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Abstract

We analyze empirically the role played by energy inflation as a determinant of downward corrections in house prices. Using a dataset for 18 OECD economies spanning the last four decades, we identify periods of downward house price adjustment and estimate conditional logit models to measure the effect of energy inflation on the probability of these house price corrections after controlling for other relevant macroeconomic variables. Our results give strong evidence that increases in energy price inflation raise the probability of such corrective periods taking place. This phenomenon could be explained by various channels: through the adverse effects of energy prices on economic activity and income reducing the demand for housing; through the particular impact on construction and operation costs and their effects on the supply and demand of housing; through the reaction of monetary policy on inflation withdrawing liquidity and further reducing demand; through improving attractiveness of commodity versus housing investment on asset markets; or through a lagging impact of common factors on both variables, such as economic growth. Our results contribute to the understanding of the pass-through of oil price shocks to financial markets and imply that energy price inflation should serve as a leading indicator for the analysis of macro-financial risks.

JEL classification: C33, G01, Q43, R21, R31

Keywords: Energy Prices, Housing Market, Financial Crisis, Conditional Logit Model

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1 Introduction

Was it mere coincidence that the global financial crisis 2007-2009 occurred in proximity to an oil shock? Between 2000 and mid-2008, the price of crude oil surged fivefold to an all-time high of around USD 145 per barrel. Already one year before this peak the US subprime mortgage crisis emerged, which led to the most severe financial crisis since the Great Depression (Bernanke, 2010) and a truly global recession. Kaufmann et al. (2011) postulate a direct role for energy prices in the 2008 financial crisis. Using cointegration methods, they identify a significant long-run relationship between household expenditures on energy and US mortgage delinquency rates.[2] Earlier research has already acknowledged that both housing price corrections and energy price volatility are important determinants of recessions. Leamer (2007) calculates that eight out of ten post-war recessions in the USA followed shocks in the housing sector.[3] According to Hamilton (2005), nine of these ten US recessions were preceded by oil price shocks. With the recent Great Recession the relation to housing price corrections gets augmented to 11 : 9 and to oil price shocks to 11 : 10 (Hamilton, 2010).

Inspection of historical data gives already a first illustration of the relationship between energy and real estate markets. Figure 1 presents the annual development of real house and crude oil prices in the US between 1890 and 2009. The correlation is not extraordinary strong over the whole period (0.52) but increases significantly during the last two decades.[4] The correlation between the post-1990 real oil price index and the real house price index in the US is 0.72 and it increases to 0.93 between 2000 and 2006. Remarkable – from today's perspective – are the modest drops of housing prices just in the initial phase of the two big oil shocks of the past century (starting in 1972 and 1979) and after the first gulf war (1990/1). In the period of oil price increases preceding the recent financial crisis, house prices accelerated

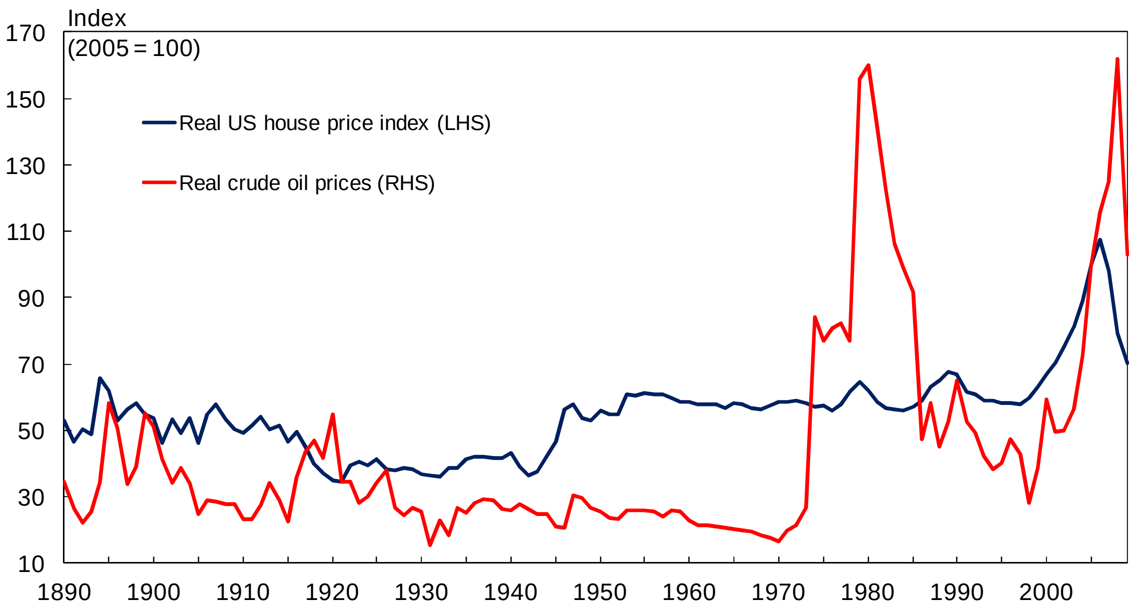
[2] Campbell and Cocco (2011) show that adjustable-rate mortgages default tends to occur when inflation (which in the short-run is energy price driven) and nominal interest rates are high.

[3] In its analysis of 19 advanced industrialized economies, IMF (2003) find that between 1970 and 2002 recessions tended to happen after an housing price bust, which all were followed by banking crisis.

[4] The correlation of nominal house and crude oil prices is significantly higher (0.89). The use of real crude oil price data is convention in economic studies, although the typically high weight of energy prices in inflation would justify the use of nominal data.

in 1997 – one year before the oil price boom. Similarly, house prices already started to decline in 2006, two years before the crash of crude oil prices.

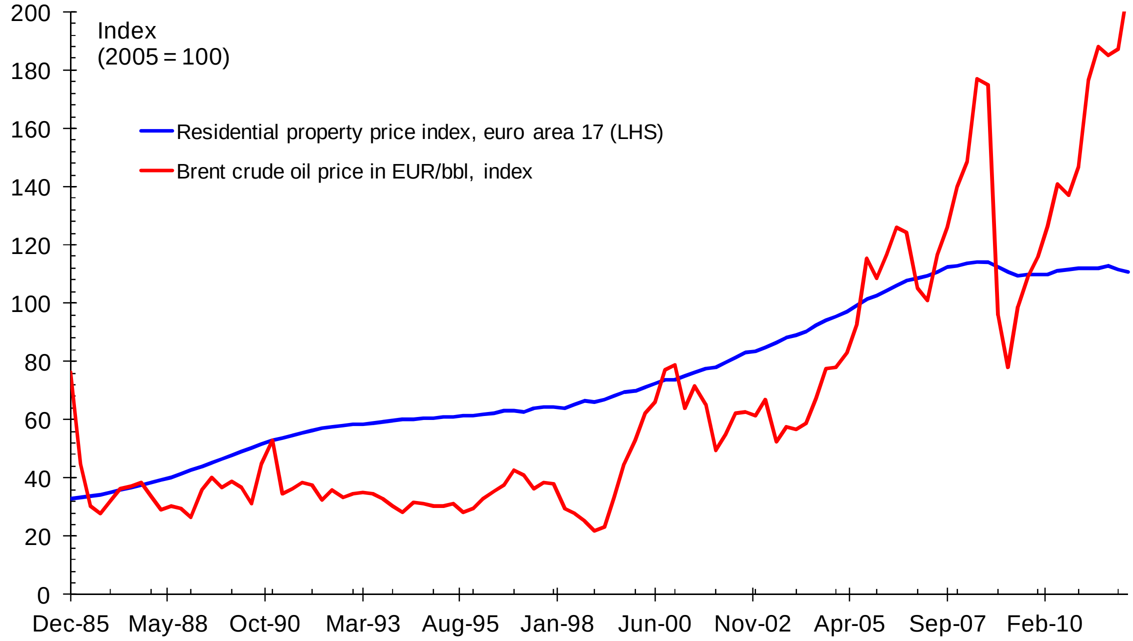
Figure 1: Annual US house prices and crude oil prices, 1890-2009



Source: BP, Shiller.

Comparable data on the euro area are only available since the mid-1980s. Figure 2 shows the development of deflated quarterly housing and euro-denominated crude oil prices. The correlation between both series amounts to 0.76 for the period starting in 1985 and 0.83, if we compute it for the pre-crisis period starting in 1990. As with the US, the recent oil price boom coincided with a housing boom in some euro area countries (especially Ireland and Spain, where the boom was fostered by a spectacular fall of risk premia after the introduction of the common currency).

Figure 2: Quarterly euro area house price index and crude oil price index



Source: ECB, Ecowin

The US and European experience indicate that a deeper analysis of the interplay between the commodity and real estate market may shed light on the nature of house price correction episodes. In our study, we go beyond case studies and focus on the interaction of energy and house price developments in a panel of advanced economies since the first oil shock. In particular, we assess empirically the role played by energy inflation as a determinant of downward corrections in house prices.

The literature identifies various channels underlying this relationship: (i) The adverse direct and indirect effects of energy prices hikes on disposable income and expenditures of households dampening the demand for housing – essentially an income effect (Spencer et al., 2008); (ii) the direct and indirect effects of energy price increases on construction and operational building costs which lead to quantity and price adjustments on the supply side; (iii) the tightening reaction of monetary policy on the pressure induced by energy price increases on headline inflation which first withdraws liquidity from the housing market and second reduces aggregated demand including that for housing (Luciani, 2010); (iv) the improving attractiveness of investment in energy commodities (extraction) compared to housing on asset markets (Basu and Gavin, 2010); (v) the lagging impact of third common factors on both variables, such as economic growth and monetary policy.

We use a panel of quarterly OECD data which spans over the period 1971-2008 for 18 OECD member countries to test empirically whether changes in energy prices affect the probability of house price adjustments. We control for a variety of relevant monetary, macroeconomic, housing market specific and demographic variables and account for misalignment of housing prices from an estimated fundamental value. Our results confirm that changes in energy inflation have a robust effect on house prices and in particular on the probability of downward corrections. To our knowledge, this is the first study to assess this issue in a rigorous econometric setting using longitudinal information from a broad group of economies. Such an empirical strategy is particularly justified by the fact that house price busts are often – but certainly not always – cross-border synchronized, presumably reflecting synchronization of monetary policy, financial deregulation and business cycles (IMF, 2003). In turn, energy price inflation is to a large extent determined by international oil price developments, although rigidities in the pass-through of oil price shocks at the national level may lead to sizeable differences in energy price dynamics across economies.

While the leading indicator quality of energy price inflation found in our study does not exclude feedback effects in the opposite direction, the robustness and magnitude of the effect of energy price inflation on house prices makes it relevant for policy considerations. Assessing risks to price stability, energy prices are already well recognized as the most important component of headline inflation volatility (ECB, 2010). Our findings imply that monitoring of energy price developments should also be an important task for financial market regulators and central banks in the framework of macro-financial risk assessment.[5] The remainder of the paper is structured as follows: Section 2 discusses the relevant literature and considers a few theoretical aspects. Section 3 tests our hypothesis empirically. Section 4 interprets the results and draws policy conclusions.

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[5] In early 2012 Eurostat, the statistical office of the European Union, started to publish a new house price index for its Macroeconomic Imbalance Procedure (MIP) Scoreboard. This set of indicators provides the basis for the economic reading of potential imbalances identified by the European Commission in its new annual Alert Mechanism Report. Apart from that Eurostat also runs pilot studies to capture price developments of owner-occupied housing (OOH), which is not included in the Harmonised Index of Consumer Prices (HICP).

2 Oil prices and house prices: Theoretical linkages

Several channels linking oil price developments and house prices have been identified in the literature. In this section we summarize the existing theoretical frameworks related to such a linkage. We build our survey about such mechanisms around the following channels: (i) an income and demand channel, (ii) an energy related building cost channel, (iii) a monetary policy channel, (iv) an asset price channel, and (v) via reversed causality or omitted factors.

(i) Income and demand channel

Energy price inflation tends to reduce aggregate demand, and in particular housing demand. This impact can be disentangled into a terms-of-trade effect, a demand-side and a supply-side effect (ECB, 2010). First, the effect of oil price increases on terms of trade leads to a reduction in purchasing power and wealth of households. Notwithstanding possible adjustments of the saving rate, this would entail a reduction in consumption and (housing) investment. Second, aggregated demand-side effects arise from inflation and its impact on real income. Ideally, under perfect competition in labour and product markets, rising energy prices would only lead to a relative price change, which could be compensated through substitution for less energy-intensive demand. Rigidities, however, imply that energy prices feed into headline inflation through first and second round effects. Third, supply-side effects relate to the input costs of production. In the short-run, firms may react by either reducing their profits or increase output prices, which in turn implies a reduction of consumption and quantities produced. In the long-run, they would tend to substitute away from energy intensive inputs. The mechanisms described above can be used to (at least partly) explain the correlation between household expenditures on energy and US mortgage delinquency rates in Kaufmann et al. (2011). The increase in the inventory of houses for sale triggered by such a linkage would, in turn, depress their prices, thus reinforcing the effects described.

Taken together, all these effects of oil price increases tend to depress income via decreased purchasing power, profit squeeze and increasing unemployment. Hamilton (2009) as well as Rubin and Buchanan (2008) explain the *Great Recession* as a result of oil price shocks, which eventually contributed to bust the "house price bubble"[6] and triggered the financial crisis.[7] Due to the fact that the response of household spending not only reflects unanticipated income changes but also a deterioration of consumer confidence leading to precautionary savings (mainly at the cost of durables), the impact of an energy price shock on consumption and housing investment is expected to be even higher than that on overall GDP (Edelstein and Kilian 2009). Hamilton (2009) also argues that the recessionary effects of the oil shock on income and unemployment depresses housing demand overproportionally. Such results are in line with the high energy price elasticity estimates for residential investment expenditures reported by Kilian (2008) that lead him to conclude that "energy price shocks make themselves felt primarily through reduced demand for cars and new houses" (Kilian 2008, p. 889).

Microeconomic arguments which stress this connection have been put forward in the recent literature. Relative to overall consumption, Cortright (2008) argues that fuel price increases were at least partly responsible for the bursting of the recent US housing bubble and presents evidence concerning the fact that house price declines were more severe in distant suburbs that require lengthy commutes. The effect of gas prices on the demand for distant suburban housing, reducing relative house prices in remote metropolitan areas, is thus put forward as a mechanism linking oil price shocks to the end of the house price bubble.[8]

(ii) Energy related building cost channel

Construction, maintenance and operation of buildings need energy. On the one hand, the embodied energy is used for the extraction, processing and transport of building materials[9] as

[6] The term "house price bubble" is widely accepted in the context of the most recent crisis (see e.g. Bernanke, 2010). Nevertheless, being aware of the general controversy over the term (Lind, 2009), we prefer to use the merely quantitative concept of "house price corrections".

[7] Explanations of recent global macroeconomic developments based on chronologies related to oil price changes are also put forward by Kilian (2009), Huntington (2005), Blanchard and Galí (2008) and Ramey and Vine (2010).

[8] Ramey and Vine (2010) summarize the adjustment behaviour of households in the US after permanent fuel price upsurges, first by reducing travel distances and in the longer run by revising their decision on where to live and work.

[9] Time series of commodity prices (oil, metal, cement, etc.) generally tend to present a strong degree of co-movement.

well as construction, maintenance and repair of the building. On the other hand, the operational energy is used in providing the building services (heating, cooling, etc.) over its lifetime[10]. This residential sector accounts for a quarter of overall energy consumption in industrialized countries (Swan and Urgusal, 2009). Hence, the presumably negative effect of rising energy costs on housing demand and real estate prices can be sizable.[11] Quigley (1984) regards the production of housing service flows (i.e. the services households derive from the dwellings they inhabit) and considers the demand for residential energy as a factor input. Using production and demand functions for housing services, he estimates i.a. the elasticity of substitution between operating inputs (largely energy) and real estate to be about 0.3. According to those estimates, a doubling of energy prices is associated with an 11-15% increase in the price of housing services, a decline of 7-10% in the demand for housing, and a small increase in housing expenditures.

(iii) Monetary policy channel

To the extent that energy price increases are passed through to medium-term headline or core inflation, they may cause a restrictive monetary policy reaction. Higher interest rates have a dampening effect on economic activity and household income, which tends to hit residential investment over-proportionally (see the evidence in Edelstein and Kilian (2009)). Tight monetary policy also reduces the inflow of liquidity to the housing sector just as low interest rates tend to inflate house prices. Barsky and Kilian (2002) hold exogenous changes in monetary policy chiefly responsible for historical stagflation episodes, which coincided with the rise in oil prices. In addition, IMF (2008) suggests that house prices have become more responsive to monetary policy innovations as a consequence of (flexible rate) mortgage deregulation. With regard to residential investment, however, the impact of monetary policy innovations has decreased since the mid-1980s, particularly in the US. Hence, more flexible and developed housing finance appears to favour monetary policy transmission through prices rather than investment in houses.

[10] The embodied energy accounts typically for between a sixth and a third of the total life-time energy consumption (Building Commission, 2006).

[11] According to our back-of-the-envelope calculation (based on data from BP, US Census Bureau and Building Commission, 2006) total lifecycle energy costs of a typical one-family house in the US in relation to the respective total construction costs may have increased from below 6% of in 2004 to more than 9% in 2006 and around 15.5% in 2008.

(iv) Financial market channel

Energy and housing-related securities compete for investment on asset markets. Increasing energy prices attract investment to commodity producers that could otherwise flow into the housing sector. Both asset markets serve as a hedge against inflation and safe haven when inflation expectations are rising. Caballero et al. (2008) and El–Gamal and Jaffe (2010) provide a narrative of the evolution of the US house price boom as a consequence of petrodollar recycling in the years before the subprime crisis.[12] Rapid growth of emerging economies and the associated rise in commodity prices induced capital flows from emerging markets toward the US in search for (apparently) sound and liquid financial instruments (see also Higgins et al., 2006). The exceptionally strong negative correlation between oil and stock prices between July 2007 and June 2008 is put forward by Caballero et al. (2008) as evidence for this interaction. After the burst of the housing bubble, the interaction between housing, energy and financial markets continues to play an important role in explaining current global developments. The crash exacerbated the scarcity of assets leading to a large positive demand shock (which has sometimes been identified as a new bubble)[13] in the oil market, as well as markets for other commodities.

(v) Omitted factors or reversed causality

Global liquidity, monetary policy, regulation and supervision of financial markets, as well as overall cyclical dynamics may impact both energy and house prices, thus leading to joint developments of these variables that may appear causal but are actually created by such a third factor. Globally accommodative monetary conditions have been documented as a factor driving commodity prices (Frankel, 2008) through a complex transmission mechanism. The interest rate channel, on the one hand, affects commodity prices through its effect on aggregate demand, inflation and incentives for producers to postpone extraction. The asset market channel, on the other hand, changes incentives for financial market participants with regard to risks or term structure, encouraging thus portfolio shifts or commodity carry trade

[12] Looking at headline inflation in the US of the 1970s Piazzesi and Schneider (2012) show that the oil shock driven Great Inflation induced a portfolio shift by making housing more attractive than equity.

[13] While there seems to be a consensus that the subprime crisis has been preceded by a housing bubble the notion of an "oil price bubble" has been much more disputed (Krugman, 2008) although some research would indeed suggest that oil price boom until 2008 went beyond fundamentals (Kaufmann, 2010).

(G-20, 2011).[14] Monetary conditions, on the other hand, also impact real estate prices. Utilizing structural VARs for several small open economies, Bjørnland and Jacobsen (2009) present empirical evidence concerning the increasing role of house prices in the monetary transmission mechanism. Goodhart and Hoffman (2008) find evidence of a multidirectional link between house prices, monetary variables and other macroeconomic variables. Such results stand in contrast with those in Bernanke (2010), who finds that the direct linkages between monetary policy and house price changes in the early part of the last decade were weak.

Global demand certainly plays an important role for oil price developments (Hamilton 2009; Kilian, 2009). This demand could originate from house price wealth effects – as expressed by Leamer (2007), who states that "housing is the business cycle". The popular account of financial crises by Reinhart and Reinhart (2010) also stresses the disastrous long-term impact of real estate crashes on the economy. Spillovers from the housing sector to the rest of the economy have widened through changes in housing finance systems in OECD economies over the past two decades by supporting the use of housing as collateral (IMF, 2008).

3 Empirical analysis

In this section we assess empirically the role played by energy price inflation as a determinant of house price corrections using a panel dataset spanning information for 18 OECD economies for the period 1971-2010 at a quarterly frequency.[15] Before concentrating on explaining turning points in house prices, we analyze the role played by energy price inflation as a determinant of overall house price dynamics.

We start by estimating panel regression models where house price inflation is assumed to depend on its own lag, energy price inflation and other determinants,

[14] Identifying these channels empirically and designating causalities is not trivial. Using a VAR model, Anzuini et al. (2010) present empirical evidence of a significant but weak relationship between an expansionary US monetary policy shocks and rising commodity prices. Erceg et al (2012), using their multi-country model SIGMA, show that "easy money in the dollar bloc" leads to a transitory run-up in oil prices.

[15] The countries in our sample are Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, South Korea, Sweden, Switzerland, US and UK.

$$\Delta p_{it}^{h} = \gamma_0 + \rho \Delta p_{it-1}^{h} + \mu \Delta p_{it}^{e} + Z_{it}\,\theta + \varepsilon_{it}\,, \tag{1}$$

where Δp_{it}^{h} and Δp_{it}^{e} denote house price inflation and energy price inflation, respectively, while Z_{it} is a vector summarizing other determinants of house price changes. The error term, ε_{it}, is assumed to be composed by a country fixed effect, a year fixed effect and a random shock which is assumed to fulfil the standard assumptions required in linear regression models. For the vector Z_{it}, we choose variables which proxy monetary policy and credit developments (credit growth, interest rate changes), macroeconomic fundamentals (GDP per capita growth), housing market variables (investment in housing, home ownership rates) and demographic dynamics (share of working age population, population growth).

The results of the estimation of different specifications of equation (1) are presented in Table 1.[16] In order to assess the unconditional within-country correlation between house price and energy price changes, we start by regressing house price inflation on energy price inflation in a specification which includes country and year fixed effects (see column 1 in Table 1). This model reveals a significant negative association between the two variables, with a (within-country) standard deviation change in energy price inflation (equal to 6.2 percentage points) being related to a decrease of approximately 0.44 percentage points in house price inflation. The negative relationship remains significant if we control for the persistence observed in house price inflation by including the lagged dependent variable as an extra regressor in the model (see column 2 of Table 1). Controlling for other determinants of house price inflation does not affect the negative and significant association and unveils how other factors relate to house price inflation dynamics. Increases in credit, GDP per capita and population growth appear positively related to house price inflation, as would be expected from theory. The apparently counterintuitive positive partial correlation between house price inflation and the current account balance can be explained by the convergent dynamics observed in this variable over the sample period. On average, for our panel dataset, there is a robust negative correlation between the change in the current account balance and its level, indicating that the

[16] The fact that the time dimension in the panel clearly dominates the cross-section dimension implies that we do not require dynamic panel methods to estimate the specification given by equation (1) (see Alvarez and Arellano, 2003).

largest positive changes tended to happen in countries with relatively sizeable current account deficits, where house prices also increased more rapidly.

Table 1: House price and energy price inflation, panel data regressions

	(1)	(2)	(3)
Energy price inflation	-0.0711***	-0.0427***	-0.0236**
	[0.0148]	[0.00909]	[0.00941]
Lagged house price inflation		0.488***	0.435***
		[0.0687]	[0.0585]
Credit growth			0.0222**
			[0.0103]
Real interest rate change			-0.0293
			[0.0168]
GDP per capita growth			0.212***
			[0.0333]
Current account balance			0.0550***
			[0.0167]
Investment in housing			-0.0608
			[0.0732]
Home ownership rate change			0.0168
			[0.259]
Share of working age pop.			-0.0236
			[0.0297]
Population growth			0.398**
			[0.139]
Observations	2,636	2,626	1,579
R-squared (within)	0.229	0.415	0.503

The dependent variable is house price inflation. Country and year fixed effects included in all specifications. Robust standard errors in brackets. *(**)[***] stands for significance at the 10% (5%)[1%] level.

The results show an overall robust negative partial correlation between energy price inflation and house price inflation that gives some indication that increases in energy prices may have contributed to the burst of house price bubbles in the past decades. However, an analysis that aims at directly quantifying the contribution of energy prices to downward corrections in house prices requires a different type of specification based on the identification of such bubble burst periods and the specification of models which assess the effect of energy prices on their occurrence probability.

Since the dependent variable of such an analysis (the occurrence of a price reversal) is of a binary nature, we use conditional logit specifications to model the process of house price reversals in our panel. The use of conditional logit models allows for the inclusion of country-specific, time invariant factors which control for fixed unobservable factors which may differ across economies. The logit models used in the analysis are thus of the type

$$P(y_{it}=1|X_{it},\alpha_i)=\frac{\exp(\alpha_i+X_{it}\beta)}{1+\exp(\alpha_i+X_{it}\beta)}\ , \qquad (2)$$

where y_{it} takes value one if period t is a house price upward trend reversal period in country i and zero otherwise and X_{it} is a vector of determinants of house price reversals. Conditional logit models of the type put forward in equation (2) can be estimated in a straightforward manner using maximum likelihood methods (see Chamberlain, 1980).

Answering our research question requires the identification of turning points in house price data and the definition of periods corresponding to the price reversal. The recent empirical literature on asset price bubbles (see Gerdesmeier et al., 2009, and Crespo Cuaresma, 2010) follows variants of the approach proposed by Bry and Boschan (1971) in order to identify peaks and troughs in house price data, which are used to date house price reversals. Starting with the series of real house prices for a given country, p_t, we define an observation as a potential peak if it is a local maximum in a 6-quarter period (that is, $p_{t-j}< p_t > p_{t+k}$ for $j=1,\ldots,3$). Local minima are identified in a similar way and we impose a minimum length for peak-to-trough/trough-to-peak phases of two quarters, as well as for full peak-to-peak and trough-to-trough cycles of three years. Such a requirement ensures that our identified turning points are not exclusively due to short-lived volatility in real estate prices. Following this identification procedure, we define a house price reversal as the period corresponding to a downward correction in house prices, as well as the previous and following quarter.[17] The dependent variable in our empirical model takes value one if the observation corresponds to a correction period in the corresponding country, and zero otherwise. Table 2 presents the dates corresponding to the identified house price turning points in the dataset. The procedure does

[17] We define the correction period as in Crespo Cuaresma (2010), allowing thus for a certain degree of flexibility in identifying the actual starting point of the correction episode. In particular, the correction period is assumed to start one quarter before the peak (when the downward price pressures are supposed to be dominant), and last until the first quarter where such pressures are realized by the decrease in house prices.

not detect any turning point in the house price series for Japan and the Netherlands, which are therefore not included in the sample used to estimate the econometric models.

Table 2: Identified turning point dates for house prices

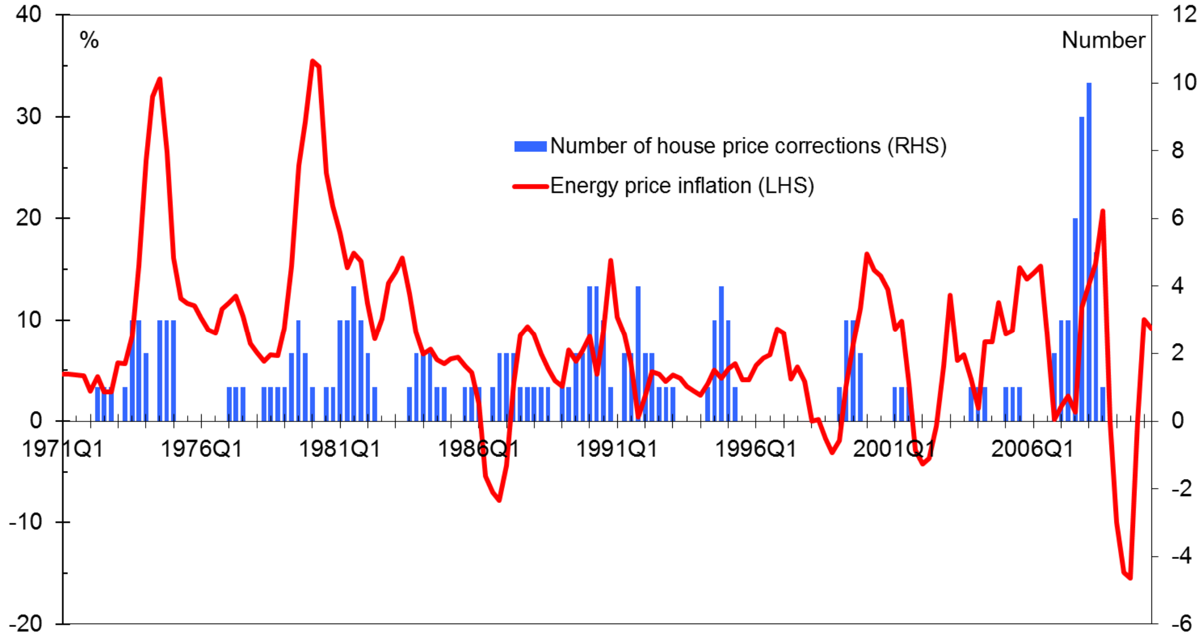
Australia	1982Q1	1994Q4	**UK**	1973Q4	
	1985Q4	2004Q1		1980Q4	
	1989Q2			1989Q4	
Canada	1981Q4		**Ireland**	1972Q3	2001Q2
	1991Q3			1984Q1	
	1994Q3			1992Q1	
Switzerland	1990Q1		**Italy**	1981Q2	
	2004Q4			1992Q4	
Germany	1981Q3	1999Q3	**Korea**	1991Q3	
	1986Q4			2003Q4	
	1995Q1				
Denmark	1973Q4		**Norway**	1977Q2	
	1979Q3			1987Q3	
	1987Q1			2007Q4	
Spain	1974Q4		**New Zealand**	1984Q3	
	1978Q3			1990Q2	
	1992Q1			1999Q3	
Finland	1974Q3	2000Q2	**Sweden**	1979Q4	
	1984Q4			1990Q2	
	1989Q2			1994Q4	
France	1974Q4		**United States**	1974Q4	2007Q1
	1981Q2			1979Q2	
	1991Q3			1990Q1	

In a first descriptive approach to the relationship investigated, Figure 3 presents the frequency of house price correction periods in our group of countries against aggregate energy price inflation in the OECD. Downward adjustments in house prices appear to be more frequent around the oil shock in 1974, in 1981, during 1991, when the first Gulf War took place, and particularly at the end of the period considered.[18] Most cases of house price corrections (9

[18] Unlike in the econometric exercise, for the creation of Figure 3 the definition criteria for housing price corrections were softened at the end of the period under examination in order to capture the adjustments that took place during the financial crisis. In particular, the minimal requirements concerning the length of a full peak-to-peak or trough-to-trough phase were dropped for the latest years, so as to be able to identify also (partly unfinished) corrections since 2007.

and 10 occurrences, respectively) occurred in the last quarter of 2007 and the first quarter of 2008.

Figure 3: Energy price inflation (left axis) and house price adjustments (frequency, right axis), OECD countries 1971-2010



Source: OECD, own calculations.

As the main determinant of house price reversals, we obtain measures of mean deviation or house price misalignment making use of cointegration analysis. Using Dynamic OLS (DOLS (Stock and Watson, 1993)), we estimate recursively cointegration regressions linking house prices with income per capita and real long-term interest rates and use the deviation of house price data from the estimated long-run relationship as a measure of misalignment. At each period in time, we obtain long-run elasticities of real prices to changes in GDP per capita and real interest rates (long term interest rates deflated by CPI inflation) by estimating a cointegration relationship enhanced with leads and lags of the right-hand-side variables. Data for the estimation of the cointegration relationship ranges back to 1971 for all countries except Germany and Korea, and the first misalignment estimate is obtained for the observation corresponding to the first quarter of 1975 (1990 for Korea and 1995 for Germany). The sample is then expanded quarter by quarter to obtain misalignment estimates based exclusively on past information. With the exception of Germany and Korea, for which only a shorter sample is available, all countries present the expected signs in the long-run elasticities, although there are remarkable differences in the absolute value of the parameters attached to the interest rate variable across countries.[19] In addition, estimating standard error correction models leads to significant adjustment to the long-run equilibrium for all countries in our sample. The largest misalignment are found for the UK and New Zealand in the period 2004-2007 (where prices are estimated to deviate from the corresponding equilibrium by about 50 percent) and for Spain in the eighties (with misalignments of around 45 percent).

In addition to energy price inflation, which is the central variable in our analysis, other determinants of house price bubble bursts have been proposed in the literature and are added to our set of covariates on the right hand side of equation (2). Table 3 presents the estimation results of conditional logit models of the form presented in equation (2) for different choices of control variables. All specifications include decadal dummies and all explanatory variables are lagged one quarter in order to ensure Granger-causal effects from the explanatory variables. The first column of Table 3 presents the results from a bivariate model where the probability of house price reversals is assumed to depend exclusively on energy price inflation. In this simple setting, the results of the estimate indicate that increases in energy price inflation augment significantly the probability of a price reversal. In this simple model the average marginal effect of energy price inflation (evaluated assuming that the country fixed effect equals zero) is 0.550, with a standard deviation of 0.0252. The effect of changes in energy price inflation on the probability of house price adjustments is thus not only statistically significant, but also sizable. Column 2 of Table 3 expands this simple specification by adding the house price misalignment variable as a covariate in the model. As expected, the parameter associated to this variable is estimated to be positive and highly significant, indicating that as house prices increase above their equilibrium level the probability of a price reversal becomes higher. The effect of energy price inflation remains positive and significant after controlling for the misalignment level.

[19] The estimated long-run elasticities which are used to obtain the measure of house price misalignments are presented in the Appendix, together with the source and descriptive statistics of all variables used in the econometric specifications.

Table 3: Estimation results for conditional logit models of house price reversals

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Energy price inflation	2.488**	3.810**	4.327***	3.769*	3.386**	3.555*	3.414**
	[1.213]	[1.564]	[1.572]	[2.014]	[1.716]	[2.055]	[1.697]
Misalignment		7.441***	7.434***	7.203***	7.811***	8.951***	7.852***
		[1.890]	[1.319]	[1.714]	[1.733]	[1.074]	[1.724]
Credit growth			1.77			3.191	
			[2.982]			[2.893]	
Real interest rate change			5.656			2.094	
			[5.024]			[4.254]	
GDP per capita growth			-6.829			-9.648	
			[7.870]			[7.945]	
Current account balance			-1.471			-3.391	
			[7.266]			[7.835]	
Investment in housing				0.836		2.609	
				[18.29]		[30.22]	
Home ownership rate change				17.48			
				[25.51]			
Share of working age pop.					-16.32*	-42.56*	-16.26*
					[9.366]	[18.73]	[9.312]
Population growth					9.264	-9.214	
					[54.41]	[82.61]	
Observations	2,089	1,911	1,668	1,401	1,911	1,608	1,911
Pseudo-R2	0.0274	0.0911	0.113	0.0901	0.0934	0.133	0.116

Conditional logit estimates. The dependent binary variable equals one in house price burst periods. Robust standard errors clustered by country in brackets. Decadal dummies included in all models. *(**)[***] stands for significance at the 10% (5%)[1%] significance level.

In column 3 of Table 3, in addition to our misalignment measure we add a group of economic variables as controls in the model which have been proposed in the literature to account for the effect of liquidity and monetary policy measures as well as income developments and external imbalances. As expected, the misalignment variable is positively related to house price corrections, but none of the additional variables appears to be a robust determinant of price reversals in house prices, while the effect of energy price inflation dynamics is still present when controlling for them. The same is true if we control instead for housing investment and home ownership, which do not appear to be systematic drivers of house price reversals (see column 4). In column 5 we include two demographic variables in the model: the share of working age population and the rate of growth of total population. These variables account for potential effects of changes in the age structure of the population on the demand for housing. Their inclusion does not affect the importance of energy prices and misalignments as determinants of house price reversals. Furthermore, age structure dynamics as captured by the share of working age population, potentially related to the probability of experiencing turning points in house prices. Finally, the last column in Table 3 presents our preferred model, where only significant variables from the specifications tried are considered. The estimates of this model reaffirm the role of energy prices as an explanatory factor of house price dynamics. The models estimated imply a marginal effect of energy price inflation on the reversal probability between 0.5 and 0.6, depending on the specification used. This implies that a 1 percentage point change in energy price inflation rates increases the probability of a house price reversal by 0.5 to 0.6 percentage points.

Several checks were carried out to ensure the robustness of our results. If contemporary variables are considered instead of lagged covariates, the results presented in Table 3 are left qualitatively unchanged, while the change in the real short term interest rate appears to be significantly and positively related to turning point probabilities. The results for this variable, which is meant to capture the role of monetary policy actions, indicate that monetary tightening tends to be related to house price corrections, although establishing a causal relationship between the two would require a more in-depth analysis that falls beyond the scope of this study. We also reestimate the model using subsamples based on excluding individual countries from the sample, which leads to some variation in the estimated parameter but does not change the qualitative results described above concerning the effect of energy price inflation on the probability of house price corrections.[20]

In Table 4 we present the results of further robustness checks based on changing the definition of our dependent variable. In the first column of Table 4 we present the benchmark results obtained with the original dependent variables and our preferred specification which contains exclusively statistically significant parameters (column 7 in Table 3). We redefine the turning point estimation method by using more restrictive conditions in order to qualify as a turning point. In particular, we impose a minimum length for peak-to-trough/trough-to-peak phases of one year (instead of two quarters), as well as for full peak-to-peak and trough-to-trough cycles of four years (instead of three), and estimate the model based on this identification procedure. The parameter estimates for this new variable are presented in the second column of Table 3 and confirm the results of our original analysis. In column 3 of Table 4 we estimate the model after redefining the price correction episodes. Instead of using a definition based on the turning point together with the previous and following quarter, we use alternative definitions based on the turning point and (exclusively) the previous quarter (presented in column 3 of Table 4), as well as on the turning point and (exclusively) the following quarter (column 4 of Table 4). The results are not qualitatively affected by these changes in the definition of the corrective period and confirm the role played by energy price inflation as a determinant of house price corrections.

	Benchmark	More restrictive turning point definition	Turning point + previous quarter	Turning point + following quarter
Energy price inflation	3.414**	3.300*	2.627*	3.682**
	[1.697]	[1.821]	[1.547]	[1.708]
Misalignment	7.852***	8.076***	8.134***	7.505***
	[1.724]	[1.452]	[1.708]	[1.744]
Share of working age pop.	-16.26*	-24.9	-13.35*	-5.984
	[9.312]	[19.52]	[7.508]	[8.115]
Observations	1,911	1,858	1,911	1,911
Pseudo-R2	0.116	0.121	0.11	0.101

Conditional logit estimates. The dependent binary variable equals one in house price burst periods. Robust standard errors clustered by country in brackets. Decadal dummies included in all models.

[20] Figure A2 in the Appendix summarizes the results of this robustness exercise.

4 Concluding remarks

This study empirically demonstrates a systematic relationship between energy and real estate markets. The results of our analysis of 18 OECD countries over a period of 37 years confirm the hypothesis that energy price inflation has significant leading indicator properties for correction dynamics in house prices. Our estimated models imply that deviations from fundamental-driven house prices play a significant role in such price corrections and thus energy price inflation can be seen as playing a role in the bursting of house price bubbles. Even without straightforward evidence of causality beyond the time lag structure used in the specifications, we conclude from our results that energy price inflation can be considered an important indicator not only for assessing challenges to price stability but also for financial market stability.

Future research focused on the interactions of energy and real estate markets in the housing boom phase appears important, as does a more systematic analysis of the reversed effect of property price corrections on commodity price developments. Establishing an unequivocal case for causality would probably require a thorough investigation of the channels sketched in our study – a quite ambitious undertaking given the various cross-linkages involved. Progress on this research agenda would provide inputs for the discussion on macro-financial policies.

Various options are debated in order to minimize the probability or costs of excessive asset price boom and bust cycles: (i) doing nothing and “cleaning up the mess” once the bubbles burst; (ii) “leaning against the wind” via restrictive monetary policy; (iii) pursuing contractionary fiscal policy and building up fiscal buffers; (iv) applying macro-prudential measures to control household lending and improve bank resilience (Bernanke, 2010; Praet, 2010); (v) reforming regulation on the underlying real estate markets. [21] Our results suggest that understanding the structure of energy markets might be particularly important for monetary authorities as lower energy price volatility (G-20, 2011) and reduced energy intensity (ECB, 2010) are important factors facilitating prudential macroeconomic policies.

[21] Repealing mortgage deregulation and preferential (tax) treatment of homeownership could reduce house price volatility and hence the risks to macroeconomic stability (Andrews, et al., 2011). Chinese authorities, for instance, used farther-reaching regulatory measures to curb housing markets in recent years (Clemens et al., 2011). Furthermore, redirecting (zoning) policies towards “walkable cities” could also dampen the proliferation of car-dependent (and hence energy–intensive) suburban fringes (Leienberger, 2011).

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Appendix

Table A1: Descriptive statistics of the variables used in the empirical models

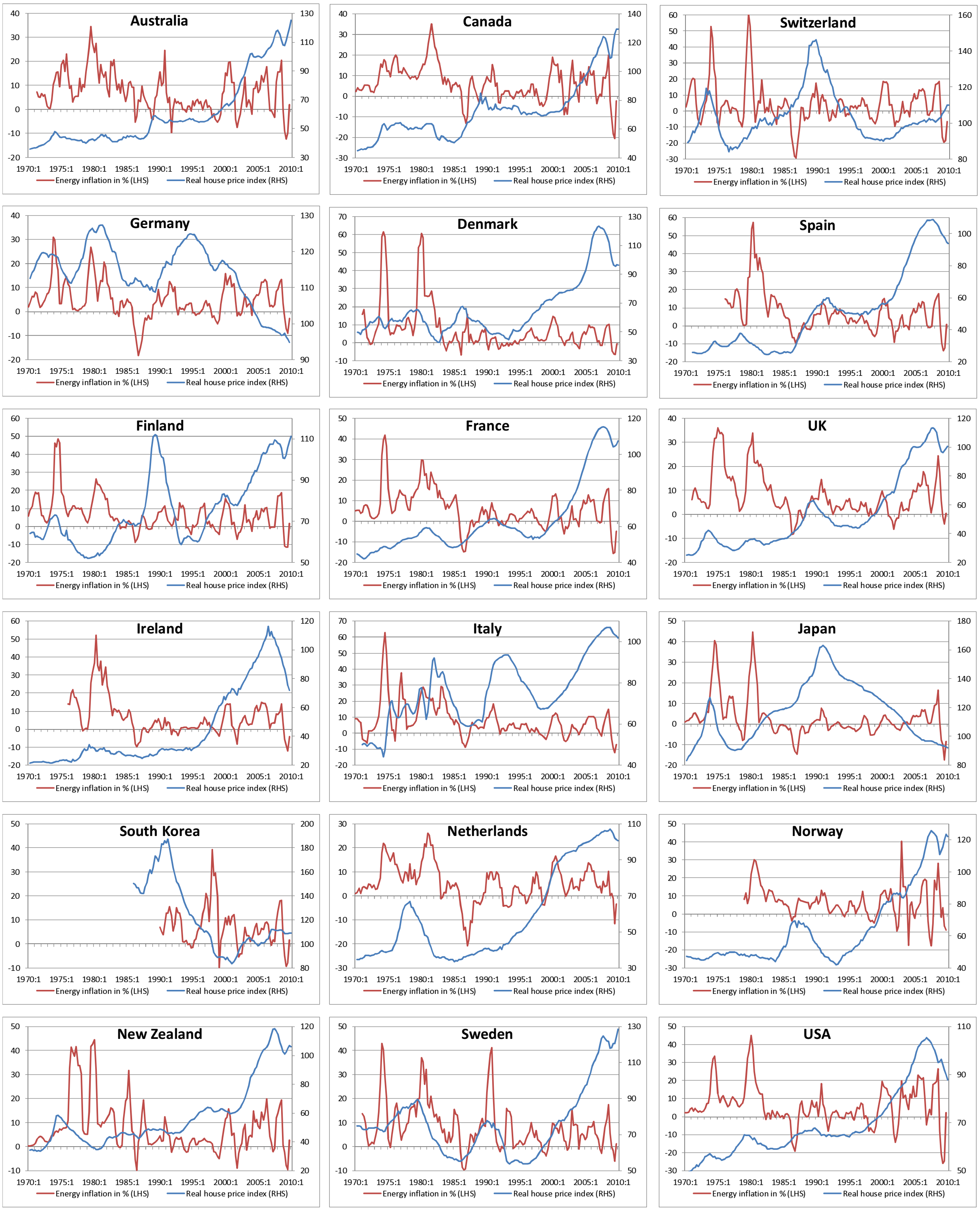
	Obs.	Mean	Std. Dev.	Min.	Max.	Source
House price correction period	2273	0.063	0.244	0.000	1.000	Own calculations based on OECD data for house price indices
Energy price inflation	2681	0.064	0.101	-0.294	0.628	OECD
Misalignment	2260	0.032	0.164	-0.736	0.497	Own calculations based on OECD data
Credit growth	2551	0.054	0.077	-0.598	0.615	OECD
Investment in housing	2457	0.059	0.020	0.015	0.151	OECD
Home ownership rate change	1957	0.001	0.003	-0.050	0.020	OECD
Real interest rate change	2343	-0.001	0.025	-0.167	0.148	OECD
Share of working age pop.	2506	0.676	0.039	0.583	0.781	OECD
Population growth	2502	0.007	0.005	-0.009	0.047	OECD
GDP per capita growth	2507	0.019	0.025	-0.147	0.179	OECD
Current account balance	2403	0.001	0.045	-0.203	0.208	OECD

Table A2: Long-run elasticities and error correction parameter estimates: house prices

Country	Income	Long-term interest rate	Error correction parameter	Obs.
AUS	0.367 (0.015)	-4.152 (0.373)	-0.026 (0.011)	154
CAN	0.290 (0.014)	-3.810 (0.389)	-0.048 (0.019)	154
CHE	0.141 (0.035)	-2.009 (0.823)	-0.021 (0.012)	150
DEU	-0.702 (0.031)	3.191 (0.319)	-0.027 (0.031)	61
DNK	0.132 (0.030)	-6.454 (0.596)	-0.024 (0.011)	154
ESP	0.300 (0.029)	-4.183 (0.492)	-0.010 (0.006)	151
FIN	0.208 (0.022)	-2.143 (0.493)	-0.024 (0.008)	154
FRA	0.296 (0.025)	-5.648 (0.564)	-0.013 (0.005)	154
GBR	0.403 (0.028)	-4.464 (0.772)	-0.014 (0.007)	150
IRL	0.404 (0.015)	-7.946 (0.448)	-0.020 (0.016)	149
ITA	0.216 (0.014)	-1.761 (0.381)	-0.052 (0.015)	154
JPN	0.238 (0.040)	0.516 (0.429)	-0.003 (0.005)	150
KOR	-0.206 (0.036)	-1.978 (0.817)	-0.040 (0.016)	91
NLD	0.630 (0.031)	-9.752 (0.846)	-0.031 (0.008)	150
NOR	0.351 (0.019)	-5.087 (0.568)	-0.017 (0.009)	154
NZL	0.394 (0.025)	-4.988 (0.556)	-0.021 (0.006)	154
SWE	0.201 (0.017)	-7.778 (0.445)	-0.022 (0.010)	154
USA	0.202 (0.011)	-2.557 (0.251)	-0.005 (0.010)	154

The columns "Income" and "Long-term interest rate" are the estimated long run elasticities based on dynamic OLS (DOLS). Dependent variable: log of house price index; independent variables: log of GDP per capita and real long run interest rate. The column "Error correction parameter" is the estimate of the adjustment parameter to the cointegration relationship in an error correction specification of the model.

Figure A1: House price index and energy price inflation



Source: OECD

Figure A2: Parameter estimates ± standard deviation for the energy price inflation variable after excluding individual countries