

## **Appendix Tables for Duca and Muellbauer with Murphy 2021 “What Drives House Price Cycles? International Experience and Policy Issues”**

Appendix Tables A1 and A2 summarize key characteristics of selected post-2006 publications that analyze cross-country and cross-metro area patterns in house prices, respectively. Table entries report the sample and dependent variables modeled by these studies along with the estimation methodology and how the articles control for critical drivers of house prices, encompassing the measurement or treatment of user costs, tax factors, expectations of house price appreciation, credit constraints, and housing supply. Also reported are how, if at all, the studies control for various aspects of mortgages, including the funding sources for mortgages, whether mortgages entail full recourse on the part of borrowers, and whether foreclosures require judicial proceedings. Other notable variables are also indicated.

Appendix Table A3 summarizes 17 country or small-panel studies of the impact of macroprudential measures on growth of credit or leverage and house prices, and on measures of loan performance. A number of studies of supervisory and other micro data apply difference-in-difference methodologies with interesting findings on how individual households are affected but without quantifying macro consequences.

**Appendix Table A1: Selected Post-2006 Cross-Country Studies of House Prices**

Study	Countries, time period	Econometric framework	Controls and/or other endogenous variables					Key findings
			User Costs: interest rate & taxes	Expected or lagged appreciation	Credit conditions, mortgage market	Supply	Other notable variables	
Cesa-Bianchi, Cespedes, and Rebucci (2015)	57 AEs & EMDEs, 1995q4-2012q4	Structural PVAR in log real HP, log consumption, real short term interest rate, current account/GDP, log real exchange rate, global liquidity. Mean group estimation.	Real short-term interest rate, no tax controls.	One lag in real HP appreciation implicit in VAR with 2 lags.	None.	None.	Global liquidity instrumented by US data.	HPs and consumption respond more to global liquidity shocks in EMDEs than in AEs. HPs amplify liquidity effects in both, mainly via the exchange rate in EMDEs, but not in AEs.
Cerutti, Dagher, and Dell'Arricia (2017)	33-77 AEs & EMDEs, 1970/1995q1-2012q4	Probit for real house price booms with housing finance controls: max LTV, term, fixed/variable rate, funding model, lender recourse & tax deductibility.	No interest rate control. Dummy for tax deductibility.	None.	Overall and hh credit booms, hh debt/GDP, time-invariant housing finance characteristics.		Lagged GDP, hh debt/GDP, inflation rate, GDP growth rate, VIX, current account/GDP.	HP and credit booms are closely linked, and most end in recession. HP booms are more likely in countries with high LTVs and non-retail mortgage funding.
European Central Bank (2015)	20 Euro-zone AE's, mid-1990s-2015q2	Log real HP inverted demand, given log income, log housing stock and real mortgage rate; Bayesian priors for long-run.	Real mortgage interest rate, no tax controls.	None in long-run equation. Implicit in VAR.	None in long-run equation. VAR includes growth of mortgage credit.	Housing stock.	Short-run dynamics in a VAR, conditional on deviation from the long-run.	Measures of over-valuation based on residual from long-run HP solution. Under-valuations in 2015 in Baltic states, Ireland, and Spain. Few overvaluations.
Geng (2018)	20 AEs, 1990q3-2016q4	Real log HP, inverted demand, cointegration. Separate residential investment model to deduce supply elasticities.	Real mortgage interest rate; separate tax index to control for tax relief and property taxes.	No lags.	None.	Housing stock.	Interactions of real interest rate with supply elasticity, income with tax index, & rent control with supply.	Measures of overvaluation, national demand & supply effects vary with structural differences.
Glindro, et al. (2011)	9 Asian AE's & EMDEs, 1993q1-2006q4	Separate level (long-run) and $\Delta$ (short-run dynamics) log real HP panel OLS equations. Various interactions in dynamics.	Real mortgage rate, no tax controls.	One lag in real HP appreciation in short-run equation.	Mortgage debt-to-GDP ratio.	(Flawed) supply proxy: building permit index.	Equity prices, REER, business environment index.	HPs are more volatile where supply elasticities are low & business environment is liberal. Little pre GFC evidence of overvaluation using flawed long-run model.
Igan and Loungani (2012)	22 AEs, 1970q1-2010q1	Real log HP change, error correction term: log HP/income. Country by country and pooled regressions.	Nominal short and long interest rates, no tax controls.	None.	Aggregate private bank credit growth.	None.	Growth rates of real per capita income, real equity prices and working age population.	Cautious conclusions in view of lack of cointegration for most equations and very heterogeneous findings.

IMF (2008, Box 3.1)	18 AEs, 1970q1-2007q4	ECM for log real HP, conditional on log per capita income, short and long nominal interest rates, growth in real credit, population and real equity prices.	Short and long nominal interest rates, no tax controls	One lag in real HP appreciation.	Growth rate of real private credit.	None.	Growth rates of real equity prices and population.	Measures of overvaluation, led by Ireland, Netherlands, UK, Australia and France.
Philipponnet and Turini (2017)	28 EU AE's, annual, 1995-2015	Log real house prices, panel cointegration, estimated by Dynamic OLS, Fully Modified OLS and OLS.	Real long-term interest rate. No tax adjustment.	One year leads and lags in HP appreciation	None.	Residential investment (coefficient positive)	Population, per capita income.	Overvaluation indicators using average of model-based measure and HP/rent and HP/per capita income
Sa, Towbin, and Wieladek (2014)	18 AE's, 1984q1-2006q4	Large structural VAR with interactions, including real HP, real private credit, and residential investment. Countries classified as having high or low mortgage market development. Sign restrictions assist identification.	Domestic short- and long-term nominal interest rates, no tax controls.	One lag in real HP appreciation implicit in VAR with 2 lags.	Aggregate real private credit growth, time-varying mortgage securitization rate.	Residential investment.	REER, current account/GDP, CPI, consumption, non-residential investment, interactions with time-varying mortgage securitization index. World interest rates, world prices, and world GDP.	Real HP, private credit and residential investment in countries with highly developed mortgage markets and higher degrees of funding from securitization are more sensitive to capital inflow shocks.
Tillman (2013)	5 or 6 Asian AE's and EMDEs, 2000q1-2011q1 or 2000q3-2010q4	6 variable VAR including HP or equity price index, capital flows/GDP, GDP, CPI, REER, short and long interest rates.	Short- and long-term nominal interest rates, no tax controls.	2 or 3 lags in real HP appreciation implicit in VAR with 3 or 4 lags.	None.	None.	None.	Capital inflow shocks drive up HP and equity prices, and more so in Hong Kong, Korea and Singapore than in the other Asian economies.

Notes: AEs denotes advanced economies and EMDEs denotes emerging market and developing economies. HP denotes house price, PVAR denotes panel vector autoregression model, VAR denotes vector autoregression model, and ECM denotes error-correction model. REER denotes real effective exchange rate. hh denotes households and LTV is a loan-to-value ratio. The inclusion of fixed effects may indirectly but imperfectly control for non-time varying, cross-country differences in credit availability, but will not capture time variation in credit constraints within countries or differences in slope parameters.

**Appendix Table A2: Selected Post-2006 Metro-Level Studies of House Prices**

Study	Countries, Metros Time Period	Econometric framework	Controls and/or other endogenous variables					Key findings
			User Costs: interest rates & taxes	Expected or lagged appreciation	Credit conditions, mortgage market	Supply	Other notable variables	
Anundsen and Heeboll (2016)	242 U.S. MSAs (ex. 5 outliers), two periods: 2000-06 boom, 2006-10 bust	2/ 3eq. system for overall $\Delta$ HP, $\Delta$ housing stock, $\Delta$ log cumulative subprime boom originations, FIML	2-phase model obviates need for time-varying mortgage interest rate.	None	1996 local loan denial rates & LTI; subprime originations, State mortgage recourse (robustness check).	Gyourko-Saiz-Summers regulation and Saiz supply elasticity measures.	Population density (robustness check).	Supply-restricted areas exhibit a larger financial accelerator and stronger price responses. Over 2000-6, little difference in supply response between low and highly supply-elastic MSAs.
Glaeser, Gyourko, and Saiz (2008)	78 U.S. MSAs, annual 1982-2007, different subperiods – 1982-96 cycle, 1990s bust, post 1996 boom	$\Delta$ log real house prices, log building permits.	None, other than those captured by common time dummies and local FEs.	None.		Saiz supply elasticity measure (robust to Gyourko-Saiz-Summers regulation measure), 1980 housing stock.	Local climate, income growth, education.	In low supply elastic areas, HP bubbles more likely, larger, but shorter with less overshooting of construction. HP bubbles in supply elastic areas rare in 1980s, less uncommon since mid-1990s.
Hilber and Vermeulen (2016)	353 local UK planning authorities, annual 1974-2008	Log real HP, OLS, 2SLS. Reduced form with year and locality FEs and exogenous changes in overall planning regime.	None, other than those captured by common time dummies.	None.		% of developed land, land elevation, planning application refusal rate.	Local real earnings, population density, political leanings.	Income elasticity of HP higher in areas with more planning limits and less undeveloped land, more so in booms. Gov't planning is the main UK supply constraint.
Holly, Pesaran, Yamagata (2010)	48 U.S. states, annual 1975-2003	Reduced form dynamic $\Delta$ log real HP eq., mean group and common correlated effects estimators, with log HP and log Y cointegrated	State specific user cost = real long-term interest – state level real HP appreciations.	Lagged appreciation in user cost. Also in an equilibrium correction specification.		State FEs implicitly control for time invariant aspects.	Real per capita income, population growth, cross-section dependence and heterogeneity.	Accounting for cross-sectional dependence & heteroscedasticity, find state HP cointegrated with income (unitary elasticity), and $\Delta$ log real HP positively affected by population growth and negatively by real user costs.
Huang and Tang (2012)	327 U.S. cities, 2000m1-2009m7	OLS eqs for overall $\%$ $\Delta$ HP in boom (2000m1 - 06 m6) and bust (2006 m7-09 m7) periods.	2-phase model obviates need for time-varying mortgage interest rate.	None.	High interest mortgage share, rejection rate in 1996	Gyourko-Saiz-Summers regulatory index & Saiz supply elasticity.	$\%$ $\Delta$ income and employment. 2000 income, employment, population, vacancy rates and state FE	Subprime boom upswings & bust downswings in HP larger in areas with less undeveloped land and greater regulation. Housing supply constraints amplified HP effect of subprime lending.
Mian and Sufi (2009)	U.S. postal zip-code, high supply elasticity MSAs 2002-05	Eqs. for $\%$ $\Delta$ mortgage and non-mortgage debt, subprime share, mortgage originations, mortgage default rate, and county/MSA FEs.	None.	None. Sub-prime share not correlated with supply elasticity. Hence doubt that subprime boom was driven by just HP expectations.	1996 local loan denial rates, FICO scores, lender composition.	Saiz supply elasticity.	$\%$ $\Delta$ employment income, # firms, & crime, and 2000 housing stock age and vacancy rate.	Correlations of subprime loans with income, loan denial rates, subprime securitization, post-boom defaults, and HP swings imply loan supply shifts drove the subprime boom, not higher income or HP expectations.

Mian, Sufi, and Trebbi (2015)	U.S. postal zip-code and states, 2006-13 and subperiods	% $\Delta$ in house prices, housing permits, auto sales and foreclosures, OLS and 2SLS.	None.	For HP growth from 2009, includes 2002-6 and 2006-7 HP appreciation.	Lagged $\Delta$ debt/income ratio, delinquency rate, subprime share, judicial vs. non-judicial foreclosure.		Various including urban, poverty education, and racial mix.	Foreclosures, for-sale housing supply, and HP declines larger in bust in nonjudicial foreclosure states. Later rebound in HP stronger in nonjudicial states (but statistically insignificant)
Oikarinen, et al. (2018)	70 U.S. large MSAs, 1980q1-2015q2	Level and $\Delta$ real HP, separate models for long- and short run dynamics given deviation from long run (1 lag), and various panel estimators (e.g. mean groups and dynamic common correlated coefficient mean groups.	Real mortgage interest rate using national CPI; no local tax controls.	Includes lags of % $\Delta$ HP in equilibrium correction models.		Real construction costs. Cross section regression uses Saiz supply elasticities.	Real MSA income, spatial spillovers.	Accounting for cross-sectional dependence, find long-run income elasticity higher, duration and size of bubbles larger in metros with lower supply elasticities.
Wu, Gyourko, and Deng (2016)	35 Chinese cities annual 2006-2013	$\Delta$ log real house prices, panel with year and city fixed effects.	None, other than those captured by common time dummies and local FEs.	Includes previous year's appreciation.	Expected relative loan balance growth in a city (insignificant)	Land supply, lagged $\Delta$ construction costs, $\Delta$ land prices, housing, lagged ratios of inventory and permits to sales	Expected export growth	While common factors account for 40% of variation in real HP growth, local supply imbalances matter. Land prices account for most metro-variation; gov't controls land supply.

**Appendix Table A3: Selected Country or Small-Panel Studies of Macroprudential Policies.**

Study	Geographic coverage and data	LTV or DTI/DSTI limits included?	Reported results			
			Empirical method	Effect on credit growth	Effect on HP growth	Effect on lender defaults
Acharya et al. (2019)	Ireland. Supervisory loan-level data, monthly 2013-2016. House price data by location.	2015 DTI and LTV caps with 20% and 15% respective caps on share of primary home buyer loans that can exceed limits.	Difference-in-difference comparing banks more or less exposed to the new limits.	DTI and LTV limits reallocated credit from low to high income borrowers, and induced portfolio shifts towards other risky assets for the more exposed banks.	DTI and LTV limits reallocated appreciation from high to low house price areas, cooling "hot" markets, but the effect was rather muted. House prices rose less in counties where a high fraction of loans was previously near the caps.	Not analyzed.
Agarwal et al (2018)	Singapore. Loan origination and performance, borrower income, financial, and demographic data.	Unexpected Aug 2010 lowering of LTV caps on 2nd home mortgages.	Difference-in-difference estimates contrasting the effects on first and second home borrowers.	Minimal overall effect in 2011:H1. Banks shift credit to a higher DTI pool of 2nd home borrowers.	Some dampening of house price inflation.	Higher incidence of investor 30 days past due mortgage and credit card penalties (default proxies). Higher investor bankruptcy rates.
Allen et al. (2017)	Canada. Loan-level administrative data plus household-level survey data.	LTV and DSTI	Micro-simulation model of mortgage demand of first-time home buyers	Both types of caps affected credit growth. LTV policies affected demand more than DSTI-oriented policies.	General equilibrium effects excluded.	LTV policies affected defaults more than DSTI-oriented policies, such as amortization years.
Armstrong et al. (2019)	New Zealand. Micro data set of housing transactions 2013-2016.	3 rounds of LTV limits differing by areas and on new vs. existing homes.	Difference-in-difference e.g. new build vs. existing homes or differences in location.	Restrictions effective at limiting credit for housing.	House appreciation slowed by curbing the credit-fueled housing demand: effect depended on prior appreciation rates.	Not analyzed.
Auer and Ongena (2019)	Switzerland. Compositional changes in banks' loan supply based on home loans held.	2012 extra capital requirements from countercyclical capital buffer for mortgages.	Contrast portfolio shifts between banks according to pre-existing proportion of residential mortgages in their portfolio.	Changes spurred higher interest rates and fees, and faster business loan growth, often in real estate.	Not analyzed.	Not analyzed.
Cantu et al. (2020)	5 Asian-Pacific countries (Australia, Indonesia, New Zealand, Philippines, Thailand). Confidential supervisory panel data of bank loans issued and NPLs.	LTV (and other macro-pru measures e.g. limits on growth & market share of riskier loans in Australia and the Philippines).	Meta-analysis of 5 country studies using broadly similar methodologies, plus the 5 studies themselves.	LTV policies curb household credit growth. Tightening is more effective than loosening. Impact is greater for banks with lower liquidity ratios.	Effects on house prices not analyzed.	LTV (and other macro-pru) policies effective in curbing bank risk – reducing non-performing loans.
De Araujo et al. (2019)	Brazil. Loan-level data from central bank merged with gov't employment registry data for households.	New LTV limit on a major share of housing loans in 2013.	Adjusted difference-in-difference method, estimating an average treatment effect. Propensity score method to control for endogeneity.	The most affected borrowers had lower LTVs.	Not directly estimated, as diff-in-diff cannot address macro spill-over effects. However, the most affected borrowers tended to buy lower-priced houses.	The most affected borrowers had lower delinquency rates. Results suggest that LTV limits lower mortgage risk.

De Fusco et al. (2019)	U.S. CoreLogic Loan-Level Market Analytics database, origination and performance data for 60% of all 1st mortgages.	DTI. Impact of Ability-to-Repay and Qualified Mortgage rule on originators of high DTI loans.	Difference-in-difference estimate of average treatment effect on the change in interest rates for jumbo loans with DTIs above and below QM-threshold before and after QM Rule.	15% of market eliminated, leverage reduced for another 20% of remaining borrowers. Some lenders exited market.	Not analyzed.	“While the policy succeeded in reducing leverage, our estimates suggest this effect would have only slightly reduced aggregate default rates during the housing crisis”. See text for discussion.
Gross and Población (2017)	7 Eurozone countries. Data on household balance sheets from Household Finance and Consumption Survey.	LTV and DSTI	Micro-macro simulation model of household default probability and loss given default. Risk depends on macro and financial factors driving structure and size of household balance sheets. House prices and equity prices endogenized in a Global VAR.	Sizable effects in some countries from implied loan demand shocks.	Effects in some countries from implied loan demand shocks in the Global VAR.	Caps on DSTI ratios somewhat more effective in containing defaults than LTV caps.
Igan and Kang (2011)	Korea, 2000-09. Sources: annual survey of housing tenure and mortgage decisions and central bank data on macro-pru policies and regional house prices.	Different LTV and DTI caps on ‘speculative’ and ‘non-speculative’ zones.	Difference-in-difference method to estimate sample average treatment effect, also for treated households.	Weak effects on aggregate household debt.	Lower LTV and DTI caps slow house price appreciation, expected appreciation, and transactions. LTV caps more effective than caps on DTIs.	Not analyzed.
Kinghan et al. (2019)	Ireland. Supervisory loan-level data covering 90% of the mortgage market. Focus on first-time buyers.	90% LTV cap for first-time buyers, with 80% on excess of value above euro 220,000.	Difference-in-difference comparing buyers above and below value threshold.	LTVs fell by about 1.4 percentage points as more affected borrowers increased down payments.	Average price similar across buyers above and below value threshold after cap imposed. No implications for macro effects on house prices.	Not analyzed.
Kuttner and Shim (2016)	57 AEs and EMDEs,	LTV & DSTI caps, capital regulation, provisioning, bank exposure caps.	Separate panel FE regression (max 4 lags) for $\Delta \log$ real house prices and $\Delta \log$ real house credit.	Both DSTI and LTV limits are effective. Housing tax rises are effective.	DSTI limits are more effective than LTV caps. Housing tax rises are effective.	Not analyzed.
Tillman (2015)	Korea. Aggregate time series data.	LTV	VAR with qualitative variables, endogenizing dummy indicator of LTV cap.	Lowering LTV limits effective in dampening credit growth.	Lowering LTV limits is effective in dampening house price growth.	Not analyzed.
Tzur-Ilan (2019)	Israel. Merging supervisory loan-level data with housing transactions data from tax authority.	LTV. Higher capital requirements in Oct. 2010 for high LTV loans; strict LTV caps in Nov. 2012.	Difference-in-difference.	Unintended effects of lower caps on credit and housing choices: higher interest rates, smaller loans, greater resort to unsecured debt.	Continued home purchase borrowing, but cheaper homes bought farther from high demand areas to lower socio-economic locales. Effect on aggregate house prices not analyzed.	Not analyzed.
Van Bakkum et al. (2019)	The Netherlands. Public register tax data on income, wealth, housing & Land Registry data on all housing transactions. 1st-time buyers.	LTV cap in 2011.	Difference-in-difference estimate of change in average LTV.	Substantial reduction in debt levels of first-time buyers and potential FTBs. Renters less likely to switch to owning.	Not analyzed.	Affected households subsequently suffered lower level of payment arrears.

Wong et al. (2011)	Hong Kong, Korea, Singapore, also 13-country panel. Aggregate data.	LTV	Panel. Estimates how LTV caps alter marginal effects of growth in house prices and GDP on mortgage delinquency. 3-country study of effects on house prices, mortgage debt/GDP and transactions.	LTV caps reduce mortgage debt/GDP in Hong Kong, Korea and Singapore. Finding is robust to presence of lender mortgage insurance.	LTV caps reduced house price growth in Hong Kong, Korea and Singapore, but only strongly significant in Hong Kong.	Panel study shows significant reduction in the sensitivity of mortgage delinquencies to falls in house prices.
Wong et al. (2016)	Hong Kong. Aggregate data.	LTV	Monthly time series 1998-2012 of effects of LTV cap on market LTV and credit growth using disequilibrium model to separate impacts on demand from supply.	LTV caps effective in reducing credit growth in Hong Kong, but more through supply than through demand.	Effects on house prices not analyzed.	Simulations suggest that reduction in household leverage reduces lenders' bad loans ratio when house prices fall.

Notes: DTI denotes debt-to-income ratio, LTV denotes loan-to-value ratio, DSTI denotes debt service-to-income ratio, and FE denotes fixed effects.