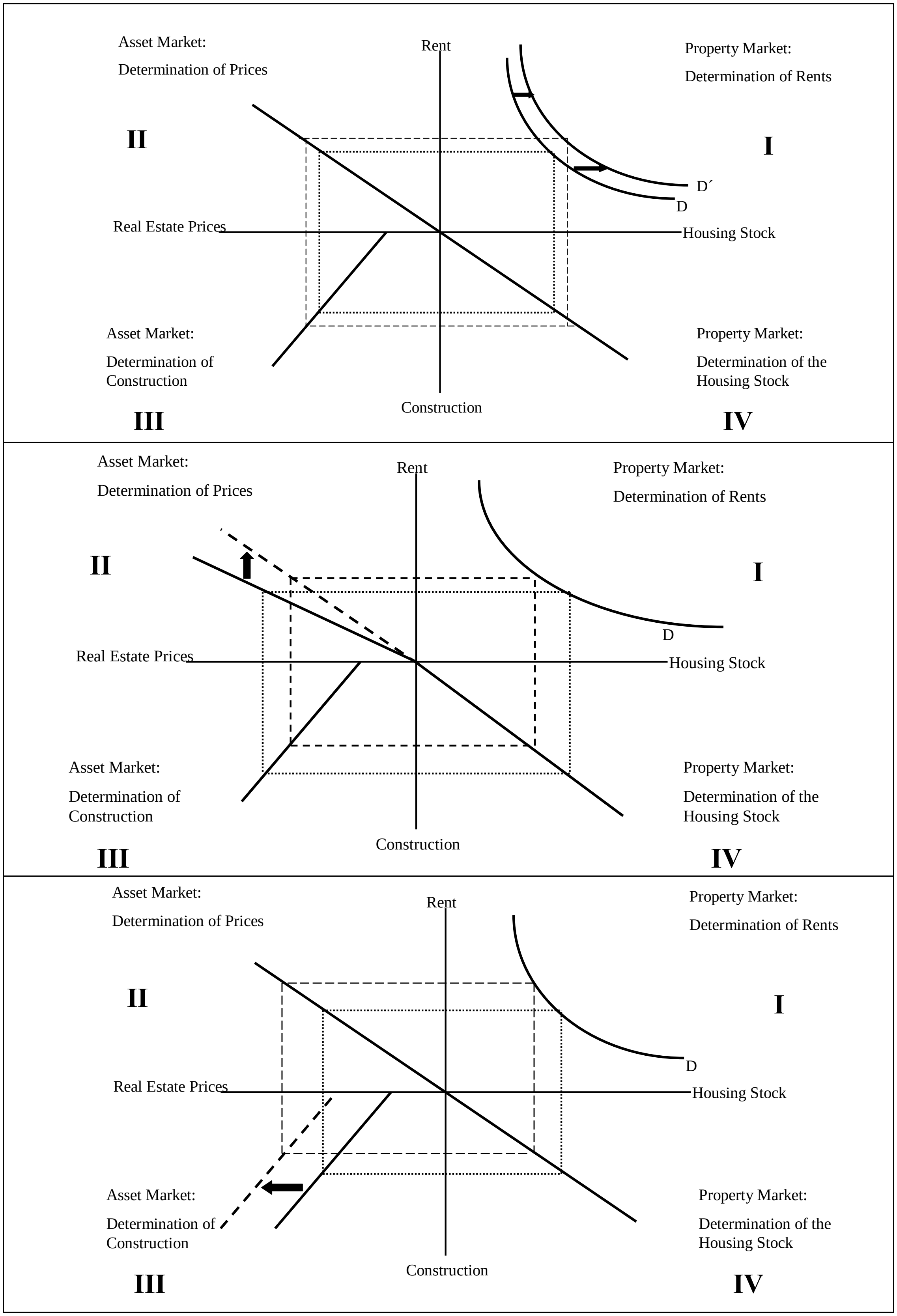

Figure 2: Log Real House Prices 1975Q1 – 2007Q2

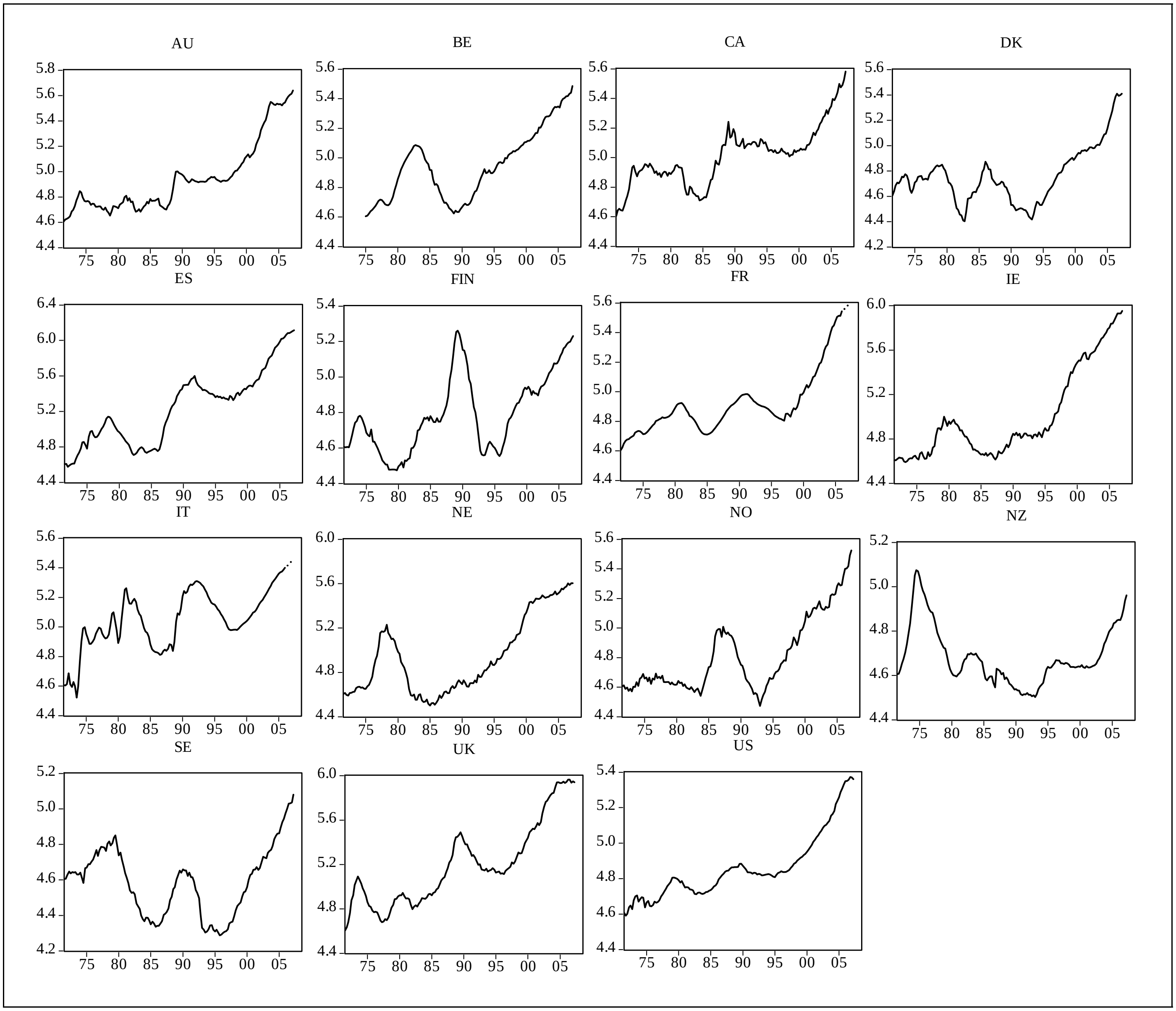

Table 1: Phillips-Perron Panel Unit Root Test

Notes: The Fisher PP test statistic follows a Chi-square distribution. The Choi PP test statistic is normally distributed. The left tail of the normal distribution is used to reject the null hypothesis of non stationarity so that values smaller than -1.65 indicate stationarity. For the bandwith selection the Newey-West bandwith using Bartlett kernel is applied. ***, ** and * for significance on the 1%, 5% and 10% level, respectively.

Variable	Fisher PP test statistics		Choi PP test statistics	
	Drift	Drift and Trend	Drift	Drift and Trend
log real house prices	8.80	5.65	6.72	5.53
log real money supply	2.87	8.86	9.44	4.33
log real industrial prod.	40.53*	63.60***	0.63	-2.13**
log (1+real short-term interest rate)	19.01	62.27**	1.61	-3.41***
log (1+nominal long-term interest rate)	7.06	45.28**	3.62	-2.71***
log employment	8.49	15.01	5.99	2.31
log construction costs	32.71	56.16***	0.90	1.30
Δlog real house prices	580.1***	544.18***	-21.93***	-21.07***
Δlog real money supply	656.42***	659.23***	-23.11***	-23.14***
Δlog real industrial production	849.96***	819.14***	-26.97***	-26.39***
Δlog (1+real short-term interest rate)	914.80***	907.88***	-27.86***	-27.99***
Δlog (1+nominal long-term interest rate)	626.16***	565.51***	-22.72***	-21.31***
Δlog employment	479.9***	435.2***	-18.12***	-16.91***
Δlog construction costs	682.8***	653.8***	-23.67***	-23.24***

Table 2: Cointegration Test Results

Notes: The test statistics are distributed $N(0,1)$. ***, ** and * for significance on the 1%, 5% and 10% level, respectively.

Test Statistic	**PPr**	**PPt**
Model I	2.74^{***}	1.76^{*}
Model II	4.15^{***}	5.04^{***}

Table 3: FMOLS Estimates – Model I

Notes: *t*-statistics in brackets. ***, ** and * for significance on the 1%, 5% and 10% level, respectively; observation period from 1975Q1 to 2007Q2; country codes are ISO standard.

Country	log real industrial production	log(1+long-term interest rate)	log(1+real short-term interest rate)
US	0.63*** [5.91]	0.81*** [3.26]	-0.85*** [-3.92]
FR	1.42** [2.24]	-0.35 [-1.56]	0.06 [0.55]
GB	0.13 [0.25]	-1.23*** [-4.54]	0.50*** [3.09]
IT	-1.99*** [-5.68]	0.09 [1.04]	-0.16*** [-3.02]
CA	-0.29*** [-2.61]	-0.53*** [-4.44]	0.08 [1.02]
ES	1.34** [1.98]	0.12 [0.48]	-0.10 [-0.79]
AU	2.08*** [4.66]	-0.15 [-0.65]	0.28** [2.29]
NE	-4.27*** [-7.90]	-0.13 [-1.04]	0.16*** [2.70]
BE	1.46*** [4.10]	0.28 [1.33]	-0.16 [-1.59]
SE	0.37** [2.13]	-0.54*** [-2.94]	0.05 [0.39]
DK	1.40*** [4.54]	-0.52*** [-3.84]	0.20*** [3.56]
NO	-2.05*** [-3.79]	-0.20 [-1.02]	-0.14 [-1.16]
FIN	1.04*** [6.35]	-1.24*** [-17.25]	0.91*** [21.47]
NZ	-0.14 [-1.02]	-0.48*** [-4.12]	0.30*** [3.62]
IE	0.51*** [8.75]	-0.27*** [-4.49]	0.11*** [3.54]
Panel Group FMOLS Results			
Coefficient	0.11*** [5.14]	-0.29*** [-10.28]	0.08*** [8.20]

Table 4: DOLS Estimates – Model I

Notes: *t*-statistics in brackets. ***,** and * for significance on the 1%, 5% and 10% level, respectively; observation period from 1975 Q1 to 2007 Q2; country codes are ISO standard. The panel group DOLS results are computed by weighting each country by the precision of its estimates.

Country	log real industrial production	log(1+long term interest rate)	log(1+real short term interest rate)
US	0.67*** [3.98]	1.03*** [2.19]	-1.03*** [-2.70]
FR	0.08 [1.10]	-0.73*** [-2.54]	0.07 [0.40]
GB	-0.13 [-0.24]	-1.41*** [-4.49]	0.61*** [3.16]
IT	-2.85*** [-2.92]	-1.38*** [-4.32]	0.59*** [2.99]
CA	-0.39*** [-3.74]	-0.42*** [-3.04]	-0.02 [-0.21]
ES	0.30*** [4.86]	0.00 [0.02]	-0.17 [-1.30]
AU	-0.28*** [-2.70]	-0.86*** [-3.64]	0.16 [1.02]
NE	-0.37*** [-3.41]	-1.35*** [-6.74]	0.13 [1.24]
BE	1.56*** [3.35]	0.59* [1.70]	-0.33* [-1.86]
SE	0.29*** [4.64]	-0.31* [-1.77]	-0.06 [-0.48]
DK	0.03 [0.28]	-0.57 [-1.25]	-0.05 [-0.22]
NO	0.29*** [4.07]	-0.06 [-0.32]	-0.19* [-1.73]
FIN	0.25*** [3.27]	-0.92*** [-5.18]	0.00 [-0.01]
NZ	-0.48*** [-3.03]	-1.24*** [-9.93]	0.83*** [8.06]
IE	0.00 [-0.15]	-0.91*** [-14.10]	0.20*** [2.99]
Panel Group DOLS Results			
Coefficient	0.03*** [2.41]	-0.64*** [-13.79]	0.17*** [2.93]

Table 5: FMOLS Estimates – Model II

Notes: *t*-statistics in brackets. ***, ** and * for significance on the 1%, 5% and 10% level, respectively; observation period from 1975Q1 to 2007Q2. Country codes are ISO standard. The panel group DOLS results are computed by weighting each country by the precision of its estimates.

Country	log real money supply	log employment	log construction costs	log(1 + long-term interest rate)
US	-0.11 [-0.56]	1.01*** [5.08]	1.50*** [4.17]	-0.17*** [-2.56]
FR	0.68** [2.24]	1.21* [1.74]	0.76 [1.35]	0.01 [0.14]
GB	-0.20 [-1.01]	2.80*** [2.49]	2.73*** [8.63]	0.06 [0.47]
IT	0.60*** [4.51]	0.75 [1.58]	2.26*** [10.11]	0.07* [1.79]
CA	0.09 [0.53]	-0.12 [-0.52]	-2.77*** [-3.75]	-0.11 [-0.57]
ES	-0.06 [-1.01]	2.46*** [3.98]	-0.51 [-1.09]	-0.52*** [-9.44]
AU	-0.17 [-0.98]	0.55 [0.65]	1.09*** [4.86]	-0.19* [-1.83]
NE	0.34*** [3.28]	1.33*** [3.42]	0.44 [1.53]	-0.22*** [-3.47]
BE	2.31*** [17.65]	-1.61*** [-3.11]	-0.20 [-1.66]	-0.07 [-1.55]
SE	0.72*** [3.55]	-1.36*** [-2.35]	3.26*** [5.81]	-0.04 [-0.97]
DK	0.61*** [6.23]	5.20*** [10.65]	-0.84*** [-4.73]	-0.03 [-0.42]
NO	0.00 [-0.01]	0.96 [1.51]	0.98*** [7.65]	0.05 [1.31]
FIN	0.96*** [8.94]	1.66*** [8.76]	1.79*** [9.92]	0.34*** [7.33]
NZ	-0.26*** [-9.02]	1.77*** [19.77]	0.27*** [7.16]	0.15*** [7.74]
IE	-1.18*** [-6.58]	6.50*** [11.36]	0.71*** [12.99]	-0.08 [-1.36]
Panel Group FMOLS Results				
Coefficient	0.29*** [7.17]	1.54*** [16.79]	0.76*** [16.26]	-0.05 [-0.87]

Table 6: DOLS Estimates Model II

Notes: *t*-statistics in brackets. ***, ** and * for significance on the 1%, 5% and 10% level, respectively. Observation period from 1975Q1 to 2007Q2. Country codes are ISO standard. The panel group DOLS results are computed by weighting each country by the precision of its estimates.

Country	log real money supply	log employment	log construction costs	log(1+ long term interest rate)
US	0.08 [0.31]	0.74*** [2.81]	1.77*** [3.65]	-0.19*** [-2.54]
FR	1.32*** [6.26]	-0.46** [-2.3]	-0.03 [-0.06]	-0.13 [-1.18]
GB	-0.14 [-0.51]	-0.13 [-0.5]	1.41*** [2.41]	-0.51** [-2.20]
IT	0.65*** [8.46]	-0.22 [-1.28]	0.04 [0.23]	0.14*** [2.43]
CA	0.41*** [3.63]	0.22 [1.56]	0.51*** [2.52]	-0.11 [-1.04]
ES	0.45*** [4.73]	0.25* [1.79]	0.19 [1.11]	-0.66*** [-6.81]
AU	-0.89*** [-5.99]	0.09 [0.42]	1.27*** [5.13]	-1.17*** [-7.55]
NE	0.63*** [4.26]	0.31** [2.03]	-0.16*** [-2.31]	-0.49*** [-3.83]
BE	0.94*** [5.42]	-0.26* [-1.81]	-0.17 [-1.59]	-0.28*** [-3.48]
SE	0.54*** [2.51]	-1.74*** [-3.13]	3.90*** [5.79]	-0.03 [-0.61]
DK	0.05 [0.85]	4.88*** [7.13]	0.05 [0.19]	-0.30** [-2.92]
NO	0.03 [0.09]	1.43*** [3.16]	0.83*** [8.37]	0.01 [0.08]
FIN	0.58*** [3.11]	1.13*** [2.48]	0.64*** [5.10]	-0.22 [-1.44]
NZ	-0.2*** [-2.58]	1.12*** [6.11]	0.65*** [2.60]	-0.16*** [-2.60]
IE	-0.34** [-2.07]	1.49*** [4.19]	-0.47*** [-3.57]	-0.44*** [-4.82]
		Panel Group DOLS Results		
Coefficient	0.22*** [7.35]	0.26*** [5.85]	0.18*** [7.63]	-0.36*** [-9.94]

Table 7: Error Correction Model for the Adjustment Process of International House Prices

Notes: Random effects panel regression with Huber-White robust standard errors and *t*-statistics in brackets. ***, ** and * for significance on the 1%, 5% and 10% level, respectively.

Variable	**Model I**		**Model II**	
	FMOLS	**DOLS**	**FMOLS**	**DOLS**
Constant	0.002*** [0.001]	0.002*** [0.001]	0.001 [0.000]	0.000 [0.001]
$\Delta \log hp(-1)$	0.268*** [0.036]	0.257*** [0.036]	0.279*** [0.035]	0.275*** [0.036]
$\Delta \log hp(-3)$	0.131*** [0.032]	0.123*** [0.032]	0.118*** [0.032]	0.116*** [0.033]
$\Delta \log hp(-4)$	0.32*** [0.036]	0.316*** [0.036]	0.306*** [0.039]	0.310*** [0.041]
$\Delta \log prod$	0.067** [0.03]	0.068** [0.03]	-	-
$\Delta \log(1+long)$	-0.005 [0.008]	-0.005 [0.008]	-	-
$\Delta \log(1+long)(-2)$	-	-	-0.035*** [0.008]	-0.034*** [0.008]
$\Delta \log(1+short)$	0.011*** [0.003]	0.01*** [0.003]	-	-
$\Delta \log rmoney$	-	-	0.091*** [0.031]	0.089*** [0.032]
$\Delta \log rmoney(-1)$	-	-	0.050** [0.025]	0.054** [0.027]
$\Delta \log employ$	-	-	0.07 [0.076]	0.094 [0.077]
$\Delta \log constr$	-	-	0.074*** [0.022]	0.069*** [0.023]
$\boldsymbol{ecm(-1)}$	-0.030*** [0.004]	-0.026*** [0.004]	-0.043*** [0.008]	-0.011*** [0.004]
Adjusted R^2	0.33	0.33	0.39	0.37