Intratemporal Substitution between Housing and Nondurable Consumption: Evidence from Reinvestment in Housing Stock

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Abstract

I investigate empirically the intratemporal dependence between nondurable consumption and housing. Using the data on maintenance expenditures and self-assessed house value, I separate the measure of housing stock and house prices, and use these data for estimation of the model, which allows for testing whether consumption and housing are characterized by intratemporal nonseparability in the contemporaneous utility. I find evidence in favor of a substitution mechanism between housing and total nondurable consumption. A similar conclusion is reached for some separate consumption categories, such as food, transport, clothing, vacations, and entertainment.

JEL C51, D12, D13, E21, R21

Keywords: Housing, Nondurable Consumption, Intratemporal Nonseparability

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1 Introduction

Nonseparability in preferences over nondurable consumption and housing is an important feature of many up-to-date consumption models with housing employed in economics and finance. In these models, the intratemporal elasticity of substitution between durable and nondurable consumption is a key parameter that helps explain a variety of important phenomena. Piazzesi et al. (2007) find the strength of the intratemporal elasticity of substitution is an important factor for predictability of excess stock returns, whereas the same modeling feature, to a large extent, allows Yogo (2006) to explain both the cross-sectional variation in expected stock returns and the time variation in the equity premium. Ogaki and Reinhart (1998) argue that accounting for the intratemporal substitution between nondurables and durables improves the estimates of another important quantity in economics and finance - the intertemporal elasticity of substitution. Subsequently, Flavin and Nakagawa (2008) rely on the limited intratemporal substitutability between housing and nondurable consumption in generating a low elasticity of intertemporal substitution to address the observed smoothness of nondurable consumption. Li et al. (2016) demonstrate that the strength of the intratemporal elasticity of substitution governs the impact of changes in house prices on household homeownership rates and nondurable consumption. These studies that characterize the intratemporal substitution between durable and nondurable consumption offer little consensus about the strength of the substitutability, ranging from the limited substitutability (Flavin and Nakagawa, 2008) to a rather strong one (Piazzesi et al., 2007). In particular, the parameters of the intratemporal elasticity of substitution found on these studies provide different implications for the nature of correlation between nondurable and durable consumption expenditures.

In this paper, I test for the intratemporal nonseparability between housing and nondurable consumption in individual preferences. Without making assumptions on the functional form of the utility function, I formulate a consumption model, in which utility depends, probably nonseparably, on two distinct goods, nondurable consumption and housing. Housing stock, from which households-homeowners derive utility, is not constant but is subject to depreciation and upkeep through maintenance and renovations. To investigate empirically the intratemporal dependence over homeowner choices of nondurable consumption and housing stock, I then exploit *within-household* variation in changes in housing stock of homeowners who do not change their residence.

Residential housing stock is not constant over the length of the same homeownership and requires significant ongoing maintenance expenses. As measured based on the Panel Study of Income Dynamics (PSID), households spend on average around $2,600 annually on improvement, maintenance and repair expenditures, which constitutes about 1.5% of house value.[1] With the median maintenance expenditure of only $600, the average cross-sectional and within-household variation in the maintenance effort is substantial, with the coefficient of variation being 289% and 113%, respectively. To the extent that homeowners expand, remodel, or fail to maintain their homes, fluctuations in both quality and quantity of their housing stock can be nontrivial.

Although homeowners' maintenance expenditures are observed in various data sources, including the PSID used in this paper, testing whether consumption and housing are nonseparable in household utility is hindered by the inability to accurately observe individual housing stock and its variation over time. Even if a comprehensive set of home attributes is observed, these characteristics usually exhibit little variation or do not change over time. Lack of variation in observed housing characteristics makes it unsuitable for linking to individual variation in consumption. To gain information about variation in housing stock, I use the data on maintenance expenditures and self-assessed house value from the PSID to separate the measure of individual housing stock from house prices of that individual housing stock. The average growth index of the imputed housing stock is close to 1, suggesting that, on average, homeowners tend to reinvest in housing stock just enough to offset its depreciation. At the same time, the imputed housing-stock growth varies reasonably over households and within households, making it suitable for the analysis of the intratemporal dependence within consumption model. The average index of house-price growth, imputed from the PSID, is also measured with substantial variation. Both nationwide and across regions, it closely matches the level and the pattern of dynamics of the house-price indices, constructed by the U.S. Federal Housing Finance Agency, S&P Case-Shiller, and Zillow. These imputed individual

[1] Gyourko and Tracy (2006) provide a similar evidence from the American Housing Survey on the average annual maintenance and repair expenditures at $2,051.

housing-stock and house-price indices are used in estimation of the consumption model.

I find evidence in favor of intratemporal dependence between total nondurable consumption and housing. In particular, my findings indicate the substitution effect between housing and nondurable consumption. I also find evidence of a substitution mechanism in the models when the utility is assumed to be additively separable over distinct categories of consumption but may be pairwise dependent from housing stock. In estimation of these models, my findings indicate the substitution effect between housing and consumption of food, transport, clothing, trips and vacation services, entertainment, and recreational services. The model is estimated based on the sample of prime-age homeowners; however, the results are also robust to extending the sample to all households-homeowners.

My results contribute to the literature that examines and provides evidence against additive separability in preferences over durable and nondurable consumption, such as Ogaki and Reinhart (1998), Piazzesi et al. (2007), and Yogo (2006) for the aggregated macroeconomic framework, and Flavin and Nakagawa (2008) and Li et al. (2016) using household data. Postulating a constant-elasticity-of-substitution utility function to represent intratemporal preferences over nondurable and durable consumption, these studies pin down the parameter of intratemporal elasticity of substitution relying on different sources of variation in durable and nondurable consumption. Ogaki and Reinhart (1998), Piazzesi et al. (2007), and Yogo (2006) exploit time-series variation in aggregated nondurable and durable consumption, Li et al. (2016) rely on cross-sectional variation in the households' house value and income, whereas Flavin and Nakagawa (2008) use household expenditure on food as a measure of nondurable consumption and discontinuous jumps in housing stock at the time of changing residence, while assuming constant housing stock until the household moves. Unlike these studies, I do not take a stand on the structure of preferences, which makes my findings robust to possible model misspecifications. Similar to Flavin and Nakagawa (2008) and Li et al. (2016), I use household data from the PSID in the test for the intratemporal nonseparability in preferences; however, I focus on the sample of homeowners who do not move, and, unlike Flavin and Nakagawa (2008) and Li et al. (2016), rely on both between- and within-household variation in total nondurable consumption and housing stock. Therefore, my results complement and extend the findings of nonseparability between nondurable consumption and housing in those studies to the sample of homeowners who do not move. The economic significance of my findings is supported by the fact that the overwhelming majority of households are homeowners and only a small fraction of them moves at a time.[2]

My findings also relate to a large literature that documents an empirical relationship between house-price changes and the households' consumption expenditure (see Aladangady, 2017; Browning et al., 2013; Campbell and Cocco, 2007; Carroll et al., 2011; Case et al., 2005; Cooper, 2013; Gan, 2010; Mian et al., 2013; Mian and Sufi, 2014; Paiella and Pistaferri, 2017). An important channel for the relationship between house-price changes and consumption considered in the above studies is the housing wealth effect, which suggests house-price appreciation may result in the perception of larger housing wealth and may lead to the increase of consumption expenditure by relaxing households' lifetime resource constraints. Other channels include the collateral borrowing channel, which, under house-price appreciation, relaxes the equity borrowing constraint for households who reached borrowing limits and allows for higher consumption-expenditure levels (DeFusco, 2017), and the channel of common factors that may simultaneously drive house prices and consumption (Attanasio et al., 2009). Intratemporal nonseparability between housing and nondurable consumption can give rise to another channel for the relationship between housing wealth and consumption, driven by the substitution effect. Higher user cost of housing may prompt consumers to substitute away from the durable good and increase consumption of the nondurable good. In particular, an increase in construction and maintenance costs may adversely affect the homeowners' demand for maintenance, and, as a result, the quality and quantity of housing stock. If consumption and housing are intratemporal substitutes, a reduction in housing stock in its quality and quantity will be accompanied by an increase in nondurable consumption. Then, under intratemporal substitution between consumption and housing, house-price appreciation (and, by common assumption, appreciation of the housing wealth of homeowners) will be observed along with an increase in nondurable consumption expenditure for households who are long in housing,

[2] Detailed moving statistics for homeowners and renters from the PSID are reported in Bajari et al. (2013). In particular, these authors compute that the average homeowner moves about three times in life.

misleading the conclusions in favor of the housing wealth effect.

The remainder of the article is as follows. Section 2 sets up a theoretical model, from which the econometric model is developed. Section 3 describes the data sample used in estimation and presents a method of measuring unobserved housing stock from the data on maintenance expenditure and self-assessed house value. Section 4 outlines the estimation strategy and presents the findings. Section 5 concludes. The further details on derivation of the econometric model and data-sample construction can be found in Appendices A and B.

2 Model

Consider households-homeowners, who maximize a lifetime utility from consumption and housing:

$$E_t \sum_{s=t}^{T} \beta^{s-t} U(C_s, H_s) \exp(\phi' z_s), \tag{1}$$

where E_t denotes expectation formed at time t, β is the time discount factor, $U(\cdot)$ is the per-period utility of consumption and housing, and $\exp(\phi' z_t)$ is the taste shifter, which may depend on demographic characteristics z_t. Households derive utility from consumption C_t, and, being homeowners, hold positive amounts of housing stock H_t (priced at P_t), which they manage. The size of the housing stock H_t is interpreted broadly as reflecting not only the physical size, but also its quality. The quantity and quality of housing stock is affected by the depreciation at the rate δ, and by the adjustments to housing stock m_t (also priced at P_t) due to maintenance, renovations, or home improvements:

$$H_t = (1-\delta)H_{t-1} + m_t. \tag{2}$$

Every period households receive income Y_t, consume C_t, and save B_t (or borrow if negative). If no trade of an existing home occurs, the flow of funds is given by

$$C_t + P_t m_t + B_t = Y_t + R_t B_{t-1}, \tag{3}$$

where R_t is the real interest rate in period t.

Households choose consumption expenditure C_t and housing investment m_t optimally by maximizing (1) subject to (2)-(3). The household's problem implies the following consumption optimality condition:

$$U_C(C_t, H_t) = \beta E_t \left[R_{t+1} U_C(C_{t+1}, H_{t+1}) \exp(\phi' \Delta z_{t+1}) \right], \tag{4}$$

where U_C is household marginal utility with respect to consumption. Under the assumption of rational expectations, equation (4) can be written as follows:

$$\beta R_{t+1} \frac{U_C(C_{t+1}, H_{t+1})}{U_C(C_t, H_t)} \exp(\phi' \Delta z_{t+1}) = 1 + e_{t+1},$$

where e_{t+1} is the expectation error. Assume marginal utilities U_C and U_H are continuously differentiable. Taking logs, applying first-order Taylor-series expansion to $\ln U_C$, and writing the resulting equation one period back, I obtain the estimable Euler equation in log-linearized form:

$$\Delta c_t = \alpha_0 + \alpha_1 r_t + \alpha_2 \Delta h_t + \phi \Delta z_t + \varepsilon_t, \tag{5}$$

where r_t is the log real interest rate in period t, $\Delta c_t = \ln(C_t / C_{t-1})$, $\Delta h_t = \ln(H_t / H_{t-1})$, and ε_t is the composite error term that includes the Taylor-series remainder and the expectation error (see Appendix A for more details).

Equation (5) allows us to test for intratemporal non-separability between nondurable consumption and housing without specifying the structure of preferences for the goods that are separable under the null. The significance and the sign of α_2 in equation (5) will be informative about the intratemporal dependence between consumption and housing. The parameter α_2 represents $-U_{CH}/U_{CC}$. Maintaining the standard assumption of $U_{CC} < 0$, the sign of α_2 corresponds to the sign of U_{CH}. If nondurable consumption and housing are characterized by substitution, then U_{CH} is negative, as will be the estimate of α_2. If non-durable consumption and housing are characterized by complementarity, then U_{CH} is positive, as will be the estimate of α_2. Additive separability between non-durable consumption and housing in contemporaneous utility ($U_{CH} = 0$) will show up as α_2 being statistically insignificantly different from zero.

Before estimating equation (5), a number of issues need to be taken into consideration. One issue concerns the relevant data. Information on individual housing is usually observed in the form of the monetary value of a house and its physical characteristics. Reported house characteristics (number of rooms, area size in square meters, various housing features, such as patios, balconies, a private garden, etc.) are normally fixed, exhibit little variation over time, and therefore can hardly be used in measuring changes in housing stock. House value in monetary terms is a fusion of many elements, where major factors are the level of local real estate prices and the degree of upkeep implemented by the homeowner to defeat natural wear and tear, and perhaps to even improve the existent quality of housing stock. Equation (5) requires the measure of housing stock in both its quantity and quality; that is, housing stock must be singled out from the price per unit of housing stock, which equivalently influences the value of a house. I deal with this issue in the next section.

Another issue is related to the possible endogeneity problem in equation (5) from the simultaneous choice between a household's consumption and housing and from the Taylor-series approximation used to derive this equation. To deal with this issue, equation (5) is estimated using the instrumental variable (IV) technique. The choice of instruments is discussed in section 4.

3 Data

I construct the data on consumption expenditures, the measure of changes in housing stock, and house-price growth using biennial longitudinal survey observations of households in the US in the Panel Study of Income Dynamics. In particular, from the survey on the level of households, I take variables on household consumption, housing wealth, home repairs and maintenance, and demographic characteristics.

3.1 Expenditures

The PSID is a longitudinal survey that follows a nationally representative random sample of families and their extensions since 1968. Since its start, the survey routinely collects information about food expenditures. The set of categories on consumption expenditures expanded significantly in 1999 to include spending on healthcare, education and childcare, transportation, and utilities. With an addition of new spending information on clothing, trips, vacations, entertainment, and the expenditure on home repairs and maintenance in 2005, the PSID currently contains all essential consumption categories. In my analysis, I use data on all these consumption categories, namely, spending on food, clothing, transportation, utilities, trips and vacations, entertainment, healthcare, education, and childcare. In addition, I construct total non-housing consumption expenditure as a sum of these separate consumption-spending categories. Data on consumption spending are deflated using the consumer price index (CPI) from the CPI releases of the Bureau of Labor Statistics applicable for each spending category (see Appendix B for details).

Housing information includes data on the number of rooms in a dwelling, house value for homeowners, and spending on home repairs and maintenance. The PSID collects information on home repairs and maintenance by asking "How much did you spend altogether on home repairs and maintenance, including materials plus any costs for hiring a professional?" Homeowners are also asked to provide an assessment of the present value of their house and the lot by giving the value of the home as if it would be sold at the time of survey. Monetary values of housing data are deflated using the CPI index (see Appendix B for details). All monetary values are in 2009 dollars.

Motivated by the availability of data on home repairs and maintenance, and a more comprehensive set of consumption categories, the initial sample of data on consumption and housing at the household level starts in 2005 and covers six periods of biennial observations up to 2015. The initial sample consists of continued homeowners ages 22-65 who do not change residence, which includes 17,297 household observations. After omitting top-coded observations on house value and any of the consumption categories, the sample reduces to 13,177 observations. I require that a household has non-missing observations over at least two consecutive periods, which results in

Table 1: Summary Statistics

	2005	2007	2009	2011	2013	2015
Consumption	36,157.1	38,394.3	35,844.3	35,324.9	34,718.9	36,623.5
Food	8,353.3	8,613.9	7,934.7	8,113.8	8,132.3	8,031.0
Clothing	2,056.9	2,100.6	1,851.7	1,908.6	1,659.4	1,715.5
Entertainment	1,135.1	1,263.5	1,286.0	1,206.4	1,135.4	1,111.4
Telecommunications	2,033.6	2,380.4	2,624.9	2,806.8	3,074.4	3,309.8
Utilities	3,244.3	2,925.2	3,026.0	3,093.5	2,865.8	2,861.7
Trips, vacations	2,129.7	2,637.1	2,478.6	2,649.8	2,614.3	2,660.0
Transportation	9,784.2	10,254.3	9,077.8	8,339.9	8,450.3	11,054.2
Education	2,887.6	3,187.4	2,583.9	2,422.6	2,363.1	2,220.6
Childcare	678.1	688.9	733.4	722.7	684.0	548.9
Healthcare	3,854.2	4,343.0	4,247.2	4,060.7	3,739.9	3,110.4
House value	265,334.8	294,511.8	252,950.8	248,267.9	231,179.8	220,685.4
Maintenance	2,730.6	3,409.9	2,683.9	2,588.8	2,343.7	2,857.1
Home size	6.9	7.1	7.0	7.0	6.9	6.9
Age	44.9	46.9	47.1	47.9	48.0	48.5
Years of education	13.8	14.0	14.2	14.3	14.3	14.3
Family size	3.0	2.9	3.0	2.9	2.9	2.9
H_t/H_{t-1}	0.984	0.984	0.982	0.986	0.990	0.998
	(0.136)	(0.121)	(0.135)	(0.164)	(0.194)	(0.198)
P_t/P_{t-1}	1.164	1.102	0.926	0.992	0.994	1.038
	(0.293)	(0.266)	(0.221)	(0.227)	(0.212)	(0.250)
Observations	1,210	1,210	1,521	1,516	1,581	1,523

All monetary values are in 2009 dollars. Standard deviation is reported in parentheses for imputed data.

further sample reduction by 3,948 observations, mostly due to utilizing lagged values of 2005. Following a common practice in the literature on estimation of consumption models, I exclude observations for which total nondurable consumption grows by more than 400% or falls by more than 75%, and that results in further reduction of the sample by 54 observations. Next, I drop any observations for which the house reportedly lost more than two-thirds of its value or more than doubled its value between consecutive periods, and the increase in house value was not supported by sizable maintenance expenditures, which lowers the sample by 146 observations. I also drop any observations for which the home was virtually rebuilt, as measured by an unusually high level of maintenance expenditures. Specifically, I omit 19 observations for which the level of maintenance expenditures exceeds 90% of the reported value of the house. Finally, because the consumption Euler equation holds for households who can freely borrow to finance consumption expenditures, I exclude homeowners who do not have a positive balance of financial liquidity (cash, stock and bond holdings), which lowers the sample by 1,667 observations. The estimation sample includes 7,347 observations over five periods.

Table 1 presents summary statistics for the data sample. Transportation, food, and health care constitute the three largest consumption-expenditure categories, amounting to about 29%, 22%, and 11% of total consumption expenditures, respectively. Child care, entertainment, and clothing are the three smallest consumption-expenditure categories, amounting to less than 10% of total consumption expenditures, altogether. Expenditure on maintenance is sizable, amounting to about 1.5% of house value. Financial contributions to improvements and maintenance are routine periodic expenditures for about 77% of households in the sample.

3.2 Housing-stock and house-price growth

Equation of interest (5) requires a measure of changes in a household's housing stock H_t/H_{t-1}, which, in general, is not observable to an econometrician. Instead, the observables include current and lagged house value (P_tH_t and $P_{t-1}H_{t-1}$) and the value of maintenance expenditures (P_tm_t). Knowing these quantities, and using the law of motion for housing stock, given by equation (2), I compute the quantities H_t/H_{t-1} and P_t/P_{t-1} in the following way:

$$(1-\delta)\frac{P_t}{P_{t-1}} = \frac{P_tH_t - P_tm_t}{P_{t-1}H_{t-1}}, \tag{6}$$

$$\frac{H_t}{H_{t-1}} = \frac{P_tH_t}{P_{t-1}H_{t-1}} / \frac{P_t}{P_{t-1}}, \tag{7}$$

where the right-hand side of equation (6) uses observable quantities, whereas the the right-hand side of equation (7) uses observable quantities and the price index computed in (6). Maintenance expenditures, reported on annual basis, are doubled to account for bi-annual frequency of the survey. From equations (6) and (7), if the housing stock of homeowners depreciates at the rate δ, the objective depreciation affects the level of the changes in housing stock for all homeowners in the same way but does not add to the individual variation in these changes. Therefore, the level of the depreciation rate is not consequential for estimation of equation (5). Nevertheless, the level of depreciation is important for computing the house-price growth in equation (6), which then affects the change in housing stock in equation (7). To account for bi-annual frequency in the data, I set the depreciation rate at 5.0%, which doubles the 2.5% depreciation rate found in Harding et al. (2007).

Table 1 reports the average values of housing-stock growth and house-price growth, and their standard deviations. The average housing-stock growth index is very close to 1, suggesting that, on average, households tend to reinvest in housing stock just enough to offset its depreciation. The imputed measure of housing-stock growth also has a sizable standard deviation, which indicates the imputed index varies reasonably over households. The average within-household standard deviation of the housing-stock growth index is 0.05, a value of a similar magnitude to the cross-sectional standard deviation, reported in Table 1. The average index of house-price growth is also measured with substantial variation. On average, house-price growth is positive in 2005 and 2007. Afterward, for three observation periods, the index is decreasing, with the largest decrease in house-price growth in 2009. The index shows positive growth again in 2015.

The imputed house-price growth is calculated based on the self-reported value of the house, priced by homeowners given the quantity and quality of their housing stock, and therefore may not be directly comparable to the house-price indices (HPIs) used in the literature. Nevertheless, the computed house-price growth from the PSID in Table 1 compares reasonably well to the established HPIs. I compare the imputed house-price growth from the PSID with the weighted, repeat-sales HPI based on transactions involving single-family homes, constructed by the US Federal Housing Finance Agency (FHFA HPI), and with methodologically similar S&P Case-Shiller HPI. I also use the Zillow Home Value Index (Zillow HVI) for comparison, whose methodology differs from the two aforementioned HPIs, mainly because it does not rely on repeat sales. Instead, it utilizes the Z-estimate, an estimated value of a home based on its proprietary machine-learning algorithm. Zillow's Z-estimate uses multiple sources of data, which includes prior sales, county

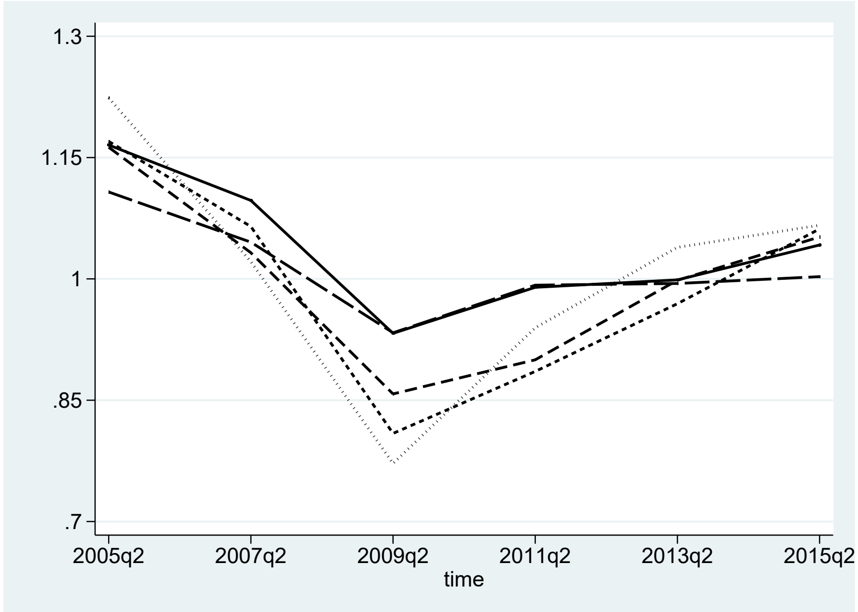

Figure 1: House-price indices. The solid line shows average house-price growth imputed from the PSID, the long-dashed line shows median house-price growth imputed from the PSID, the dotted line represents S&P Case-Shiller HPI, the dashed line represents FHFA HPI, and the short-dashed line corresponds to the Zillow index.

records, tax assessments, real estate listings, mortgage information, and geographic information-system data. Importantly, Zillow's website allows homeowners to view the entire history of Z-estimates and to report home improvements, which altogether makes the Zillow HVI index relevant for comparison. The comparative analysis is presented in Figure 1. This figure reports average and median house-price growth imputed from the PSID, S&P Case-Shiller HPI, FHFA HPI, and Zillow HVI for the second quarter of the odd years between 2005 and 2015. During the sample years, the PSID is a biennial survey, in which the overwhelming majority of the interviews are conducted in the second quarter, which explains the choice of the second quarter for comparisons. S&P Case-Shiller HPI, FHFA HPI, and Zillow HVI are adjusted accordingly to show house-price growth for the second quarter of the year relative to the same quarter two years ago. The three well-known HPIs and the one constructed from the PSID paint the same qualitative picture during the observed period. The imputed house-price growth closely matches the level and the pattern of dynamics in house prices over the observed period.

Further analysis shows that similarities between indices' values are even stronger on a regional

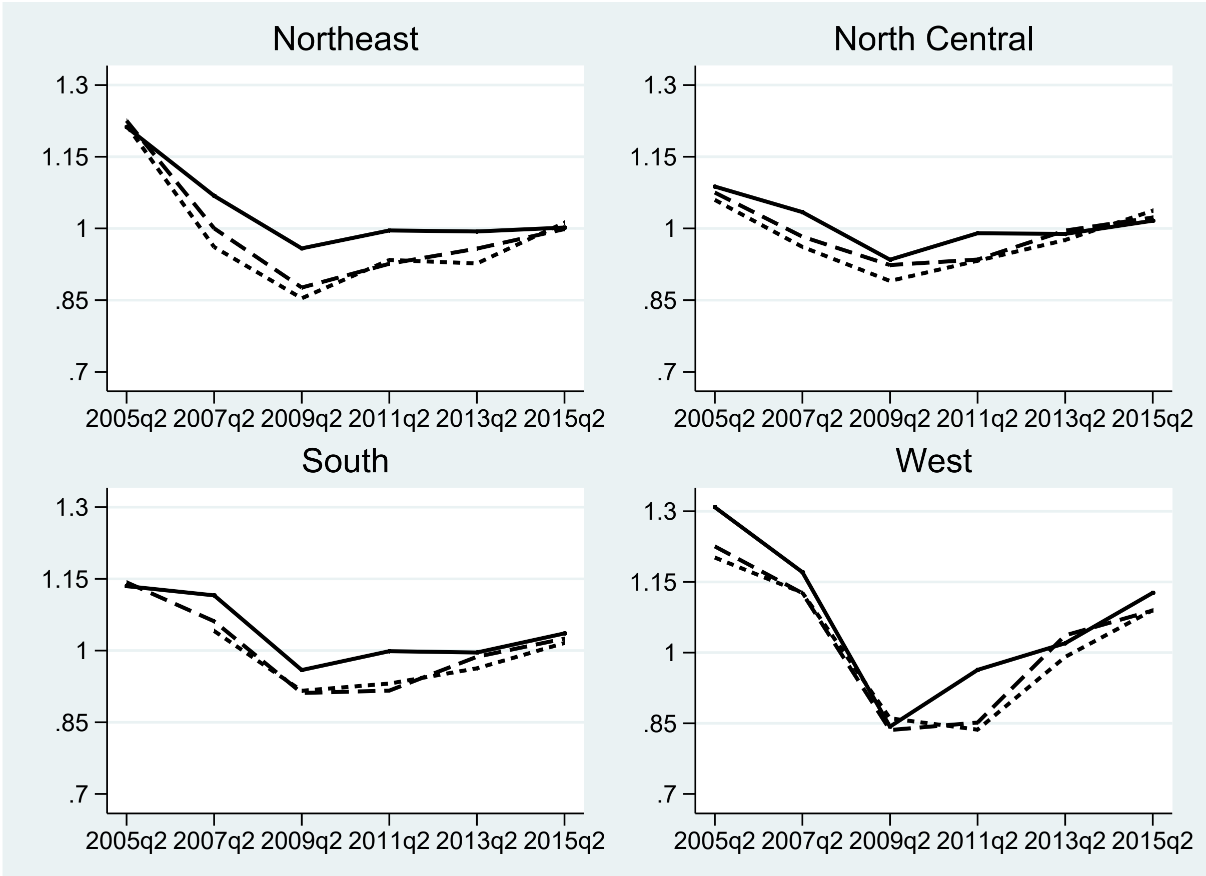

Figure 2: House-price indices over four regions. The solid line shows average house-price growth imputed from the PSID, the dashed line represents FHFA HPI, and the short-dashed line corresponds to the Zillow index.

level. PSID provides information about a state of residence, which I use in constructing a state and regional measure of house-price growth. I compare the imputed house-price growth from the PSID to HPIs, available on a state level – FHFA HPI and Zillow HVI. Figure 2 shows the HPIs imputed from the PSID housing data, and the HPI's by the US Federal Housing Finance Agency and Zillow over four major regions: Northeast, North Central, South, and West (see Appendix B for the state composition of these regions). State comparisons can be found in Appendix B, Figure 3. Overall, the house-price growth, imputed from equation (6), is remarkably close to the HPIs reported by Zillow and the US Federal Housing Finance Agency.

4 Estimation and empirical findings

If consumption and re-investment in housing are simultaneous choices, the choice to reinvest in housing stock may be directly affected by the consumption choice and be correlated with the unobserved shocks that drive consumption. This possibility creates the standard endogeneity problem in simultaneous decision-making. Ordinary least squares estimation of equation (5) could result in biased estimates. The remedy is to find IVs, such that they are not affected by nondurable consumption but are correlated with changes in housing stock. Then the IV estimation technique could be used for obtaining consistent estimates of the parameters in equation (5).

As argued in Harding et al. (2007), home attributes tend to be correlated with maintenance and therefore with the changes in housing stock. Indeed, in my data sample, the correlation between house size and level of maintenance expenditures is positive, significantly different from zero at the 1% significance level, and equals 0.10. Also, home attributes have no natural role in the consumption-model specification (5). Even if home attributes could have affected the consumption level, the observed physical characteristics of the home are usually constant over time and therefore would drop out of the model in first differences. Hence, the observed attributes of a home can be used as instruments for reinvestment in consumption equation (5). I use the observed house size as an IV.

When households derive utility from consumption and housing, a household's optimization problem can be supplemented by one more restriction, namely, the one describing the optimal choice of reinvestment in housing stock. The resulting demand for housing stock, along with its dependance on consumption, also depends on house prices (see equation (11) in Appendix A). Homeowners actively manage the quantity and quality of their housing stock by implementing housing improvements, taking house prices as exogenously given. House prices have no natural role in the consumption model (see equations (10)-(11) in Appendix A), and being exogenous to nondurable consumption choice, house prices are relevant for explaining changes in housing stock, making an excellent instrument. Indeed, in my data sample, the correlation between changes in housing stock and the imputed individual house-price index is negative, significantly different from zero at the 1% significance level, and equals -0.24. The negative correlation between housing stock and house prices is in agreement with the restrictions of the demand theory, whereby home improvements are expected to react negatively to the increase in prices. See early empirical estimates of price elasticity of the demand for housing consumption in Rosen (1979), Hanushek and Quigley (1980), MacRae and Turner (1981), Goodman and Kawai (1986), and more recently in Goodman (2002) and Ioannides and Zabel (2003).

To capture the utility taste shifter, in estimation of equation (5) I include a set of demographic variables, such as the level of education, change in age squared, and change in family size. Following Mazzocco (2007) and Meghir and Weber (1996), I also include conditioning variables of the change in a dummy if the husband works and the change in a similar dummy for the wife, to capture a possible nonseparability between modelled choices of consumption and housing, and the choice of leisure that is not formally modelled in this paper. In addition to house size and the imputed house-price index, I use the instruments typical in estimation of the consumption Euler equations: lagged growth in real household income, lagged growth in hours worked by all family members, lagged growth in hours worked by the wife if present, a dummy for whether the head of the household lost a job involuntarily during the previous period, and lagged food-consumption-expenditure growth.

The results from a first-stage regression of changes in housing stock on house size and changes in house prices, reported in Table 2, confirm a negative relationship between house prices and housing stock. According to the first-stage results, the estimated coefficients on both instruments are negative and statistically significant at the 5% significance level. The results in Table 2 also point to a negative correlation between house size and a growth in housing stock, suggesting that, after we control for the house-price dynamics, smaller homes experience a faster growth in housing stock. The partial R^2 statistic from a regression of changes in housing stock on the instruments after partialling out change in demographic shifters and interest rate (not reported), is 0.17, indicating the instruments explain a decent fraction of the variance in house stock. The F-statistic for the test of the hypothesis that the coefficients on the excluded instruments are zero (Staiger and Stock, 1997; Stock and Yogo, 2005), equals 13, which is outside of the problematic range.

Table 2: First-stage results

Dependent variable: change in housing stock	
House size	−0.0014 (0.0006)
House-price index	−0.1655 (0.0201)
Lagged head involuntarily lost job	−0.1589 (0.0169)
Lagged income growth	−0.0098 (0.0052)
Lagged household hours growth	0.00018 (0.00020)
Lagged wife's hours growth	0.00014 (0.00005)
Lagged food expense growth	0.0005 (0.0008)
Partial R^2	0.170
F(7,49)	13.0

Standard errors, clustered by state level, are reported in parentheses. The F-statistic is adjusted for clustering by state level. The Treasury bill rate, change in a dummy if the husband works, change in a similar dummy for the wife, and demographic controls, such as changes in family size, a householder's age interacted with education and age squared are included but not reported.

The equation (5) is estimated with different consumption categories as dependent variables, and the presentation of the results keeps the focus on the coefficient on housing-stock change, α_2. First, I test whether an intratemporal dependence exists between total nondurable consumption and housing stock. Next, I test whether an intratemporal dependence exists between separate categories of nondurable consumption and housing stock. This test is possible under the assumption that in the utility $U(C_t, H_t)$, distinct categories of consumption are additively separable between each other but may be pairwise dependent from housing stock. That is, I estimate 11 different models. Table 3 reports findings based on the instrumental variables (GMM) estimation of equation (5).

The estimation results show the evidence in favor of the intratemporal dependence between total nondurable consumption and housing. The coefficient on change in housing stock is negative and statistically different from zero at the 5% significance level. This finding indicates the substitution effect between housing and total nondurable consumption. The coefficient on the change in housing stock in separate regressions for many consumption categories, such as food consumption, transport, clothing, vacation services, and recreational services, is negative and statistically signif-

Table 3: Instrumental variables (GMM) estimation results for the model
$$\Delta c_t = \alpha_0 + \alpha_1 r_t + \alpha_2 \Delta h_t + \phi \Delta z_t + \varepsilon_t$$

	Dependent variable	α_2
(1)	Total nondurable consumption	-0.256^{**} (0.132)
(2)	Food	-0.311^{*} (0.177)
(3)	Health expenditures	0.505 (0.535)
(4)	Education	1.221 (1.223)
(5)	Child care	1.656 (1.765)
(6)	Clothing	-0.946^{***} (0.318)
(7)	Recreation and entertainment	-0.751^{***} (0.304)
(8)	Transport	-0.485^{*} (0.288)
(9)	Telephone and internet	-0.155 (0.263)
(10)	Utilities	0.061 (0.246)
(11)	Trips and vacations	-1.809^{***} (0.511)

Each row and column corresponds to a separate estimation of equation (5) with a different consumption category as dependent variable; that is, 11 different regression models are estimated. The reported coefficients are the estimates of α_2 in these 11 model specifications. Instruments include house size, house-price index computed as in equation (6), lagged growth in real household income, lagged growth in hours worked by all family members, lagged growth in hours worked by the wife if present, dummy for whether the head of the household lost a job involuntarily during the previous period, and lagged food-consumption-expenditure growth. Standard errors, clustered by state level, are reported in parentheses. All regressions include the Treasury bill rate, change in a dummy if the husband works, change in a similar dummy for the wife, and demographic controls, such as changes in family size, a householder's age interacted with education, and age squared.

icant. Coefficient on change in housing stock is negative and statistically different from zero at the 1% significance level for clothing, vacation services, and recreational services. The coefficient on change in housing stock for food consumption and transport is negative and marginally significant. Extending the sample to include retirees confirms the conclusions made with the base estimation. The coefficients in consumption models that are statistically significant for the base sample remain so for the extended sample.[3]

These microempirical findings of the substitution effect between housing and nondurable consumption are consistent with the findings of the studies based on macro-level aggregate consump-

[3] The results are not reported but are available by request.

tion, in particular, the study of Piazzesi et al. (2007). Postulating constant-elasticity-of-substitution preferences over nondurable and durable consumption, Piazzesi et al. (2007) find the value of the parameter of the intratemporal elasticity of substitution larger than 1, which implies households reduce their expenditure share on housing when house prices move up relative to prices of nondurable consumption.

5 Conclusion

This study investigates empirically the intratemporal dependence between nondurable consumption and housing. Using the data on maintenance expenditures and self-assessed house value, I separate the measure of housing stock and house prices. I use the constructed measures of housing stock and house prices in estimation of the theoretical model, which allows for testing whether consumption and housing are characterized by the intratemporal nonseparability in the contemporaneous utility.

For the model of simultaneous choice of nondurable consumption and housing, I find evidence in favor of the intratemporal dependence between total nondurable consumption and housing. In particular, my findings indicate the substitution effect between housing and nondurable consumption. I reach a similar conclusion for food consumption, transport, clothing, trips and vacation services, entertainment, and recreational services.

Overall, my results contribute to the relatively sparse literature investigating the structure of households' preferences over durable and nondurable consumption. My results complement and extend the findings of nonseparability between nondurable consumption and housing in that literature to the sample of homeowners that do not move, who in reality constitute an overwhelming majority of the population. The importance of understanding the structure of household preferences over housing and nondurable consumption for academic research and economic policy warrants further research on this topic. For example, the finding of nonseparability between nondurable consumption and housing in individual preferences is relevant for testing the housing wealth effect on consumption. Because I do not rule out substitution between housing and consumption, the tests for other channels between housing prices and consumption expenditure (wealth effect, collateral channel, common factors) for homeowners may likely be hindered by nonseparability between housing and consumption. The results may also be relevant for the life-cycle literature that often relies on preferences over consumption and housing being additively separable in contemporaneous utility. The evidence on nonseparability in preferences over consumption and housing, found in this paper suggests that if economic-policy conclusions strongly rely on the assumption of additive separability over consumption and housing in an agent's preferences, then on the disaggregated level, these conclusions may be sensitive to the composition of the target group, in particular in relation to households who are long in housing.

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A Log-linearized Euler equations

Denote $\bar{C}$ and $\bar{H}$ as the expected values of nondurable consumption and housing stock. Let $\hat{C} = \ln(C/\bar{C})$ and $\hat{H} = \ln(H/\bar{H})$. The subsequent derivations closely follow Mazzocco (2007).

Let ϕ_1 and ϕ_2 be defined as follows:

$$\phi_1(\hat{C},\hat{H}) = \ln\left\{U_C(\exp\{\hat{C}\}E[C],\exp\{\hat{H}\}E[H]\right\},$$
$$\phi_2(\hat{C},\hat{H}) = \ln\left\{U_H(\exp\{\hat{C}\}E[C],\exp\{\hat{H}\}E[H]\right\},$$

where U_C and U_H are household marginal utilities with respect to consumption and housing. Assume marginal utilities U_C and U_H are continuously differentiable. Let the one-variable functions $\vartheta_1 : I_1 \to \mathbb{R}$ and $\vartheta_2 : I_2 \to \mathbb{R}$ be defined as $\vartheta_1(k) = \phi_1(k\hat{C},k\hat{H})$ and $\vartheta_2(k) = \phi_2(k\hat{C},k\hat{H})$, where $I_1 = (-a,a)$ and $I_2 = (-b,b)$. Applying the one-variable Taylor expansion formula with remainder, I get

$$\vartheta_i(k) = \vartheta_i(0) + \vartheta_i^{'}(0)k + r_i(k) \qquad \text{for} \quad i = 1,2 \tag{8}$$

with

$$r_i(k) = \int_0^k (k-t)\vartheta_i^{''}(t)dt.$$

From (8) and the definition of $\vartheta_i(k)$ with $k = 1$, I get

$$\phi_i(\hat{C},\hat{H}) = \phi_i(0) + \frac{\partial\phi_i(0)}{\partial\hat{C}}\hat{C} + \frac{\partial\phi_i(0)}{\partial\hat{H}}\hat{H} + R_i(\hat{C},\hat{H}) \qquad \text{for} \quad i = 1,2. \tag{9}$$

Under the assumption of rational expectations, the households' Euler equations can be written as

$$\beta R_{t+1} \frac{U_C(C_{t+1}, H_{t+1})}{U_C(C_t, H_t)} \exp(\phi' \Delta z_{t+1}) = 1 + e_{t+1}^C,$$
$$\beta R_{t+1} \frac{P_t}{P_{t+1}} \frac{U_H(C_{t+1}, H_{t+1})}{U_H(C_t, H_t)} \exp(\phi' \Delta z_{t+1}) = 1 + e_{t+1}^H,$$

where e_{t+1}^C and e_{t+1}^H are the expectation errors. Taking logs, using $\phi_1 = \ln U_C$ and $\phi_2 = \ln U_H$, I have

$$\phi_1(\hat{C}_{t+1}, \hat{H}_{t+1}) - \phi_1(\hat{C}_t, \hat{H}_t) = -\ln\beta - \ln R_{t+1} - \phi \Delta z_{t+1} + \ln(1 + e_{t+1}^C),$$
$$\phi_2(\hat{C}_{t+1}, \hat{H}_{t+1}) - \phi_2(\hat{C}_t, \hat{H}_t) = -\ln\beta - \ln R_{t+1} - \phi \Delta z_{t+1} + \ln(P_{t+1}/P_t) + \ln(1 + e_{t+1}^H).$$

By definition of $\phi_i(\hat{C}, \hat{H})$, I have $\partial\phi_1/\partial\hat{C} = U_{CC}/U_C$, $\partial\phi_1/\partial\hat{H} = U_{CH}/U_C$, $\partial\phi_2/\partial\hat{C} = U_{HC}/U_H$, and $\partial\phi_2/\partial\hat{H} = U_{HH}/U_H$. Then from (9),

$$\frac{U_{CC}}{U_C} \ln\frac{C_{t+1}}{C_t} + \frac{U_{CH}}{U_C} \ln\frac{H_{t+1}}{H_t} = -\ln\beta - \ln R_{t+1} - \phi \Delta z_{t+1} - \Delta R_1 + \ln(1 + e_{t+1}^C), \quad (10)$$
$$\frac{U_{HC}}{U_H} \ln\frac{C_{t+1}}{C_t} + \frac{U_{HH}}{U_H} \ln\frac{H_{t+1}}{H_t} = -\ln\beta - \ln R_{t+1} + \ln\frac{P_{t+1}}{P_t} - \phi \Delta z_{t+1} - \Delta R_2 + \ln(1 + e_{t+1}^H) \quad (11)$$

where ΔR_i for $i = 1,2$ is the Taylor-series remainder. Equation (5) follows from rearranging equation (10) and writing the resulting equation one period back.

B Data Construction

B.1 Deflating

Consumption categories reported in the PSID include food, clothing, transportation, utilities, trips and vacations, entertainment, healthcare, education, and childcare. Deflating of the consumption expenditures and housing data is closely related to the timing of the relevant survey question. Some questions ask about expenditures in the month when the interview occurred, whereas others are asked about the previous year.

Food. Food-consumption expenditures include food consumed at home, away from home, delivered food, and the value of food stamps. Data on food consumed at home and the value of food stamps are deflated using the CPI for food at home. Data on food consumed away from home and delivered food are deflated using the CPI deflator for food away from home. Food-consumption data are deflated according to the month and year when the interview occurred, whereas food stamps and data on income are deflated using the CPI for the end of the year before the interview was conducted.

Clothing. Spending on clothing and apparel is deflated using CPI for apparel for the end of the year before the interview was conducted.

Utility. Utility data include payments for gas or other types of heating fuel, electricity expenses, payments for water and sewer, and other utilities. Each of these utility spending categories is deflated using CPI appropriate for the category (utility fuels and gas service, electricity, water, and sewerage maintenance) according to the month and year when the interview occurred.

Communication. Data on telecommunication include payments for telephone, cable or satellite TV, and internet service. Telecommunication data are deflated using CPI for communication according to the month and year when the interview occurred.

Healthcare. Healthcare spending includes payments for health insurance, prescriptions, in-home medical care and special facilities, doctors, outpatient surgery, dental bills, hospital bills, and nursing home. At the time of the interview, the PSID collects healthcare expenditures combined over two previous years. The total healthcare expenditures are divided by 2 to obtain the value at annual frequency, comparable with other expenditure categories. Total spending on healthcare is deflated using CPI for medical care for the end of the year before the interview was conducted.

Education and childcare. School-related expenses are deflated using CPI for education, whereas childcare expenditures are deflated using CPI for childcare and nursery school for the end of the year before the interview was conducted.

Entertainment and vacations. Recreation and entertainment spending and expenditures on vacations and trips are deflated using CPI for recreation. Vacations and trips data are deflated according to the month and year when the interview occurred, whereas recreation and entertainment data are deflated using the CPI for the end of the year before the interview was conducted.

Transportation. Transportation expenditures are deflated using CPI for transportation. Many of the transportation categories (expenses on gasoline, parking, bus and train, cab fare, vehicle repair, additional car or lease payments, and other transportation-related spending) are reported for the month before the interview was conducted and were deflated according to the previous month of the current year when the interview occurred.

Housing. Housing-related data (home repairs and maintenance, and house value) are deflated using CPI for owners' equivalent rent of primary residence. House-value data are deflated according to the month and year when the interview occurred, whereas data on home repairs and maintenance are deflated using the CPI for the end of the year before the interview was conducted.

B.2 US Regions

Figure 2 reports comparisons of the imputed house-price growth from the PSID and the HPIs by the US Federal Housing Finance Agency and Zillow over four major US regions: Northeast, North Central, South, and West. Following the regional assignment of the states in the PSID, states were grouped into regions as follows:

1. Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont;
2. North Central: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin;
3. South: Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Washington DC, West Virginia;
4. West: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming

The price-growth indices for the fifth region, which includes Alaska and Hawaii, are not reported due to a small number of observations in the PSID for these states.

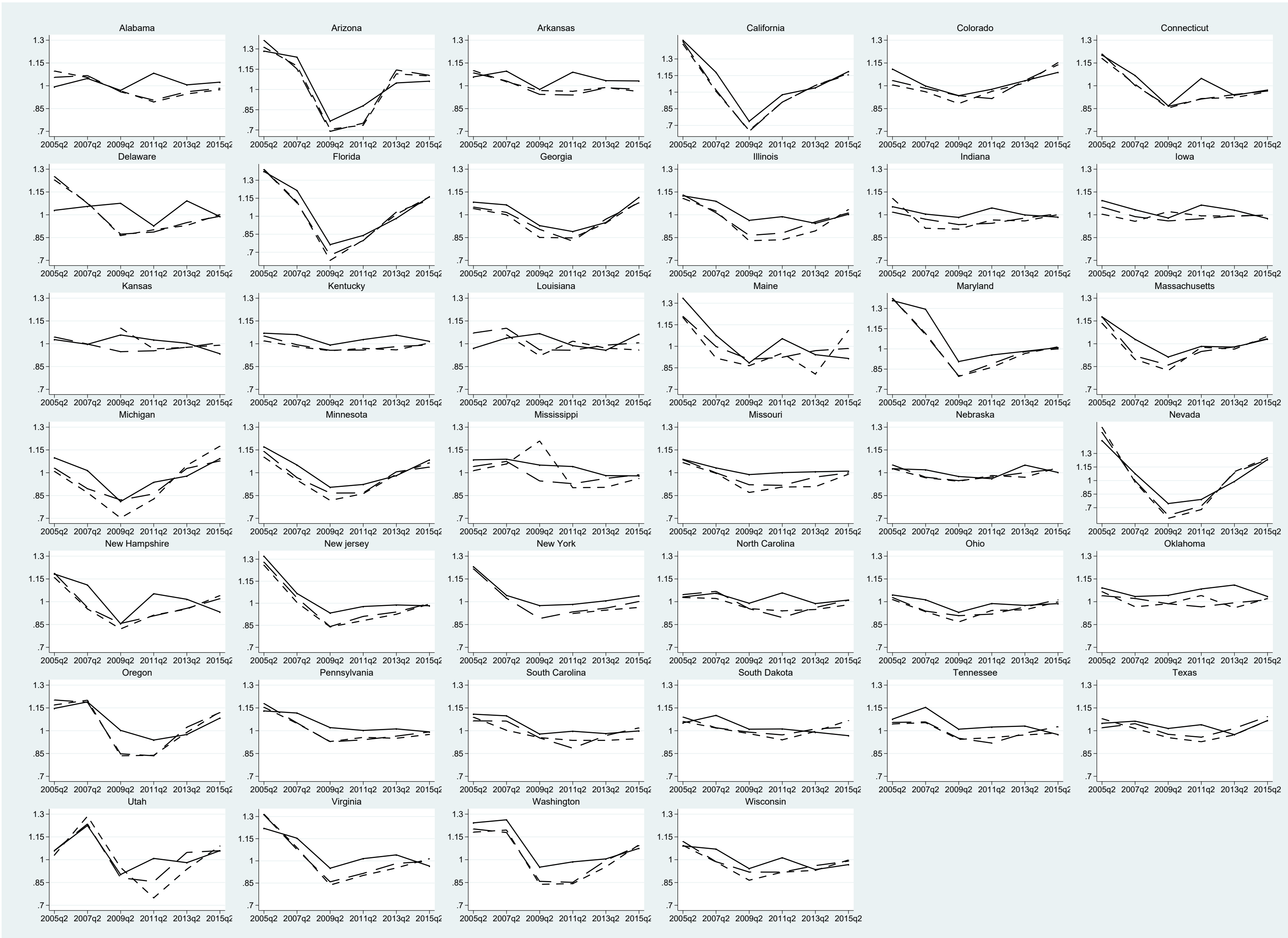

Figure 3: House-price indices over states. The solid line shows average house-price growth imputed from the PSID, the dashed line represents FHFA HPI, and the short-dashed line corresponds to the Zillow index. Alaska, Delaware, District of Columbia, Hawaii, Idaho, Montana, New Hampshire, North Dakota, Rhode Island, Vermont, West Virginia, and Wyoming are not reported due to a small number of observations (less than 10 per period).