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The Diversification Benefits of Free Trade in House Value

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Abstract
This paper finds that homeowners could substantially reduce house price risk if they would reinvest their housing wealth in a market portfolio of houses. Free trade in the value of the house among homeowners would allow them to do so. To quantify the diversification benefits of free trade in house value, we estimate simple CAPM and APT models based on a detailed panel dataset of house price changes in the Netherlands. We find that about 92 to 96 percent of house price risk is diversifiable. In most cases, these diversification benefits outweigh the hedging effectiveness of house price futures.

Keywords: house price risk, free trade, financial market, diversification, futures

JEL classification: G10; G11; G15; R30

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1. Introduction

The recent decline in house prices in many countries has served as a reminder that house price risk may be substantial and that the consequences of this risk may be severe. House price risk is relatively high for homeowners in comparison to standard institutional investors since the typical homeowner cannot adequately diversify the housing investment across locations or market segments. As a result, Case et al. (1991) and Shiller (2008) have advocated the establishment of derivatives markets for home prices. They argue that homeowners could sell futures based on house price indices to hedge their exposure to house price risk. Although the establishment of derivative markets deals with the problem of the sizeable transaction costs associated with investing in a diversified housing portfolio, it still ignores another main reason as to why house price risk is relatively high for homeowners. This risk is high because most homeowners only invest in a single house. In particular, the indivisibility of the housing investment impairs the homeowners' investment allocation, especially since the typical homeowner has only limited wealth to invest in housing. As a result, a homeowner usually does not hold a diversified housing portfolio.

The aim of this paper is to investigate the reduction in house price risk (diversification benefits) if a homeowner could reinvest his housing wealth in a market portfolio of houses. We argue that free trade in house value would allow homeowners to invest in each other's property and, consequently, to diversify (share) house price risk. Homeowners could freely trade in the value of the house if the housing investment would be divisible and transaction costs would be low. A housing stock market could, for example, facilitate such trade.[1] Since free trade in house value currently does not exist, the analysis in this paper is a counterfactual analysis.

To quantify the diversification benefits, we estimate Capital Asset Pricing Method (CAPM) and Arbitrage Pricing Theory (APT) models. Although it is common in the finance literature to investigate diversification benefits and hedging effectiveness using these models, these methods have not been widely applied in a housing market setting.[2] To estimate these models, we use a dataset of quarterly house price changes per municipality and type of house in the Netherlands between 1995 and 2008. The main advantages of this dataset are twofold. First, this dataset contains house price data per type of house. As a result, we can also

[1] This paper does not discuss in detail how such a stock market could be established. Rather, our results are simply meant to provide empirical evidence about the usefulness of a financial market to deal with house price risk. For a short discussion, see the conclusion and discussion section.

[2] In a notable exception, Case et al. (2009) estimate housing CAPM models and APT models based on quarterly house price returns at the MSA level. They show that there is a strong positive risk-return relationship in the US housing market.

investigate diversification across market segments. Second, the Netherlands may be comparable to large MSAs such as the New York MSA.[3] Hence, the analysis in this paper may be interpreted as a highly detailed within-MSA analysis. By contrast, most previous studies have focused on cross-MSA house price variation (e.g. Sinai and Souleles, 2009; Case et al., 2009). However, since most households move within MSAs, it is especially the variation in house price changes within MSAs that contributes to the risk of owning a home.

To compare our results with the risk-reducing benefits of a derivatives market, we also discuss the effectiveness of hedging with house price futures. The diversification benefits of free trade in house value are expected to be high based on a country-wide portfolio of houses. Instead, hedging with futures may be more effective if those futures are based on highly disaggregate (regional) house price indices. Hence, our research also provides novel evidence about the risk-reducing benefits of diversification versus the hedging effectiveness of house price futures.

The remainder of this paper is organized as follows. Section 2 discusses the previous literature. Section 3 presents the data and methodology. Section 4 reports the regression results. Section 5 concludes.

2. Previous literature

In a remarkable feat of foresightedness, Case et al. (1991) already advocated the establishment of derivative markets for home prices during the 1990s:

"We need instead some other medium, that allows real estate owners to hedge the risk of their real estate while at the same time owning the real estate. What is needed is some market that stands between individual property owners and broader portfolio investors, allowing the portfolio investors to share the risk of the property without owning it. What is needed, inherently, are future and option markets cash settled on indexes of real estate prices." (Case et al, 1991, p. 6)

In recent years, this idea has gained renewed momentum as a result of the impact of the subprime crisis (i.e. see Shiller, 2008). To some extent, homeowners could have reduced their house price risk by option or futures contracts based on house price indices.[4] [5] In particular, homeowners could sell house price futures to institutional investors as a hedge against house price risk. Bertus et al. (2008) show that such a strategy (trade of futures on the Chicago

[3] For instance, the population in the Netherlands is about 16.5 million in 2009, which is comparable to the number of people in the New York MSA of about 19 million in 2009. In addition, the Netherlands consists of an urban core and a pheriphery. A typical MSA has a similar structure.

[4] For a discussion of futures based on the OFHEO index in the US, see Deng and Quigley (2008).

[5] Hinkelman and Swidler (2008) show that existing CME futures contracts do not provide an effective hedge. As a result, they argue that futures based on house price indices may provide homeowners with a valuable hedging opportunity. Alternatively, Englund et al. (2002) find that homeowners can also hedge their lumpy investment in housing (i.e. in Stockholm) with stock and bonds.

Mercentile Exchange (CME)) could have reduced the homeowner's house price risk by about 88 percent in Las Vegas over the period 1994-2006. In addition, Quigley (2006) finds that futures markets based on house price indexes could have increased portfolio returns for European investors by several percentage points at the same level of risk.

It is fair to say that real estate derivative markets are still not widely used by homeowners. In many countries these markets do not exist (anymore) or they are still of minor importance.[6] De Jong et al. (2008) provide a possible reason why house price derivatives markets have failed to take off. They argue that futures based on the Case-Shiller city price index in the US may not be effective hedging instruments since the expected returns on these futures is positive (and homeowners would in general short sell futures). Moreover, they find that the idiosyncratic risk within a city is too large to use futures as an effective hedging strategy.

An alternative explanation for the absence of a fully functioning derivatives market based on house prices may be the hedging benefits of homeownership (i.e. see Sinai and Souleles, 2009). In particular, the current home may be used as a hedge against future housing costs. Specifically, a change in the price of the current home may cancel out the change in the price of the future home. Since selling futures may lead to a similar negative exposure as buying a new home, the use of both hedging instruments may easily "unhedge" the homeowner (Sinai and Souleles, 2009).

There are two notable differences between hedging with futures and hedging with the current house. First, a futures contract needs to be financed by own cash/savings, while a new home may be partly financed by the old home (and a mortgage). Since the housing investment is usually too large to be fully paid by the homeowner himself, the typical homeowner may not have enough additional private wealth to fully hedge his exposure to house price risk with futures. A second difference is that the choice of investing in a house is also based on housing consumption. In particular, there may be a consumption demand and an investment demand for housing (i.e. see Ioannides and Rosenthal, 1994). Part of the investment demand may even be hedging demand (i.e. see Cocco, 2000; Han, 2008; Sinai and Souleles, 2009). As a result, the "natural" hedge against house price risk is likely to be imperfect since the investment decision may well be distorted by the housing consumption choice.

[6] In 2001, the firm City Index introduced spread betting based on house prices in London, while IG Index launched its own spread betting in 2002. Both markets were closed by 2004. In May 2006, the CME introduced house price options and futures. However, until November 2007 the notional value of these contracts only reached about 612 million dollars (for a discussion see Shiller, 2008). In March 2009, the Frankfurt-based Eurex started its trade in house price futures (for commercial real estate). Until August 2009, the value of the traded future contracts was only 15 million euros (see Piazolo, 2010).

Finally, Caplin et al. (2003) have argued for insurance against decreases in house prices. The problem with this approach is that the investment and the risk associated with this investment may be so substantial that it is questionable whether homeowners can afford the insurance premium to insure against house price risk. In addition, if there is a market bust, the financial burden on insurance companies may simply become too high to bear. Consequently, it may be too risky to provide such insurance to homeowners in the first place.

The studies mentioned above discuss some of the possibilities to reduce house price risk. In particular, a homeowner has invested in his current home and he may insure, hedge, or diversify (with other assets), his exposure to house price risk. Nevertheless, all of these studies are based on the fact that the housing investment is fixed. That is, the housing investment itself is not diversified. In particular, two standard features of housing market models are that selling or buying a home is associated with substantial transaction costs and that the housing investment is indivisible (e.g. see Flavin and Nakagawa, 2008; Han, 2008). The second housing market feature suggests that homeowners need to invest a large sum of money to obtain a house at a particular location. Given the limited wealth of a household, a household may not freely diversify the housing investment across locations. Transaction costs add to the distortion in the investment allocation. Both of these housing market features make the housing investment illiquid (i.e. a lumpy investment). As mentioned, this paper investigates the diversification benefits of free trade in house value. As such, we do not necessarily argue for trade between individual homeowners and broader portfolio investors (i.e. Case et al., 1991), but we also emphasize the benefits of trade between individual homeowners.

3. Data and methodology

This paper uses quarterly house price changes in the Netherlands between 1995 and 2008. These price changes are based on the median house price per municipality i, type of house r, and time t. We used all administrative transaction prices of existing homes between 1995 and 2008 to calculate the median prices.[7] The median prices are based on at least 4 transaction prices. There are 5 types of houses available in the dataset: apartments, row/terraced houses, corner houses, semi-detached houses, detached houses. In what follows, we use for these types of houses the abbreviations AP, RH, CH, SH, DH, respectively. There are 441 municipalities in the Netherlands. Therefore, if there would be no missing observations, there

[7] By law, these prices were recorded by the Kadaster. The Kadaster provided the dataset to Statistics Netherlands. Statistics Netherlands granted us access to this dataset ("Bestaande Koopwoningen 200812V1").

should be 121,275 price change observations (55 quarters * 5 types of houses * 441 municipalities). However, due to missing values there are only 84,038 price change observations available in the dataset. The quarterly average number of municipalities with a non-missing house price change is 188 for apartments (RH: 376; CH: 303; SH: 326; DH: 334). The average time dimension of the return series is about 32 quarters for apartments (RH: 48; CH: 40; SH: 43; DH: 43).

Table 1: Descriptive statistics, quarterly house price changes and controls, 1995-2008

	Mean	Std. dev.	p25	p50	p75	Nr. Obs.
House price changes						
Apartments $\Delta \log p_{i,t,r=1}$ (x100%)	1.9	23.7	-4.2	1.5	7.8	10,327
Row houses $\Delta \log p_{i,t,r=2}$ (x100%)	1.7	10.7	-2.7	1.7	6.2	20,704
Corner houses $\Delta \log p_{i,t,r=3}$ (x100%)	1.7	13.8	-5.5	1.6	8.8	16,692
Semi-detached houses $\Delta \log p_{i,t,r=4}$ (x100%)	1.8	18.2	-6.8	1.7	10.2	17,922
Detached houses $\Delta \log p_{i,t,r=5}$ (x100%)	2.0	22.3	-10.5	2.0	14.3	18,393
All house types $\Delta \log p_{i,t,r}$ (x100%)	1.8	17.7	-5.5	1.7	9.1	84,038
Controls						
$\Delta \log GDP_t$ (x100%)	1.3	4.4	-2.5	2.3	5.8	84,038
I_t (Euribor, percentage)	3.8	1.2	2.7	3.8	4.5	84,038

Source: Houses prices are from the Kadaster, the GDP data is from Statistics Netherlands (GDP at market prices, current prices), the 3-month Euribor interest rate is taken from the OECD. Notes: This table is based on house price changes for 441 municipalities. The Euribor interest rate is a quarter-specific rate that is annualized.

Table 1 reports the descriptive statistics of the price changes per type of house and two control variables: GDP growth and the 3-month Euribor. Table 1 suggests that the average quarterly percentage return on houses has been about 1.8 percent. This return seems to be relatively high for detached houses (2.0 percent) and apartments (1.9 percent). In addition, the spread of returns for these two types of houses is also relatively high. Moreover, Table 1 shows that the quarterly nominal GDP growth is 1.3 percent and the quarterly 3-month Euribor interest rate (annualized) is 3.8 percent.

In this paper, we will also use house price changes for 40 standard regions (40 COROPs, NUTS-3 classification) in the Netherlands. The acronym COROP is named after the commission that defined these regions in 1971. These regions are in accordance with regional labor/housing markets in the Netherlands. The average quarterly price changes across

COROPs g, including the minimum and maximum regional return, is reported per type of house in Table 2.

Table 2: Descriptive statistics, quarterly house price changes across regions, 1995-2008

	Min.	Mean	Max.
House price changes			
Apartments $\overline{\Delta \log p}_{g,t,r=1}$ (x100%)	-2.1	1.9	5.6
Row houses $\overline{\Delta \log p}_{g,t,r=2}$ (x100%)	1.1	1.7	2.2
Corner houses $\overline{\Delta \log p}_{g,t,r=3}$ (x100%)	-0.1	1.7	2.2
Semi-detached houses $\overline{\Delta \log p}_{g,t,r=4}$ (x100%)	-0.4	1.8	2.6
Detached houses $\overline{\Delta \log p}_{g,t,r=5}$ (x100%)	-1.1	2.0	3.3

Notes: This table is based on average house price changes for 40 COROP regions.

Table 2 suggests that there is substantial heterogeneity in house price changes across regions. In particular, returns for apartments are highest at Kop van Noord-Holland (5.6 percent) and lowest at Noord-Drenthe (-2.1 percent). With regard to row houses, the quarterly price changes are highest at the region Het Gooi en Vechtstreek (2.2 percent) and lowest at Delftzijl en omgeving (1.1 percent). Corner houses seem to have a high return in Oost-Groningen (2.2 percent) and a low return in Zuid-West Friesland (-0.1 percent). Moreover, the region Noordoost-Noord Brabant has a relatively high return with regard to semi-detached houses (2.6 percent), while Delft en Westland has a relatively low return (-0.4 percent). Finally, the price changes of detached houses are highest at Delftzijl en omgeving (3.3 percent) and lowest at IJmond (-1.1 percent).

To investigate the diversification benefits of free trade in the value of the house, we estimate the following CAPM type of models:

$$\Delta \log p_{i,t,r} = \beta_{0,i,r} + \beta_{1,i,r} \overline{\Delta \log p}_{t,r} + \varepsilon_{i,t,r}, \qquad (1)$$

where $\Delta \log p_{i,t,r}$ is the difference in the logarithm (approximate percentage change) of the median transaction price at municipality i, time t, and of house type r, the term $\overline{\Delta \log p}_{t,r}$ is the cross-sectional average percentage price change, and $\varepsilon_{i,t,r}$ is the error term. To avoid endogeneity, $\Delta \log p_{i,t,r}$ is excluded from the cross-sectional average percentage price change for each i (we make this correction throughout this paper). We estimate equation (1) per municipality and type of house (i.e. time series regressions).

The size of $\beta_{1,i,r}$ captures the sensitivity of the house price changes per municipality to the fluctuations in the total housing market returns. Specifically, our estimates will suggest whether the housing investment in a municipality is an aggressive ($|\beta_{1,r,i}| > 1$) or defensive investment ($|\beta_{1,r,i}| < 1$) relative to the market portfolio. In addition, the total housing investment divided by the beta coefficient equals the total amount that an investor (e.g. homeowner) would need to invest in house price futures to hedge his exposure to house price risk (i.e. to hedge against the variation in $\Delta \log p_{i,t,r}$).

We measure the diversification benefits of free trade in house value by the coefficient of determination. In particular, the variation in returns that is associated with the variation in market returns, $R^2_{i,r}$, captures the undiversifiable (market/country/systematic) risk. By contrast, $1 - R^2_{i,r}$ is our measure of the diversifiable (idiosyncratic) risk.[8] This measure captures the reduction in the variation of house price returns if the homeowner could invest the value of his house in a market portfolio of houses. Hence, if we find a low $R^2_{i,r}$ the diversification benefits of free trade in house value are high. Instead, the hedging effectiveness of futures is exactly opposite to the diversification benefits of free trade in house value. In particular, a high $R^2_{i,r}$ is associated with a high hedging effectiveness. As mentioned, we will compare the diversification benefits of free trade in house value with the hedging effectiveness of futures to examine which one is more effective in reducing house price risk.

We also estimate several extensions of the basic CAPM model. In particular, equation (1) investigates the diversification benefits of a homeowner who owns a house of type r and would invest the value of this house in a market portfolio of houses of type *r*. However, it may be interesting to examine whether this homeowner could obtain additional diversification benefits if he would diversify across market segments. As a consequence, we also estimate an

[8] This approach does not deviate substantially from the method used by Case et al. (2009). In particular, they use the standard deviation of the residuals as a measure of diversifiable risk. Since the residuals have an expected value of zero by construction, this measure is equal to the Sum of Squared Residuals (SSR). The measure we use benchmarks the SSR to the total variation in returns (SST).

extended CAPM model where the returns per municipality i are regressed on the aggregate returns of all types of houses r: [9]

$$\Delta \log p_{i,t,r} = \theta_{0,i,r} + \sum_{1}^{r} \theta_{1,i,r} \overline{\Delta \log p}_{t,r} + \eta_{i,t,r}, \tag{2}$$

where the summation part of equation (2) captures the market returns for the 5 types of houses and $\eta_{i,t,r}$ is the error term. Again, we will estimate this model per municipality and type of house.

A further issue is that equation (1) does not take into account additional systematic risk factors. As a result, we also estimate APT type of models. In particular, we include GDP growth, $\Delta \log GDP_t$, and the Euro Interbank Offered Rate (3-month Euribor), I_t, as additional control variables in equation (1):

$$\Delta \log p_{i,t,r} = \lambda_{0,i,r} + \lambda_{1,i,r} \overline{\Delta \log p}_{t,r} + \lambda_{2,i,r} \Delta \log GDP_t + \lambda_{3,i,r} I_t + \mu_{i,t,r}, \tag{3}$$

where $\mu_{i,t,r}$ is again the error term. Although there may be other systematic risk factors, we only add the aforementioned two control variables. We argue that these control variables may capture additional important risk factors associated with owning a home (i.e. the risk of default, mortgage interest rate risk). For instance, especially during an economic bust (i.e. $\Delta \log GDP_t$ is low) the risk of mortgage default may be relatively high since an economic bust is usually associated with a decrease in house prices and a relatively high chance that homeowners may loose their job. With regard to the second control variable, the Euribor interest rate, we argue that variation in this interest rate may capture (mortgage) interest rate risk. In particular, the mortgage interest rate is the Euribor interest rate plus a risk premium, which depends on the riskiness of the mortgage.[10]

Finally, equation (1) examines the diversification benefits if the owner of a home invests his housing wealth in a Dutch housing market portfolio. However, it is also interesting to investigate the diversification benefits if a homeowner could simply invest in a regional

[9] The returns on the other types of houses than the type of house under consideration are not interpreted as a systematic risk for this type of house. Hence, we do not interpret this model as an APT model. Instead, we focus on a homeowner who invests in a market portfolio consisting of all 5 types of houses.

[10] The Euribor interest rate may also be interpreted a proxy for the riskless rate of return.

portfolio of houses. In particular, the diversification benefits based on a regional portfolio of houses may be less than the diversification benefits of investing in a total market portfolio since a regional portfolio does not cover against the cross-regional variation in house price changes. By contrast, futures based on regional house prices may be more effective since these returns are more likely to be similar to the homeowner's returns than the highly aggregated Dutch housing market returns.[11] As such, it is interesting to examine whether in this case futures would be more effective than free trade in reducing house price risk. As a consequence, we also estimate CAPM models based on regional average returns:

$$\Delta \log p_{i,t,r} = \delta_{0,i,r} + \delta_{1,i,r} \overline{\Delta \log p}_{g,t,r} + \omega_{i,t,r}, \qquad (4)$$

where $\overline{\Delta \log p}_{g,t,r}$ is the average price per time *t*, type of house *r*, and region *g* (again this average excludes $\Delta \log p_{i,t,r}$ for each *i*), and $\omega_{i,t,r}$ is the error term. As mentioned, we use 40 standard regions.

4. Regression results

Table 3 reports some descriptive statistics (average slope coefficient, average R-squared across municipalities) of the time series estimates of equations (1) to (4). The first panel in Table 3 shows the basic CAPM model estimates per type of house based on equation (1). These estimates suggest that on average a house is a defensive investment relative to the market portfolio. In particular, the average slope coefficients are less than one across all types of houses. That is, the municipal-specific returns do not seem to be very sensitive to changes in the market return. Specifically, the average coefficient ranges from 0.50 for apartments to 0.71 for row houses. This result implies that a homeowner who would like to hedge his exposure to house price risk/housing market risk would need to sell 1.4 to 2.0 euros in futures contracts per euro investment in the house. Although the average coefficients are below one, there is a substantial fraction of the municipalities, between 45 to 55 percent of the total number of municipalities, in which the house is a relatively aggressive investment.

Based on the CAPM estimates it is also possible to quantify the extent to which (undiversifiable) house price risk is priced. The difference in the annualized market returns

[11] Preferably, futures should be based on the individual homeowner's house price returns (tailor made). However, given the heterogeneity in returns, these contracts would no longer be standardized, which would impair the trade in those contracts. As a consequence, city/regional average housing returns may be more suitable to base futures constracts on.

and the 3-month Euribor (risk free rate) times the average slope coefficient per type of house suggests that the yearly risk premium on housing is about 4.6 percent for apartments (i.e. (1.9^4 - 3.8) * 0.5), 3.2 percent for row houses, 3.0 percent for corner houses, 4.2 percent for semi-detached houses, and 8.3 percent for detached houses. These results indicate that especially apartments and detached houses are relatively risky to invest in.

A further result with regard to the regression coefficients reported in the first panel of Table 3 is that only 6 to 10 percent of the regression coefficients are statistically significant at the 5 percent significance level. This result is also reflected in the relatively low average R-squared coefficient per type of house. This finding is a first indication that the diversification benefits of free trade in house value may be substantial.

As mentioned, we estimate the diversification benefits of free trade in the value of the house by one minus the R-squared. The R-squared estimates with regard to the basic CAPM models suggest that the owner of a type of house *r* could reduce the variation in house price changes by 92 to 96 percent if he would reinvest his housing wealth in a market portfolio of houses of type *r*.[12] The remaining 4 to 8 percent of the variation in house price changes represents the systematic risk a homeowner cannot diversify against by investing in the total housing market portfolio. These results imply that homeowners could substantially reduce house price risk by investing their housing wealth in a market portfolio of houses. Even though sharing the (price) risk and returns on housing wealth reduces house price risk, it cannot hedge the homeowner against market wide shocks (e.g. financial crisis).

Finally, the low average R-squared estimates in the first panel of Table 3 suggests that house price futures based on the market average house price would have a relatively low hedging effectiveness. In particular, the hedging effectiveness only dominates the diversification benefits in 0.2 to 4 percent of the municipal-specific regressions (R-squared>0.5). This result implies that in most cases the diversification benefits of free trade in house value seem to outweigh the hedging effectiveness of house price futures.

The extended CAPM model estimates, see equation (2), are reported in the second panel of Table 3. As mentioned, the extended CAPM model is used to estimate the diversification benefits if, for instance, the owner of an apartment would reinvest his housing wealth in a market portfolio consisting of all types of houses. Table 3 indicates that the diversification benefits of such a strategy would be 79 to 85 percent, depending on the type of

[12] Case et al. (2009) estimated similar CAPM models for the US. The results of their basic housing CAPM model suggest that about 81 percent of the MSA return variation may be diversifiable. Their regression results corroborate our finding that there may be substantial diversification benefits of investing in a diversified housing portfolio.

house. These benefits are lower than suggested by the simple CAPM estimates. Hence, diversification across types of houses does not seem to lead to additional diversification benefits. This result reflects that investing in a portfolio consisting of different types of houses may introduce additional systematic risk that a homeowner cannot directly diversify against.

Table 3: Housing CAPM models and 3 extensions, 1995-2008, equations (1)-(4)

Apartments (r=1)	**Row houses** (r=2)	**Corner houses** (r=3)	**Semi-det. Houses** (r=4)	**Detached houses** (r=5)
CAPM models, Equation (1)				
$\overline{\beta}_{1,r} = 0.50$ $\overline{R_r^2} = 0.08$ $N_r = 284$ $\beta 1\ sig. = 6\%$ $\lvert\beta 1\rvert > 1 = 45\%$ a) $R^2 > 0.5 = 4\%$	$\overline{\beta}_{1,r} = 0.71$ $\overline{R_r^2} = 0.04$ $N_r = 423$ $\beta 1\ sig. = 14\%$ $\lvert\beta 1\rvert > 1 = 45\%$ a) $R^2 > 0.5 = 0.2\%$	$\overline{\beta}_{1,r} = 0.66$ $\overline{R_r^2} = 0.04$ $N_r = 397$ $\beta 1\ sig. = 10\%$ $\lvert\beta 1\rvert > 1 = 53\%$ a) $R^2 > 0.5 = 0.8\%$	$\overline{\beta}_{1,r} = 0.63$ $\overline{R_r^2} = 0.04$ $N_r = 408$ $\beta 1\ sig. = 10\%$ $\lvert\beta 1\rvert > 1 = 55\%$ a) $R^2 > 0.5 = 0.5\%$	$\overline{\beta}_{1,r} = 0.68$ $\overline{R_r^2} = 0.04$ $N_r = 412$ $\beta 1\ sig. = 10\%$ $\lvert\beta 1\rvert > 1 = 48\%$ a) $R^2 > 0.5 = 0.2\%$
Extended CAPM models, Equation (2)				
$\overline{\theta}_{1,r=1} = 0.54$ $\overline{\theta}_{1,r=2} = 0.31$ $\overline{\theta}_{1,r=3} = 0.028$ $\overline{\theta}_{1,r=4} = 0.29$ $\overline{\theta}_{1,r=5} = -0.12$ $\overline{R_r^2} = 0.21$ $N_r = 245$ $\theta 1\ sig. = 7\%$ $other\ \theta 1\ sig. = 16\%$ $R^2 > 0.5 = 8\%$	$\overline{\theta}_{1,r=1} = 0.007$ $\overline{\theta}_{1,r=2} = 0.27$ $\overline{\theta}_{1,r=3} = 0.28$ $\overline{\theta}_{1,r=4} = 0.18$ $\overline{\theta}_{1,r=5} = 0.020$ $\overline{R_r^2} = 0.15$ $N_r = 406$ $\theta 1\ sig. = 10\%$ $other\ \theta 1\ sig. = 19\%$ $R^2 > 0.5 = 1\%$	$\overline{\theta}_{1,r=1} = -0.02$ $\overline{\theta}_{1,r=2} = 0.32$ $\overline{\theta}_{1,r=3} = 0.51$ $\overline{\theta}_{1,r=4} = -0.17$ $\overline{\theta}_{1,r=5} = 0.18$ $\overline{R_r^2} = 0.16$ $N_r = 377$ $\theta 1\ sig. = 8\%$ $other\ \theta 1\ sig. = 16\%$ $R^2 > 0.5 = 4\%$	$\overline{\theta}_{1,r=1} = 0.08$ $\overline{\theta}_{1,r=2} = 0.64$ $\overline{\theta}_{1,r=3} = -0.13$ $\overline{\theta}_{1,r=4} = 0.04$ $\overline{\theta}_{1,r=5} = 0.41$ $\overline{R_r^2} = 0.16$ $N_r = 386$ $\theta 1\ sig. = 10\%$ $other\ \theta 1\ sig. = 16\%$ $R^2 > 0.5 = 2\%$	$\overline{\theta}_{1,r=1} = -0.15$ $\overline{\theta}_{1,r=2} = 0.43$ $\overline{\theta}_{1,r=3} = -0.08$ $\overline{\theta}_{1,r=4} = 0.55$ $\overline{\theta}_{1,r=5} = 0.36$ $\overline{R_r^2} = 0.16$ $N_r = 388$ $\theta 1\ sig. = 11\%$ $other\ \theta 1\ sig. = 18\%$ $R^2 > 0.5 = 3\%$
APT models, Equation (3)				
$\overline{\lambda}_{1,r} = 0.81$ $\overline{\lambda}_{GDP} = 0.003$ $\overline{\lambda}_{I} = -0.16$ $\overline{R_r^2} = 0.14$ $N_r = 263$ $\lambda 1\ sig. = 6\%$ $\lvert\lambda 1\rvert > 1 = 44\%$ a) $\lambda gdp\ sig. = 10\%$ $\lambda I\ sig. = 0\%$ $R^2 > 0.5 = 5\%$	$\overline{\lambda}_{1,r} = 0.70$ $\overline{\lambda}_{GDP} = -0.033$ $\overline{\lambda}_{I} = 0.10$ $\overline{R_r^2} = 0.08$ $N_r = 414$ $\lambda 1\ sig. = 14\%$ $\lvert\lambda 1\rvert > 1 = 45\%$ a) $\lambda gdp\ sig. = 10\%$ $\lambda I\ sig. = 0\%$ $R^2 > 0.5 = 1\%$	$\overline{\lambda}_{1,r} = 0.60$ $\overline{\lambda}_{GDP} = -0.07$ $\overline{\lambda}_{I} = 0.16$ $\overline{R_r^2} = 0.10$ $N_r = 386$ $\lambda 1\ sig. = 6\%$ $\lvert\lambda 1\rvert > 1 = 50\%$ a) $\lambda gdp\ sig. = 11\%$ $\lambda I\ sig. = 1\%$ $R^2 > 0.5 = 3\%$	$\overline{\lambda}_{1,r} = 0.51$ $\overline{\lambda}_{GDP} = -0.07$ $\overline{\lambda}_{I} = 0.08$ $\overline{R_r^2} = 0.08$ $N_r = 397$ $\lambda 1\ sig. = 5\%$ $\lvert\lambda 1\rvert > 1 = 50\%$ a) $\lambda gdp\ sig. = 11\%$ $\lambda I\ sig. = 1\%$ $R^2 > 0.5 = 1\%$	$\overline{\lambda}_{1,r} = 0.59$ $\overline{\lambda}_{GDP} = -0.09$ $\overline{\lambda}_{I} = 0.08$ $\overline{R_r^2} = 0.09$ $N_r = 402$ $\lambda 1\ sig. = 7\%$ $\lvert\lambda 1\rvert > 1 = 51\%$ a) $\lambda gdp\ sig. = 10\%$ $\lambda I\ sig. = 0.4\%$ $R^2 > 0.5 = 1\%$
CAPM models based on regional average returns, Equation (4)				
$\overline{\delta}_{1,r} = 0.19$ $\overline{R_r^2} = 0.07$ $N_r = 282$ $\delta 1\ sig. = 10\%$ $\lvert\delta 1\rvert > 1 = 17\%$ a) $R^2 > 0.5 = 2\%$	$\overline{\delta}_{1,r} = 0.12$ $\overline{R_r^2} = 0.04$ $N_r = 423$ $\delta 1\ sig. = 12\%$ $\lvert\delta 1\rvert > 1 = 13\%$ a) $R^2 > 0.5 = 0.4\%$	$\overline{\delta}_{1,r} = 0.13$ $\overline{R_r^2} = 0.05$ $N_r = 401$ $\delta 1\ sig. = 11\%$ $\lvert\delta 1\rvert > 1 = 13\%$ a) $R^2 > 0.5 = 2\%$	$\overline{\delta}_{1,r} = 0.06$ $\overline{R_r^2} = 0.05$ $N_r = 407$ $\delta 1\ sig. = 13\%$ $\lvert\delta 1\rvert > 1 = 14\%$ a) $R^2 > 0.5 = 0.5\%$	$\overline{\delta}_{1,r} = 0.13$ $\overline{R_r^2} = 0.05$ $N_r = 414$ $\delta 1\ sig. = 14\%$ $\lvert\delta 1\rvert > 1 = 13\%$ a) $R^2 > 0.5 = 1\%$

Notes: This table reports some descriptive statistics of the municipal-specific regressions (average beta and r-squared). Heteroskedasticity robust standard errors are used in each regression. With regard to the CAPM models, *Nr* is the number of municipal regressions on which the results are based. *β1 sig.* is the percentage of slope coefficients that are significant at a 5% significance level across municipalities. *|β1|>1* is the percentage of slope coefficients that are in absolute terms larger than 1. $R^2>0.5$ is the percentage of municipal-specific regressions with an R-squared larger than 0.5. These statistics are also reported in the 3 extensions. With regard to the extended CAPM model, *other θ1 sig.* is the percentage of municipalities that have jointly significant coefficients (other than the type of house under consideration) at a 5% significance level. In addition, in the APT models, *λgdp sig.* is the percentage of significant coefficients on GDP growth and *λI sig.* is the percentage of significant coefficients on the 3-month Euribor. We excluded regressions with an R-squared of one. In addition, we removed outliers with regard to the slope coefficients. a) Most of these coefficients where larger than 1, not larger than -1.

The third type of estimates, summarized in the third panel of Table 3, is based on the APT model stated in equation (3). The APT estimates suggest that both the growth in GDP and the 3-month Euribor interest rate mainly have a positive effect on house price changes, ceteris paribus. However, in most cases these estimates are economically and statistically insignificant. In addition, the results in panel three suggest that there are less statistically significantly coefficients on the aggregate market returns in comparison to the standard CAPM model. Only with regard to apartments, the coefficient on the market return seems to be substantially higher.

With regard to the diversification benefits of free trade in the value of the house, our findings indicate that the diversification benefits are between 86 and 92 percent, which is somewhat lower than the standard CAPM estimates. This result again reflects the broader interpretation of systematic risk in comparison to the standard CAPM model. Nevertheless, these results still seem to suggest that the addition of the two control variables does not change our main finding that the reduction in risk due to investing in a diversified housing market portfolio may be substantial.[13]

Finally, we estimated the CAPM model stated in equation (4). The results are reported in the fourth panel of Table 3. As mentioned, the model in equation (4) is based on the regional average returns for 40 COROP regions. In comparison to the standard CAPM estimates, the results in the fourth panel of Table 3 indicate that the significance of the coefficient estimates has increased. In particular, between 10 to 14 percent of the estimates are significant. Nevertheless, the average of the coefficients ranges between 0.06 and 0.19, which is lower than the basic CAPM estimates. This result implies that a homeowner would need to sell more futures to hedge the exposure to house price risk than if the futures would be based on the average Dutch housing market price. Specifically, a homeowner would need to sell between 5.3 and 16.7 euros in futures contracts per euro of housing investment, which is higher than the previous estimate of 1.4 to 2.0 euros. This result is also reflected in the fact that in only 13 to 17 percent of the municipalities the house is an aggressive investment.

With regard to the diversification benefits of free trade in house value, the average R-squared per type of house suggests that a homeowner could reduce the variation in house prices by 93 to 96 percent if this homeowner would invests his housing wealth in a regional portfolio of houses. These results imply that the average hedging effectiveness does not increase if futures are based on regional house price indices instead of country house price

[13] As a robustness check, we also estimated the APT models based on the 10-year Dutch government bond yield. In this case, the diversification benefits decreased to 75 to 89 percent.

indices (i.e. the basic CAPM R-squared estimates are of the same size). In addition, diversification of the housing investment across regions does not seem to add to the diversification benefits of free trade in house value. That is, a homeowner could already obtain most of the diversification benefits by simply reinvesting his housing wealth in a regional portfolio of houses. Finally, in accordance with the previous outcomes, the results seem to suggest that the diversification benefits of free trade in house value still dominate the risk-reducing benefits of house price futures.

5. Conclusion and discussion

House price risk is high for homeowners since the typical homeowner concentrates the housing investment at a single location only. This is the result of the indivisibility of the housing investment, in combination with the limited wealth of homeowners, and high transaction costs in the housing market. By contrast, this paper has investigated the diversification benefits if homeowners could freely trade in the value of the house among each other. In particular, we focussed on the question whether homeowners could reduce house price risk by reinvesting the value of the house in a market portfolio of houses.

The results in this paper suggest that the diversification benefits of free trade in house value may be substantial. In particular, our basic CAPM model estimates have indicated that a homeowner could reduce the variation in house price changes by as much as 92 to 96 percent, depending on the type of house, if he would reinvest his housing wealth in a market portfolio of houses. Diversification across types of houses or regions would not lead to additional diversification benefits. Most of the diversification benefits could already be obtained by investing in a regional portfolio of houses instead of a country portfolio of houses. These diversification benefits may even be an underestimate since they ignore the variability of house price returns within municipalities. By contrast, the results in this paper indicate that the hedging effectiveness of house price futures is relatively low. This strategy would reduce the variation in returns by only 4 to 8 percent. Hence, the diversification benefits of free trade in house value seem to dominate the hedging benefits of futures.

As mentioned, Sinai and Souleles (2009) have argued that the hedging benefits of homeownership may explain why derivatives markets have failed to take off. An alternative explanation why derivatives markets are not in common use today may be that the idiosyncratic risk in local housing markets is simply too high to make hedging with futures an effective hedging strategy (i.e. see De Jong et al., 2008). Our results seem to corroborate this finding.

A housing stock market could facilitate free trade in the value of the house. Such a market would allow homeowners to trade stocks based on the value of the home. As a result, homeowners could reduce house price risk by investing in a diversified market portfolio (houses of other homeowners). Alternative ways to obtain the diversification benefits would be that homeowners jointly buy houses, albeit with substantial transaction costs, or that the homeowner could sell his house for instance to the government or housing corporations.

Currently, a housing stock market does not exist. There may be several issues with establishing such a market. The following discussion briefly summarizes some of these issues, but is not meant to be exhaustive. First, the financial literacy of households may play an important role in the usefulness of a financial (stock) market based on house prices. In particular, if homeowners are unaware of house price risk, its implications, or if they do not know how to deal with this risk, these markets would not be widely used by homeowners. As a result, there may be a potential role for governments/policy makers to increase the awareness about house price risk.

A second issue relates to the tradability of housing stocks. In particular, it may be too costly to create stocks (stock emission) for each individual homeowner. Moreover, there would need to be a "critical mass" of homeowners that sell housing stocks to make the trade in house value viable. The stocks could, for instance, be pooled in a fund per city (municipality/region) to enhance the tradability of those stocks.

A third problem may be the ownership structure of the house. In particular, most homeowners use the house as collateral for the mortgage. That is, a mortgage provider is also a stakeholder regarding the housing investment. Selling the (excess) value on the house would introduce additional stakeholders, which could potentially lead to a conflict of interest between those stakeholders, for instance, in case of default.

A final issue is that, although free trade in house value may substantially reduce house price risk, a financial market clearly cannot fully shelter the homeowner against market risk (e.g. the subprime crisis). As a consequence, homeownership may still be associated with a substantial amount of house price risk even if a housing stock market would exist.

In sum, this paper has emphasized the potential risk-reducing benefits of free trade in house value. Further research should focus on how financial markets based on house prices could be established and what the effect of such markets would be on housing market dynamics.

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