A micro-powered model of mortgage default risk: the case of Chile[1]

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[1] DISCLAIMER: The views expressed here are my own and do not necessarily represent those of the Central Bank of Chile or its Board.

The paper in a nutshell

The question:
Which are the determinants of mortgage default in a full-recourse economy?

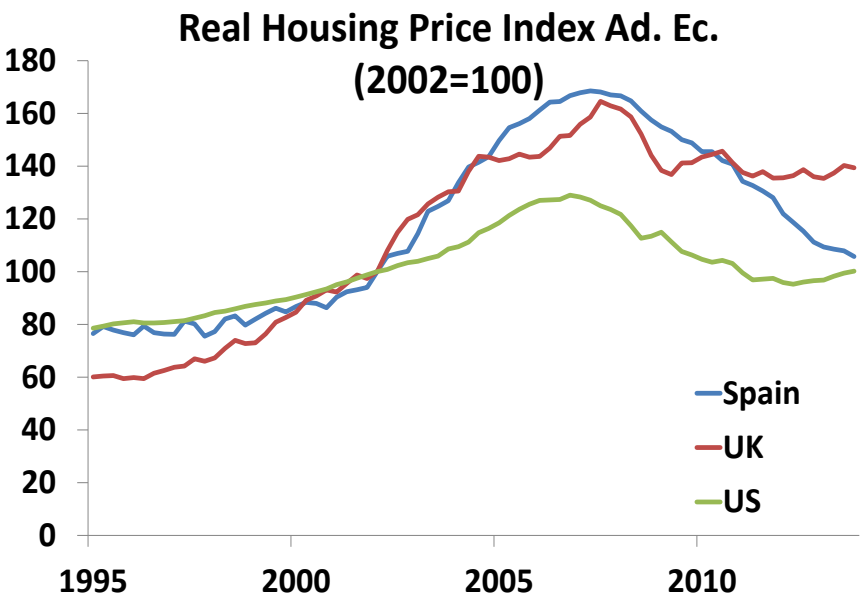
- Full-recourse vs. non-recourse regulatory frameworks
- Systemic vs. idiosyncratic factors
- Application: the case of Chile

What we do:

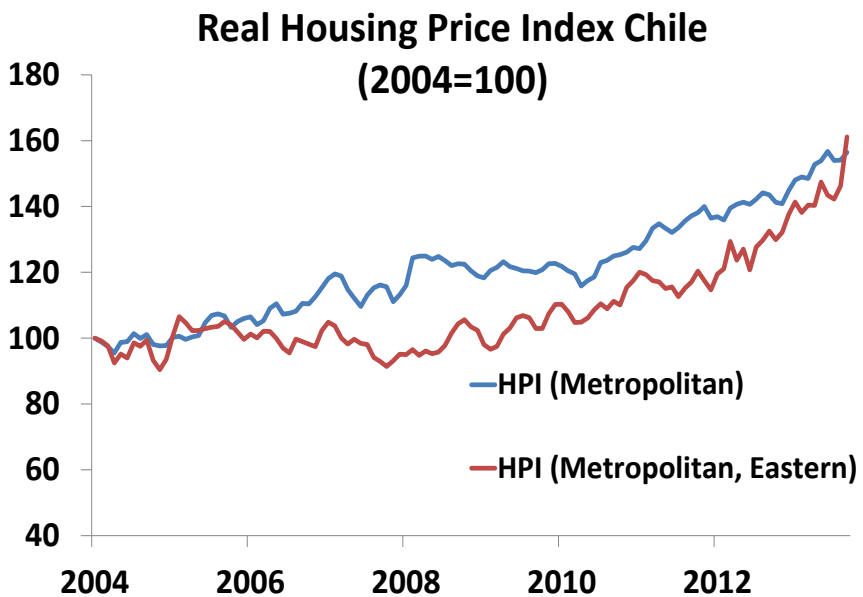
1. A theoretical model of the determinants of mortgage default under a full-recourse credit regulation
2. A suitable estimation strategy for mortgage default
3. Results from a micro-powered model estimation

Context for the question

- Real estate prices are growing fast in Chile
- These prices follow economic growth and fundamentals
- However, advanced economies had difficulties keeping up with high growth levels in the past...

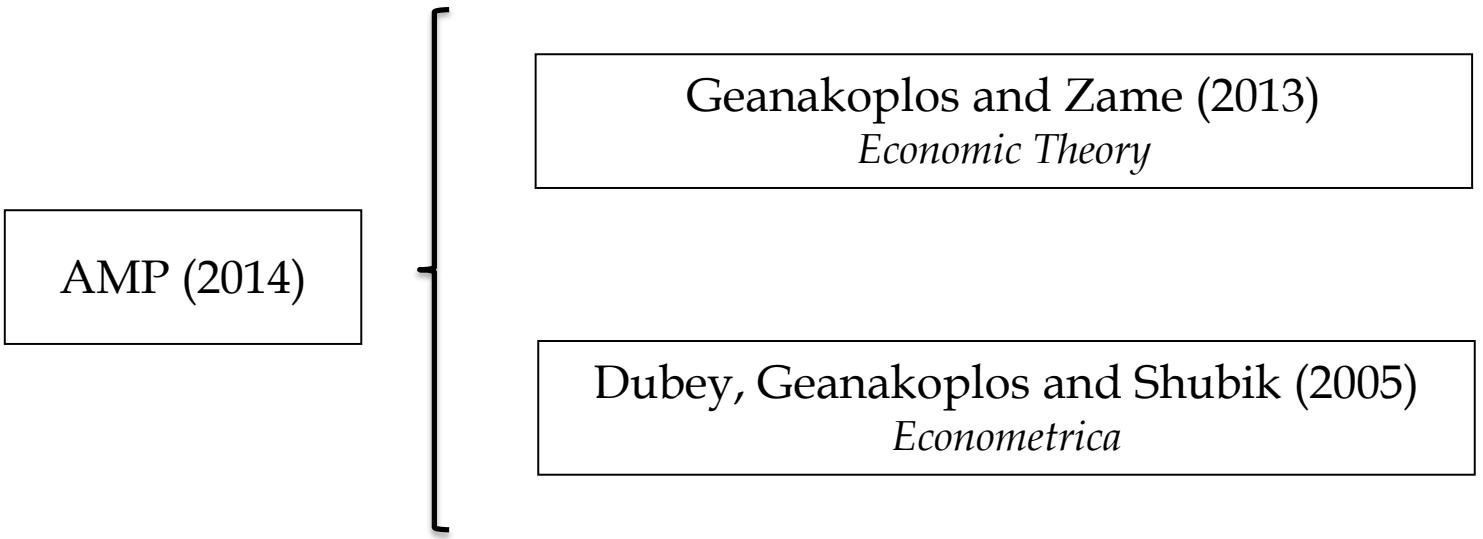


Quarterly data. Source: Own calculations based on Dallas FED International Housing Prices database.



Monthly data. Source: CChC database for houses.

Theory


AMP (2014)
Geanakoplos and Zame (2013)
Economic Theory
Dubey, Geanakoplos and Shubik (2005)
Econometrica

Empirics

AMP (2014)

- Foster and Van Order (1984)
  Housing Finance Review
- Bhutta, Dokko and Shan (1999)
  Finance and Economics Discussion Series, Federal Reserve (USA)
- Harrison, Noordewier, and Yavas (2004)
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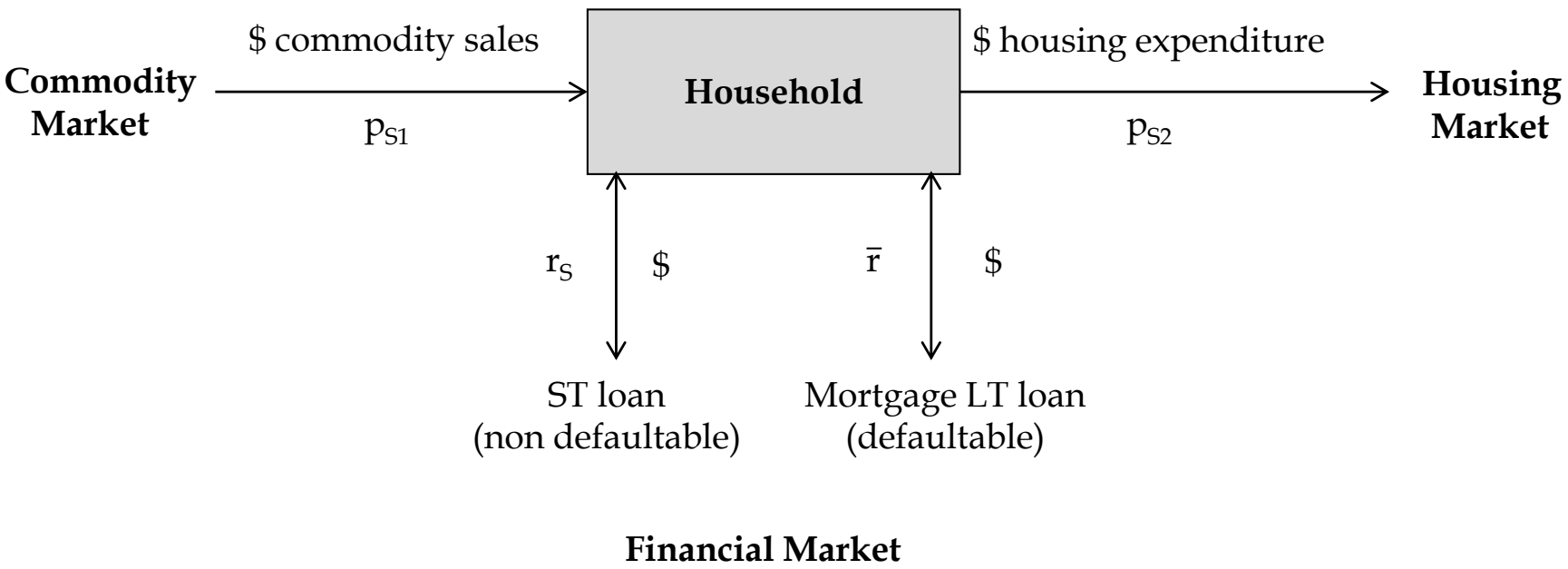
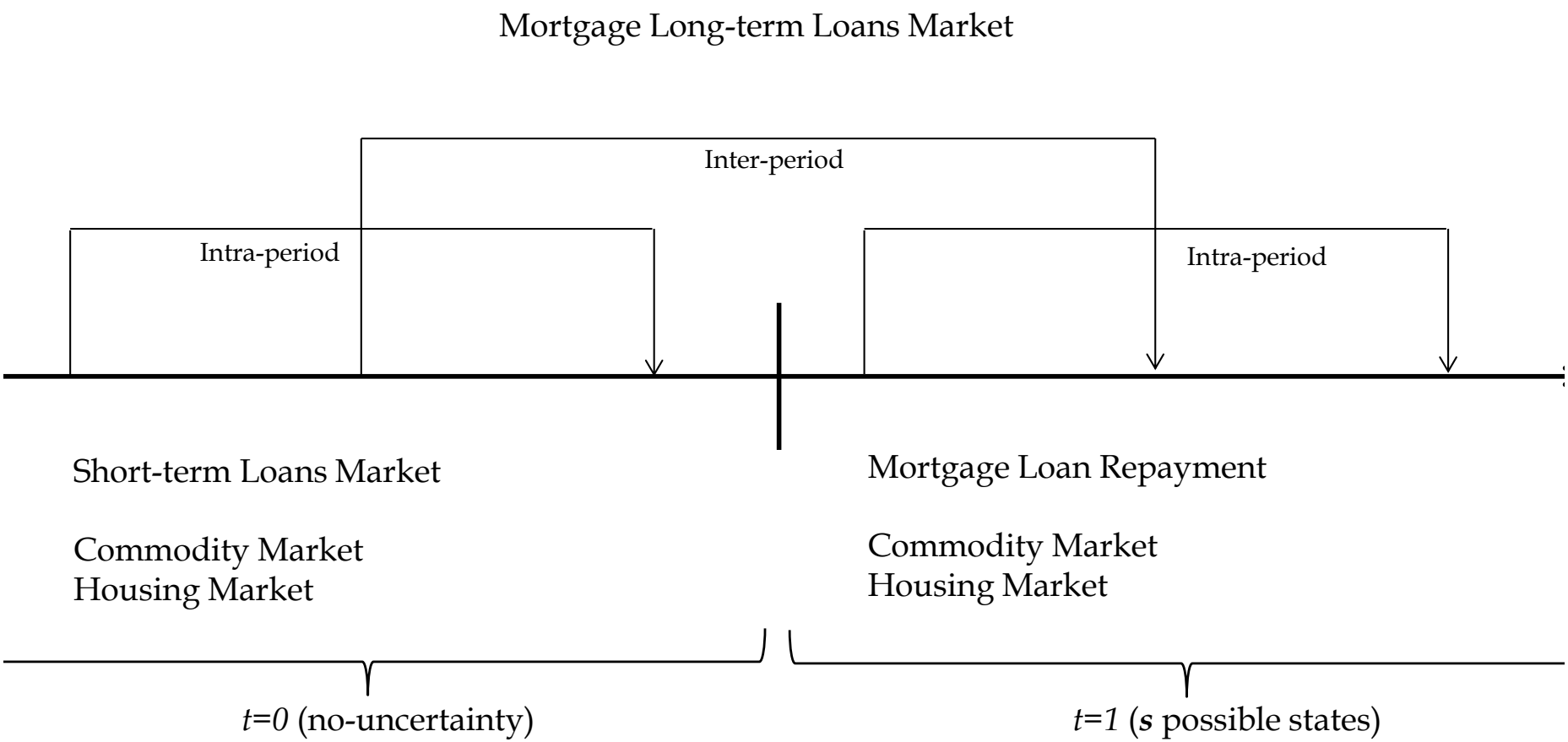
- Elul, Souleles, Chomsisengphet, Glennon and Hunt (2010)
  Journal of Housing Research
- Alfaro and Gallardo (2012)
  Economic Analysis Review

Nominal Flows of the Household



Timing of the household decisions



Household optimization problem

$\max_{\mu_{s},\bar{\mu},b_{s2},q_{s1}}$

$$
\begin{aligned}
& U\left(e_{01}-q_{01}\right)+U\left(\frac{b_{02}}{p_{02}}\right) && t=0 \\
& +E_{G}\left\{U\left(e_{G1}-q_{G1}\right)+U\left(\frac{b_{02}}{p_{02}}+\frac{b_{G2}}{p_{G2}}\right)\right\} && t=1,\ s\in G \\
& +E_{B}\left\{U\left(e_{B1}-q_{B1}\right)+U\left(\frac{b_{B2}}{p_{B2}}\right)-\lambda\left(1-\frac{b_{02}p_{B2}}{p_{02}\bar{\mu}}\right)\right\} && t=1,\ s\in B
\end{aligned}
$$

Household budget constraint

Period 0 (Deterministic):

- The short term loans must not exceed the revenues from commodity sales
- The housing expenditure must be lower than or equal to its long and short term credits and monetary endowment
- There is a LTV limit (i.e. ϕ) required for a mortgage loan

Period 1 (Stochastic):

- The short term loans must not exceed the revenues from commodity sales
- Good state: The repayment of the mortgage loans plus the new housing consumption of the household must not exceed the agent's short-term borrowing and monetary endowment
- Bad state: The new housing consumption of the household must not exceed the agent's short-term borrowing and monetary endowment

Household budget constraint

$$\mu_0 \leq p_{01} q_{01}$$

ST loan repayment $\leq$ Sales of commodities at t=0.

$$b_{02} \leq \frac{\mu_0}{1+r_0} + \frac{\bar{\mu}}{1+\bar{r}} + m_0$$

Money spent in houses$\leq$ ST loan + mortgage + monetary endowment.

$$\frac{\bar{\mu}}{1+\bar{r}} \leq \phi b_{02}$$

Mortgage Money spent in houses$\leq$ LTV*Money spent in houses.

$$\mu_s \leq p_{s1} q_{s1}$$

ST loan repayment $\leq$ Sales of commodities at t=0.

$$b_{s2} + \bar{\mu} \leq \frac{\mu_s}{1+r_s} + m_s \quad /\forall s \in S_1$$

Money spent in houses$\leq$ ST loan + mortgage + monetary endowment.

$$b_{s2} \leq \frac{\mu_s}{1+r_s} + m_s \quad /\forall s \in S_2$$

Money spent in houses $\leq$ ST loan + mortgage + monetary endowment.

- In a non-recourse mortgage economy we would only have that defaulters are enforced to repay by the threat of their collateral being confiscated. This approach includes three modelling devices within the framework:
  1. Utilities:

$$\sum_{s \in S_\alpha^1} \pi_s \left\{ U\left(\frac{b_{02}}{p_{02}} + \frac{b_{s2}}{p_{s2}} \right) \right\} + \sum_{s \in S_\alpha^2} \pi_s \left\{ U\left(\frac{b_{s2}}{p_{s2}} \right) \right\}$$

  2. Budget constraint

$$b_{s2} + \bar{\mu} \leq \frac{\mu_s}{1 + r_s} + m_s \quad /\forall s \in S_1$$

$$b_{s2} \leq \frac{\mu_s}{1 + r_s} + m_s \quad /\forall s \in S_2$$

  3. Interest rates (hence expectations)

$$1 + \bar{r}_s = \frac{\min\left\{ \frac{b_{02}}{p_{02}} p_{s2}, \bar{\mu} \right\}}{\bar{l}^\theta}$$

- In a full-recouse economy, we propose to add a reputational cost that further discourages default

$$-\lambda \sum_{s \in S} \pi_s \max\left\{ \left(1 - \frac{b_{02} p_{s2}}{p_{02} \bar{\mu}} \right), 0 \right\}$$

Household's Default Decision

$$\underbrace{1-\frac{b_{02}p_{22}}{\bar{\mu}p_{02}}}_{Default}=\omega_0+\omega_1\bar{\mu}\underbrace{U'^{\alpha}\left(\frac{b_{02}}{p_{02}}\right)}_{Ut.Mg\ Houses\ t=0}+\omega_2\bar{\mu}\underbrace{U'^{\alpha}\left(\frac{b_{02}}{p_{02}}+\frac{b_{12}}{p_{12}}\right)}_{Ut.Mg\ Houses\ s=1}+\omega_3\bar{\mu}\underbrace{U'^{\alpha}\left(e_{01}-q_{01}\right)}_{Ut.Mg\ Commodities}$$

Where,

$$\omega_0=1-\frac{\lambda\pi_2 p_{22}}{p_{02}(1+\bar{r})\phi}$$

$$\omega_1=\frac{-1}{p_{02}\lambda\pi_2(1+\bar{r})\phi}$$

$$\omega_2=\frac{\pi_1(\phi p_{02}(1+\bar{r})-p_{12})}{p_{12}p_{02}\lambda\pi_2(1+\bar{r})\phi}$$

$$\omega_3=\frac{-(1+r_0)(1-\phi)}{p_{01}\lambda\pi_2(1+\bar{r})\phi}$$

Household's Default Decision

$$Default = \omega_0 + \sum_{i=1}^{3} \omega_i U_i'$$

- Where U_i for $i = 1, 2, 3$ are *Idiosyncratic Default Incentives*

$$U_1' = \bar{\mu} U' \left(\frac{b_{02}}{p_{02}} \right)$$

$$U_2' = \bar{\mu} U' \left(\frac{b_{02}}{p_{02}} + \frac{b_{G2}}{p_{G2}} \right)$$

$$U_3' = \bar{\mu} U' \left(e_{01} - q_{01} \right)$$

- And ω_i stand for Systemic factors

Household's Default Decision

$$Default = F\left(\underbrace{\lambda, \phi, \pi_s, p_0, p_s, \overline{r}, r_0}_{\substack{\text{Systemic Factors} \\ (\text{Regulation, Prices, Expectations}) \\ (\omega's)}}, \underbrace{\overline{\mu}, e_0, q_0}_{\substack{\text{Idiosyncratic Factors} \\ (\text{Income, Indebtedness}) \\ (U''\text{s})}}\right)$$

Data Description: Households Situation

Table: Distribution of Households by Income Group (%)

	2007	2008	2009	2010	2011	Total
Stratum 1	26.38	31.28	25.88	29.46	30.45	28.65
Stratum 2	24.97	29.03	31.09	29.7	29.1	28.1
Stratum 3	48.64	39.69	43.03	40.84	40.45	43.25

Note: Stratum 1: percentiles 1-50; Stratum 2: percentiles 51-80; Stratum 3: percentiles 81-100.

Data Description: Distribution of Variables

Table: Mortgage Loans and Delinquency (%)

	2007	**2008**	**2009**	**2010**	**2011**	**Total**
Mortgage holders	16.77	13.17	13.70	18.85	15.00	15.90
Defaulted mortgages	8.26	13.82	9.2	8.07	8.87	8.92
Delinquent mortgages (SBIF)	0.97	1.29	1.95	2.01	1.70	1.58

Table: Distribution of Mortgage Characteristics

	p25	**p50**	**p75**
Current Loan to Value	24.6 %	45.1 %	67.9 %
Initial Loan to Value	63.6 %	85.0 %	100.0 %
Monthly Installment	CLP$ 95,000 $\sim$ *USD*$ 180	CLP$ 185,000 $\sim$ *USD*$ 350	CLP$ 320,000 $\sim$ *USD*$ 600
Term of Credit (in years)	19	20	20
Age of Debt (in years)	3	6	11

Data Description: Distribution of Variables

Table: Default and Renegotiation in the Sample

	Did not renegotiated	**RENEGOTIATED**	**Total**
Paying	74.5 %	16.6 %	91.1 %
DEFAULTED	6.0 %	2.9 %	8.9 %
Total	80.5 %	19.5 %	100 %

Note: Percentages are calculated over the complete group of mortgagors in the sample.

Estimation Methodology

Problems with mortgage delinquency data:

- Defaulting a loan (specially mortgages) is not an usual event
- Statistical procedures can sharply underestimate the probability of rare events
  1. Increasing the size of the sample does not alleviate the bias
  2. The bias of the estimated coefficients tend to underestimate the probability of the rare event
  3. Finite samples aggravate the underestimation problem

Solution:

- Apply *Rare Events Logistic Regression* (King and Zeng, 2001, 2002)
- The procedure corrects bias and variance using auxiliary information (e.g. public records)

Estimation Results 1: No interactions

Dep. Var.: Mortgage Default Dummy	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Idiosyncratic - Demographic Variables				
Number of persons in house	0.211***	0.235***	0.214**	0.213**
	(0.0715)	(0.0826)	(0.0844)	(0.0856)
Income (in logs)	-0.827***	-0.563***	-0.734***	-0.524***
	(0.133)	(0.153)	(0.155)	(0.162)
Primary Education	0.348	0.0446	0.215	0.109
	(0.333)	(0.424)	(0.440)	(0.466)
Tertiary Education	-0.633***	-0.417	-0.554*	-0.397
	(0.241)	(0.291)	(0.308)	(0.309)
Gender	-0.285	-0.214	-0.285	-0.301
	(0.199)	(0.229)	(0.244)	(0.242)
Age 18-35	-0.0218	-0.155	0.0266	0.105
	(0.260)	(0.295)	(0.306)	(0.308)
Age 55-99	-0.699	-0.0802	-0.0578	-0.0759
	(0.603)	(0.675)	(0.696)	(0.683)
Idiosyncratic - Finance Variables				
Negative Shock	1.745***	1.715***	1.668***	1.683***
	(0.207)	(0.245)	(0.255)	(0.256)
Credit Applications Rejected	0.276			
	(0.398)			
Renegotiation	1.352***	1.052***	1.016***	1.073***
	(0.244)	(0.309)	(0.332)	(0.336)

Estimation Results 1: No interactions

Dep. Var.: Mortgage Default Dummy	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Idiosyncratic - Finance Variables				
Negative Shock	1.745***	1.715***	1.668***	1.683***
	(0.207)	(0.245)	(0.255)	(0.256)
Credit Applications Rejected	0.276			
	(0.398)			
Renegotiation	1.352***	1.052***	1.016***	1.073***
	(0.244)	(0.309)	(0.332)	(0.336)
Systemic Variables				
Current Loan to Value		0.253**		
		(0.117)		
Initial House Price (in logs)		-0.416***		-0.450***
		(0.113)		(0.152)
Initial Loan to Value			0.0407	-0.0835
			(0.0249)	(0.0794)
Constant	6.125***	9.095***	4.663**	9.413***
	(1.761)	(2.302)	(2.074)	(2.631)
Observations	1,894	1,446	1,301	1,337

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1

Estimation Results 2: Including Interactions

Dep. Var.: Mortgage Default Dummy	**Model 1**	**Model 2**
Idiosyncratic - Demographic Variables		
Number of persons in house	0.237***	0.231***
	(0.0820)	(0.0819)
Income (in logs)	-0.578***	-0.582***
	(0.150)	(0.149)
Primary Education	0.0564	0.0804
	(0.421)	(0.414)
Tertiary Education	-0.423	-0.425
	(0.290)	(0.290)
Gender	-0.260	-0.247
	(0.228)	(0.227)
Age 18-35	-0.189	-0.195
	(0.298)	(0.298)
Age 55-99	-0.0714	-0.0950
	(0.675)	(0.675)

Estimation Results 2: Including Interactions

Dep. Var.: Mortgage Default Dummy	**Model 1**	**Model 2**
Idiosyncratic - Finance Variables		
Negative Shock	1.678***	
	(0.245)	
Credit Applications Rejected	0.687	0.677
	(0.437)	(0.439)
Renegotiation	1.319***	1.325***
	(0.277)	(0.276)
Systemic Variables		
Initial House Price (in logs)	-0.417***	-0.443***
	(0.112)	(0.111)
Interaction Variables		
Income and current loan to value	0.0199**	0.0195**
	(0.00810)	(0.00814)
Initial House Price and Negative shock		0.102***
		(0.0147)
Constant	9.326***	9.817***
	(2.265)	(2.243)
Observations	1,446	1,446

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1

Final remarks

- We are able to estimate a micro-powered model of mortgage default determinants
- Contrary to the existing literature, we find that interaction between macro and micro factors is key

- Income is an important determinant of the probability of default
- A negative shock in the recent past significantly increases the probability of defaulting a mortgage loan
- Higher housing prices lessen the probability of default (the contrary is problematic)

- A higher value of the interaction between income and current LTV is associated to higher mortgage default
- Also, a higher value of the interaction between origination housing prices and negative budget shocks is associated with higher default rates

- We propose to extend this framework to analyze further financial issues in a more general setting

Appendix: Nominal Flows of the Economy