Internet Appendix for "The Anatomy of the Transmission of Macroprudential Policies"

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ABSTRACT

This Internet Appendix provides additional details, tables, and figures supporting the main text. Section IA.A shows how we reconstructed the 2014 branch network for Irish banks. Section IA.B provides a list of other housing policy interventions in Ireland during the period from October 2013 to July 2017. Section IA.C presents our data sources. Section IA.D presents a simple model of bank portfolio choice and lending limits. Section IA.E present additional tables. Section IA.F present additional figures.

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IA.A. Reconstructing the 2014 Branch Network

In this section, we describe how we construct the bank level exposure variable $Exposure_b$ presented in Section V.B.

Our goal is to obtain the 2014 bank branch network of our sample banks. Given that the historical bank branch network is not available, we reconstruct it using the most recent (2020) branch network available at https://sortcode.bpfi.ie/Branches/DownloadAllCaptcha together with news coverage of branch closures and openings since 2014 by our five sample banks from the main Irish newspapers, including The Independent, Joe.ie, and Echolive.ie.

The period after the global financial crisis has been largely characterized by banks closing branches, with each set of branch closures making national news. This gives us confidence in the accuracy of the reconstructed branch network. Moreover, several articles provide detailed summaries of the evolution of the branch network of Irish banks. For example, *The Independent* reported in 2018: *"AIB, for example, had 274 branches in early October 2008; it now has 207. AIB shut 73 branches between 2008 and 2013 - with 51 closures in 2012. The bank opened six new branches between 2008 and 2017."*[2] Using the 2020 branch network and the various news outlets allows us to check whether the number of branches found by our methodology coincides with the number of branches per bank reported at different points in

[2]See "Finance sector unrecognisable 10 years after bank guarantee", The Independent, 9/23/18.

time. Matching these figures gives us further confidence in the accuracy of our measure of the 2014 branch network.

We then use the number of branches of each of our sample banks in 2014 to compute the bank level exposure variable $Exposure_b$. Specifically, for each bank b, the variable $Exposure_b$ is the difference of bank b average market share in hot housing markets (above median house price appreciation in the pre-policy period, see Figure 7) from bank b average county-level market share in the entire country (with market shares calculated using the number of branches).

IA.B. Other Housing Policy Interventions

Table IA.I enumerates the policies targeting the housing market around our sample period.

IA.C. Data Sources

Our data is obtained from the Central Bank of Ireland. The data on mortgages is from the Loan Level Data (Financial Stability Division) up to January 2015 and from the Monitoring Templates (Financial Stability Division) from January 2015 to June 2016. The data on commercial lending is from the Financial Stability Division. Bank quarterly security holdings are from the Statistics Division. Bank balance sheet variables are from the Individual Balance Sheet Items ECB survey. The county level house prices are from www.daft.ie/report. The regional house prices are from Central Statistics Office of Ireland. The loan level characteristics are (i) date of

Date	10/25/2013
Regulation	Home Renovation Incentive
Description	Tax credit to homeowners who carry out renovation/improvements (<€4,450)
Date	01/01/2015
Regulation	Rent-a-room-relief (Link)
Description	When renting out a room(s) in your home to private tenants, the rental income is be exempt from income tax (up to €14,000)
Date	07/19/2016
Regulation	Help-to-buy scheme (Link)
Description	Tax refund for FTBs (up to €20,000)
Date	12/24/2016
Regulation	Planning and Development and Residential Tenancies Act 2016 (Link)
Description	Cap rent increases to 4% per year in Rent Pressure Zones such
Date	02/01/2018
Regulation	Rebuilding Ireland Home Loan (Link)
Description	FTBs can get a 90 LTV loan backed by the government if borrower earns <€50,000
Date	06/01/2018
Regulation	Affordable Housing Scheme (Link)
Description	Newly constructed dwellings can be purchased for less than their market value by FTBs with income <€36,800
Date	07/18/2016
Regulation	Repair and Leasing Scheme (Link)
Description	Paying owners of vacant homes to convert them to social housing
Date	07/23/2017
Regulation	Fast track large scale housing developments (Link)
Description	Increase housing supply through greater efficiencies in the planning system.

Table IA.I. Other Policies Targeted at the Housing Market. This tables shows a list of policy interventions targeted at the Irish housing market from October 2013 to July 2016.

origination, (ii) amount outstanding (current and at origination) (iii) interest rate and interest type (current and at origination), and (iv) data on collateral (location, type, purpose, and value; all at origination). The borrower level characteristics (measured at origination of the loan) include (i) the type of borrower (FTB, SSB, BTL), (ii) age, marital status, occupation, and (iii) total household income.[3]

[3]For one of our banks, this income is missing from 2010 to 2014. As we expect heterogeneity in the bank-borrower match across banks, we do not assume that income will be the same for similar borrowers across banks. In particular, we use the period where we have the income data to construct a scalar that measures how income of costumers of this specific bank behaves differently from all other borrowers. For the period we do

IA.D. Bank Portfolio Choice and Lending Limits

In this section, we develop a simple model of bank portfolio choice to show how the lending limits affects bank portfolio choice. In our environment, a representative bank solves:

$$
\begin{aligned}
& max_{x_i} \sum_{i=1}^{3} \left(x_i \mathbb{E}(R_i) - \frac{\alpha_i}{2} x_i^2 \right) \\
s.t. \quad & x_i \leq K_i \qquad\qquad i = \{1, 2, 3\} \\
& \sum_{i=1}^{3} \kappa_i x_i \leq K_4
\end{aligned}
$$

The bank chooses how much to invest in three assets x_i, where $i = \{1, 2, 3\}$, subject to four constraints. The first three constraints are lending limits that constrain each asset to be less than a specific threshold. The last constraint is a balance sheet constraint where the weighted sum (weights κ_i) of each asset is forced to be less than a threshold.

In this environment, we compare the bank portfolio choice with and without lending limits. In the economy with no lending limits, only the last constraint binds. In an economy with lending limits, the constraint on asset 1 also binds, namely $x_1 = K_1$.

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not have income data for this specific bank, we then take the average income of a similar borrower in terms of loan- and borrower characteristics and multiply it with the scalar.

Portfolio Choice with No Lending Limit Suppose only the last constraint binds. The bank then chooses:

$$x_1^* = \frac{\mathbb{E}(R_1)(\alpha_2\kappa_3^2 + \alpha_3\kappa_2^2) - \alpha_3\kappa_1\kappa_2\mathbb{E}(R_2) - \alpha_2\kappa_1\kappa_3\mathbb{E}(R_3) + K_4\alpha_2\alpha_3\kappa_1}{\alpha_2\alpha_3\kappa_1^2 + \alpha_1\alpha_3\kappa_2^2 + \alpha_1\alpha_2\kappa_3^2}$$
$$x_2^* = \frac{\mathbb{E}(R_2)(\alpha_1\kappa_3^2 + \alpha_3\kappa_1^2) - \alpha_3\kappa_1\kappa_2\mathbb{E}(R_1) - \alpha_1\kappa_2\kappa_3\mathbb{E}(R_3) + K_4\alpha_1\alpha_3\kappa_2}{\alpha_2\alpha_3\kappa_1^2 + \alpha_1\alpha_3\kappa_2^2 + \alpha_1\alpha_2\kappa_3^2}$$
$$x_3^* = \frac{\mathbb{E}(R_3)(\alpha_1\kappa_2^2 + \alpha_2\kappa_1^2) - \alpha_1\kappa_2\kappa_3\mathbb{E}(R_2) - \alpha_2\kappa_1\kappa_3\mathbb{E}(R_1) + K_4\alpha_1\alpha_2\kappa_3}{\alpha_2\alpha_3\kappa_1^2 + \alpha_1\alpha_3\kappa_2^2 + \alpha_1\alpha_2\kappa_3^2}$$

Portfolio Choice with a Lending Limit Suppose now that $\widetilde{K}_1 < K_1$ such that the last constraint and the first constraint, namely $x_1 = \widetilde{K}_1$, bind. The bank then chooses:

$$x_1^{**} = \widetilde{K}_1$$
$$x_2^{**} = \frac{\alpha_3\kappa_2(K_4 - \kappa_1\widetilde{K}_1) - \kappa_2\kappa_3\mathbb{E}(R_3) + \kappa_3^2\mathbb{E}(R_2)}{\alpha_3\kappa_2^2 + \alpha_2\kappa_3^2}$$
$$x_3^{**} = \frac{\alpha_2\kappa_3(K_4 - \kappa_1\widetilde{K}_1) - \kappa_2\kappa_3\mathbb{E}(R_2) + \kappa_2^2\mathbb{E}(R_3)}{\alpha_3\kappa_2^2 + \alpha_2\kappa_3^2}$$

Comparison We now want to compare the two portfolio choices. In particular, we ask under what conditions the bank chooses to increase more its investment in x_3 than its investment in x_2 in the presence of the lending limit on x_1 compared with the portfolio choice with no lending limit. More formally, we ask under what conditions $x_3^{**} - x_3^* > x_2^{**} - x_2^*$. By comparing

the solutions above, we obtain that $x_3^{**} - x_3^* > x_2^{**} - x_2^*$ if and only if

$$\frac{\alpha_2}{\alpha_3} > \frac{\kappa_2}{\kappa_3}$$

To develop some intuition, note that we can write the first order conditions with respect to x_2 and x_3 in the problem with and without a lending limit as follows:

$$\mathbb{E}(R_2) - \alpha_2 x_2^* = \kappa_2 \lambda_4 \qquad \mathbb{E}(R_3) - \alpha_3 x_3^* = \kappa_3 \lambda_4$$
$$\mathbb{E}(R_2) - \alpha_2 x_2^{**} = \kappa_2 \lambda_4' \qquad \mathbb{E}(R_3) - \alpha_3 x_3^{**} = \kappa_3 \lambda_4'$$

where λ_4 and λ_4' are the Lagrange multipliers for the last constraint in the case without and with the lending limit, respectively. By combining these conditions, we obtain $\frac{\alpha_2}{\kappa_2}(x_2^* - x_2^{**}) = \frac{\alpha_3}{\kappa_3}(x_3^* - x_3^{**})$. In general, (i) a smaller risk aversion α_i causes asset i to be more desirable and (ii) a larger contribution κ_i to the balance sheet constraint causes that asset i to be more constrained in the optimal portfolio choice. When we move to the portfolio choice with a lending limit, we analyze how x_2 and x_3 change following a de facto relaxation of the balance sheet constraint. The asset that gains the most has a low α (less risk) and a high κ (more constrained before the relaxation of the balance sheet constraint).

IA.E. Additional Tables

	Income Quintiles				
LHS: House Price	Q1	Q2	Q3	Q4	Q5
$HP1BR$	0.632	0.779**	1.131**	0.0431	-0.796
	(0.399)	(0.394)	(0.439)	(0.657)	(1.030)
$HP2BR$	-1.315***	-1.568***	-2.492***	-2.280***	-2.441*
	(0.391)	(0.379)	(0.449)	(0.736)	(1.266)
$HP3BR^{+}$	0.593***	0.717***	1.070***	1.496***	2.314***
	(0.156)	(0.154)	(0.184)	(0.299)	(0.519)
Observations	1,862	2,356	2,752	2,339	3,323
R-squared	0.155	0.206	0.183	0.178	0.189

Table IA.II. House Prices, Number of Bedrooms, Borrower Income. This table shows the estimation results for the following specification: $CollateralPrice_{lct} = \alpha + \beta_1 1BRHP_{ct} + \beta_2 2BRHP_{ct} + \beta_3 3BR^{+}HP_{ct} + \epsilon_{lct}$. The unit of observation is loan l, county c, and quarter t. The dependent variable is the price of the residential property used as collateral (from the credit registry data). The independent variables are the house prices (from the county level house price data) for one-bedroom properties, two-bedroom properties, and three-or-more-bedroom properties. The specification is estimated separately in each quintile of the borrower distribution. Source: Central Bank of Ireland, Daft.ie.

	Unit	**Dec13**	**Dec14**	**Dec15**
Exposed Banks				
Domestic Govt Bond	% Assets	0.05	0.05	0.07
Loans	% Assets	0.46	0.46	0.47
Total Assets	million €	75,498	68,288	62,906
Leverage	% Assets	0.23	0.24	0.24
Non-Exposed Banks				
Domestic Govt Bond	% Assets	0.04	0.05	0.05
Loans	% Assets	0.51	0.51	0.53
Total Assets	million €	69,626	66,337	57,229
Leverage	% Assets	0.23	0.24	0.24

Table IA.III. Banks' Summary Statistics. This table shows banks' balance sheet characteristics (subsample means) at an annual frequency from December 2013 to December 2015 separately for high-exposure (above median exposure) and low-exposure (below median exposure) banks. Source: Central Bank of Ireland.

Panel A		Volume	Size	No. Loans	LTV	LTI	Rate
Distance × Exposure × Post	(β_1)	9.055***	14.206*	-27.266	325.225*	2.770	-3.483*
		(0.719)	(6.939)	(22.749)	(159.100)	(2.704)	(1.764)
Distance × Exposure	(β_2)	-13.071***	-15.777*	15.141	-367.510**	-3.574	4.484**
		(2.951)	(8.577)	(20.682)	(152.536)	(2.910)	(1.599)
Distance × Post	(β_3)	0.150***	0.286***	-0.577	10.262***	0.190***	0.021
		(0.028)	(0.093)	(0.453)	(0.583)	(0.058)	(0.019)
Fixed Effects							
County-Time		✓	✓	✓	✓	✓	✓
County-Bucket		✓	✓	✓	✓	✓	✓
Bank-Time		✓	✓	✓	✓	✓	✓
Observations		12,960	12,960	12,964	12,757	12,708	12,577
R-squared		0.603	0.477	0.518	0.223	0.451	0.543

Panel B		Volume	Size	No. Loans	LTV	LTI	Rate
Distance × Exposure × Post	(β_1)	11.596***	19.219**	-52.616	273.233*	3.652	-3.156
		(2.270)	(8.789)	(38.096)	(149.147)	(3.602)	(2.363)
Distance × Exposure	(β_2)	-15.861***	-20.073*	32.335	-375.119**	-4.942	5.200*
		(2.660)	(9.873)	(28.262)	(146.398)	(3.290)	(2.565)
Fixed Effects							
Bank-Time		✓	✓	✓	✓	✓	✓
County-Bucket-Time		✓	✓	✓	✓	✓	✓
Observations		12,960	12,960	12,964	12,757	12,708	12,577
R-squared		0.796	0.768	0.647	0.656	0.740	0.764

Table IA.IV. Bank Mortgage Credit Reallocation, Robustness. This table presents the results from specification (6). Panel A includes county-time, county-bucket, and bank-time fixed effects. Panel B includes bank-time and county-bucket-time fixed effects. The sample period runs monthly from February 2014 to January 2016. The unit of observation is county-month-bank-income bucket. The dependent variables are the logarithm of mortgage volume, the logarithm of the median loan size, the number of mortgage loans issued, the value-weighted LTV, the value-weighted LTI, and the value-weighted rate. *Exposure* is defined in Section V.B, and *Post* is a dummy equal to one from February 2015 to January 2016. All regressions include the share of originations to first-time buyers and to buy-to-let investors at the county-time-income bucket level. Standard errors double clustered at the county-bank and income bucket level in parentheses. Source: Central Bank of Ireland.

IA.F. Additional Figures

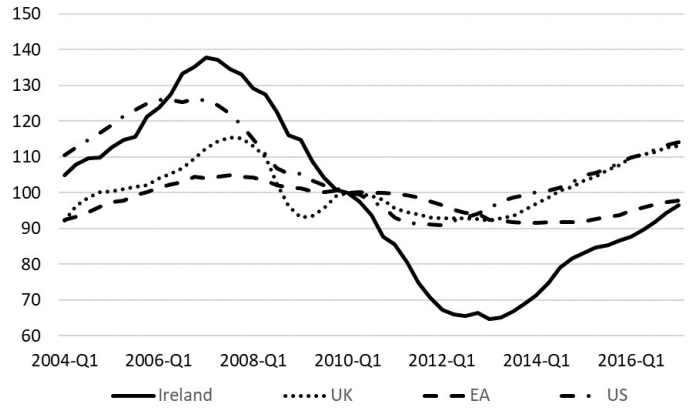

Figure IA.1. House Prices Outside Ireland. This figure shows real house prices (index 100 in 2010Q1) for Ireland, the U.K., the Euro Area, and the U.S. Source: OECD.

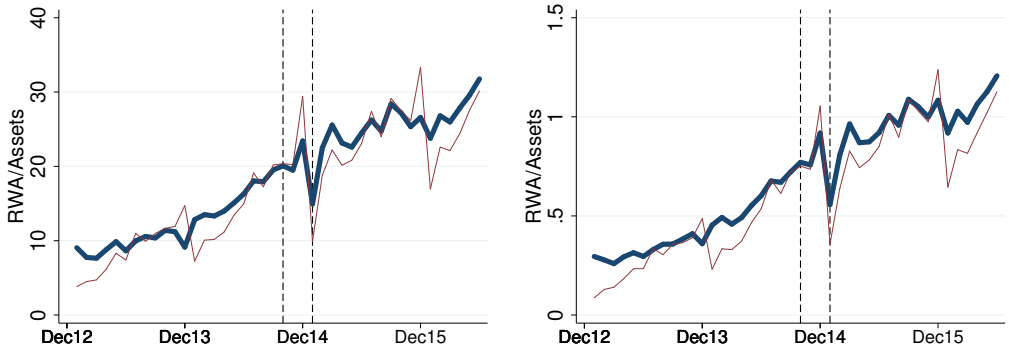

Figure IA.2. Aggregate Residential Mortgage Issuance. This figure shows the evolution of residential mortgage issuance of our sample banks weighted by LTV and LTI from January 2013 to June 2016. The left panel shows LTV-weighted monthly mortgage issuance divided by total assets (percentage). The right panel shows LTI-weighted monthly mortgage issuance divided by total assets (units). Thick lines are seasonally adjusted and thin lines are not seasonally adjusted. The vertical dashed lines indicate the first rumors about the limits and their implementation. Source: Central Bank of Ireland.

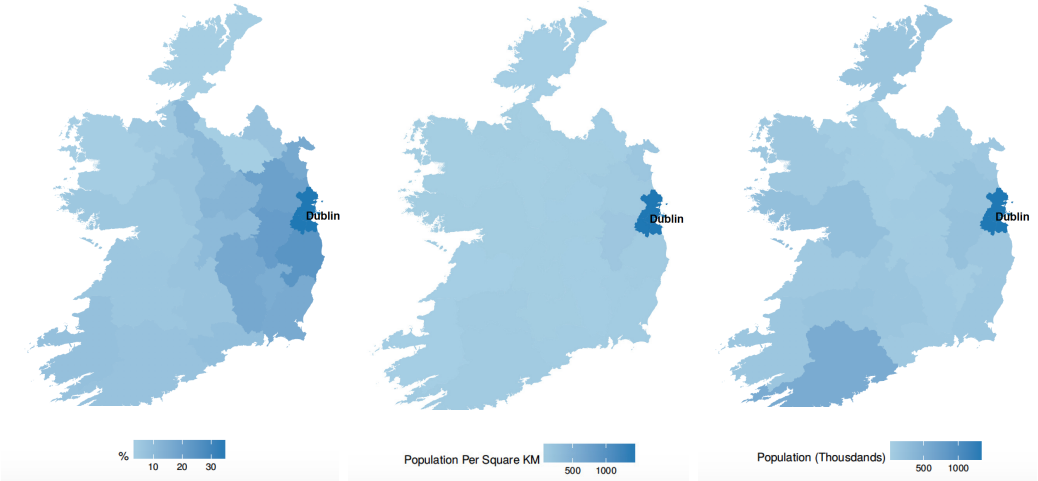

Figure IA.3. Demographics and House Price Appreciation Across Counties. The left panel of this figure shows county level increase in house prices from their lowest point after the bust to September 2014. Darker colors indicate a larger increase in house prices. The center panel shows county level density. Darker colors indicate more densely populated counties. The right panel shows county level population (thousands). Darker colors indicate more populated areas. Source: Central Bank of Ireland, Daft.ie

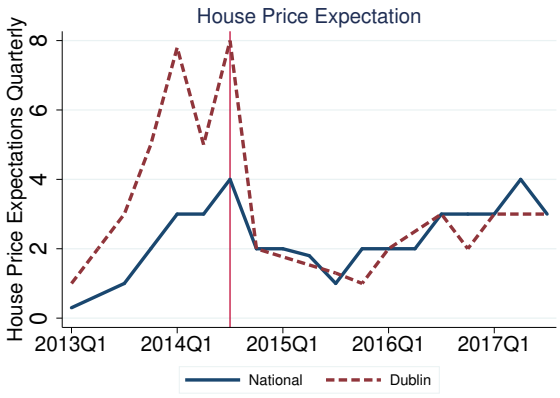

Figure IA.4. House Price Expectations. This figure shows survey evidence suggesting that the first rumors about the limits caused households to revise their expectations about house prices downward, especially in low-distance counties. The figure shows the evolution of house price expectations in Dublin (dashed line) and at the national level (solid line) at a quarterly frequency. Source: Central Bank of Ireland.

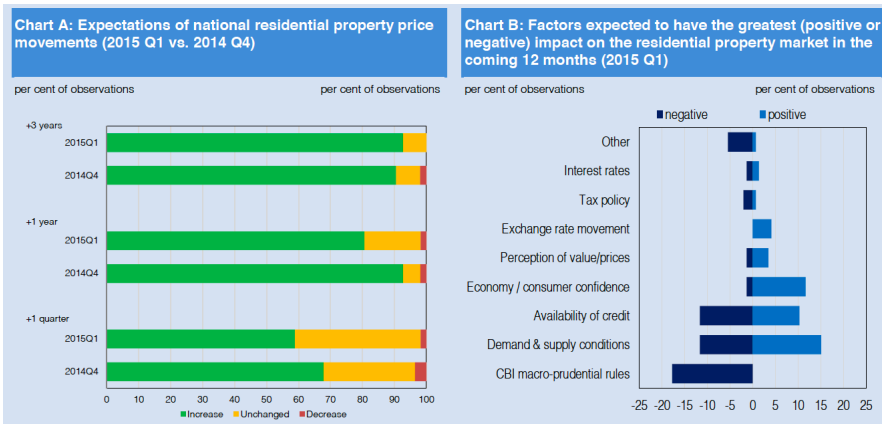

Figure IA.5. House Price Survey Expectations. This figure shows expectations in May 2015 about future national residential property prices (left panel) and factors affecting these expectations (right panel). The data is based on a residential property survey carried out by the Central Bank of Ireland and Society of Chartered Surveyors of Ireland. Survey respondents include estate agents, auctioneers and surveyors, as well as those with a more indirect interest in the industry such as economists, market analysts and academics. Source: Central Bank of Ireland (2015).

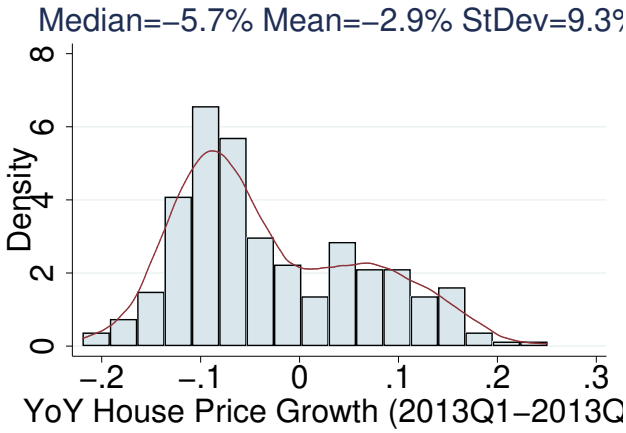

Figure IA.6. Pre-Policy Distribution of House Price Growth. This figure shows the distribution of house price growth (YoY) from 2013Q1 to 2013Q4. Source: Daft.ie.

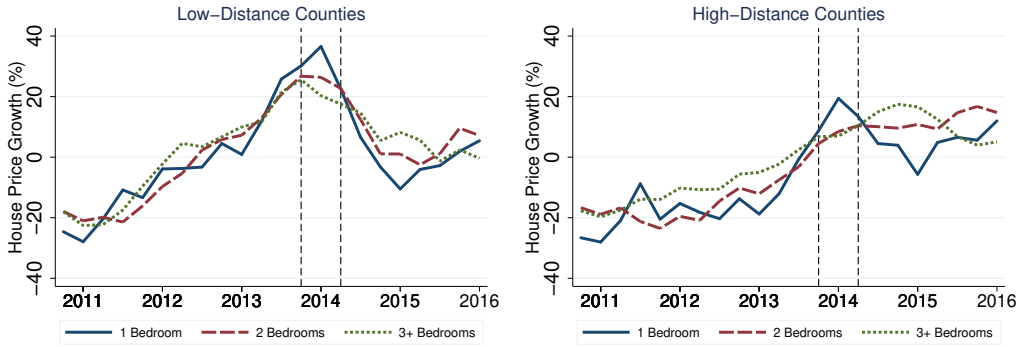

Figure IA.7. House Prices and Property Type. These figures shows house price growth for 1-bedroom (solid line), 2-bedroom (dashed line), and 3-bedroom or larger properties (dotted line). The top (bottom) panel shows data for low-distance (high-distance) counties. The vertical dashed lines indicate the first rumors and the implementation date of the lending limits. Source: Central Bank of Ireland, Daft.ie.

REFERENCES

Central Bank of Ireland, 2015, Macro Financial Review.