The Feasibility of Reverse Mortgages for Japan

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Agenda

- Overview
- A Brief Discussion of HECMs in U.S.
- Modeling Techniques
- Policy Implications

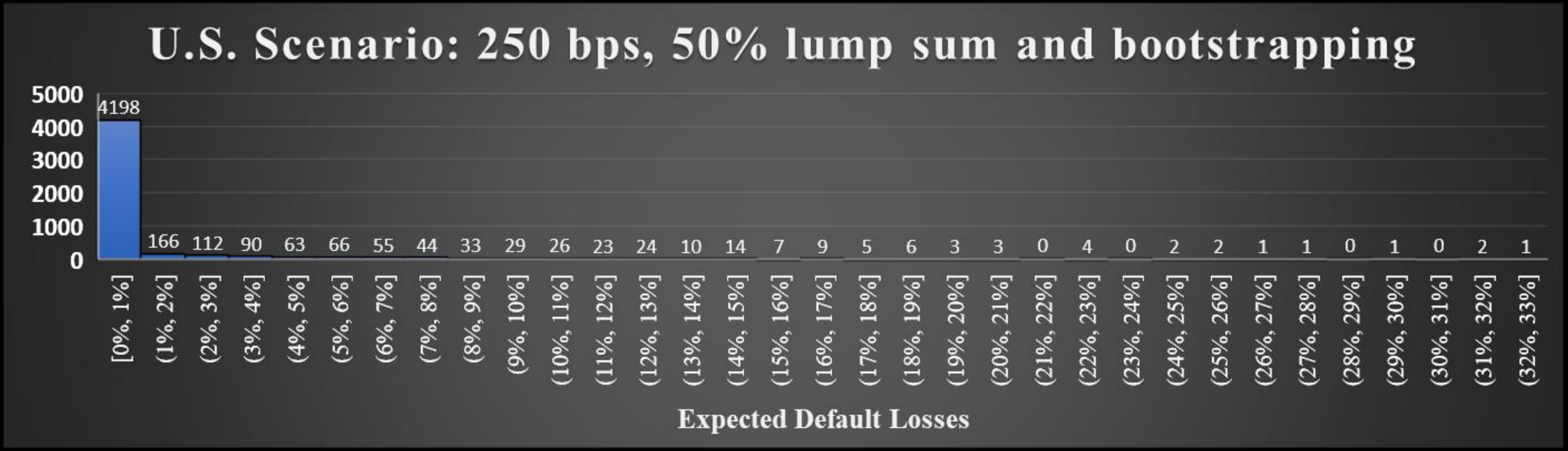
Overview

- Like Japan, US has an aging population whose wealth is largely taken up by home equity.
- Elderly are reluctant to move.
- Question is: is there an efficient mechanism for tapping home equity?
- Possibility: reverse mortgage, or Home Equity Conversion Mortgage (HECM)
- But they have been proved to be expensive—lots of equity goes to paying fees.

Overview

- **Previously, we have detected high tail risk may drive high HECM costs in the U.S. context.**

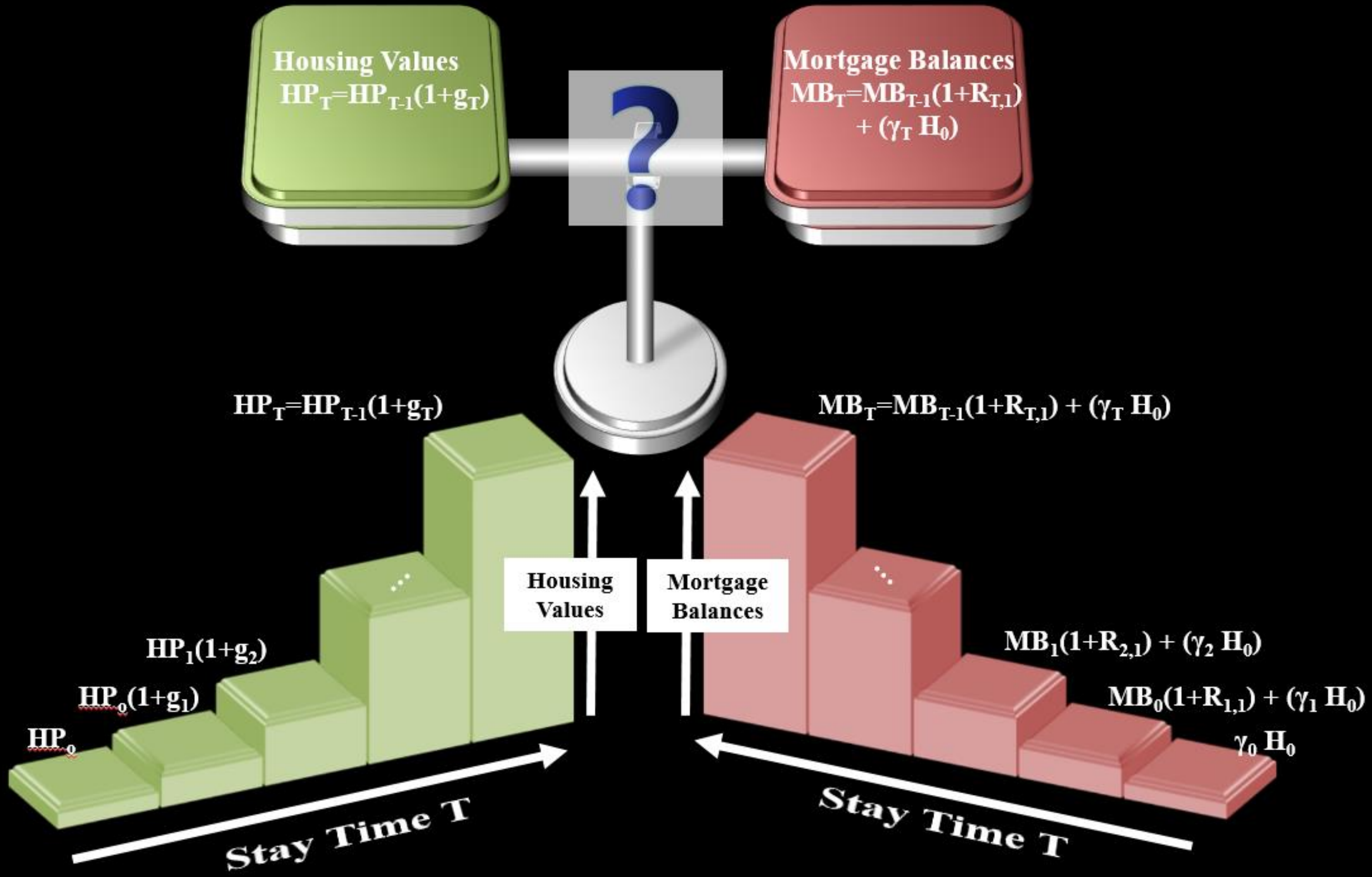
- **In this presentation, we apply modeling techniques used in our US analysis to the Japanese context to discuss the feasibility of reverse mortgages in Japan.**



Source: Authors' simulations based on U.S. treasury rates, life expectancy and FHFA housing price data.

Mean	Std Dev	Max	Min	99.5-Percentile	97.5-Percentile
0.90%	2.99%	32.54%	0%	18.06%	10.86%

Why do HECM insurers face potential losses?



Mortgage Interest Rates ($R_{T,1}$) Housing Price Appreciate Rates (g_T)
Home Equity Withdrawal Rates (γ_T) Terms of the Reverse Mortgage (T)

Why the lending institutions are facing potential losses?

Housing Values
>
Mortgage Balances

- **Households: get ($HP_T - MB_T$)**
- **Banks: get MB_T**

Housing Values
<
Mortgage Balances

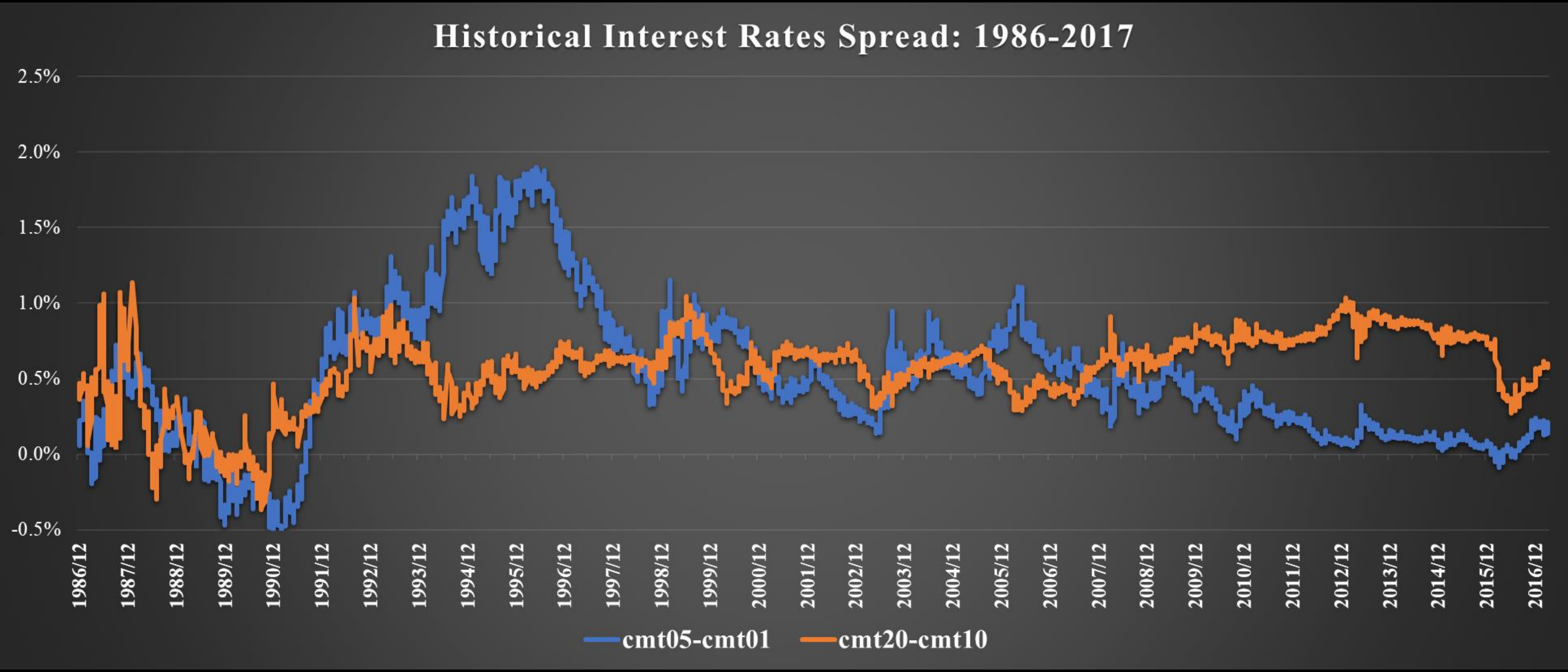
- **Households: Default**
- **Banks: Losses= MB_T - HP_T**
- **At each period T, the predicted loss is conditional on moving out (death)**

- We assume in our model that the maximum term of reverse mortgages is 30 years and that death is the only reason for the termination of reverse mortgages loans.
- Therefore, to estimate the potential losses associated with default risk, we need to model stochastic movements for interest rates, house price appreciation rates and mortality rates.

Interest Rates: JGB Yield Curves

Source: Authors' calculations based on data of JGB daily yields from 1986 to 2017.

Interest Rates: Inverted Yield Curves

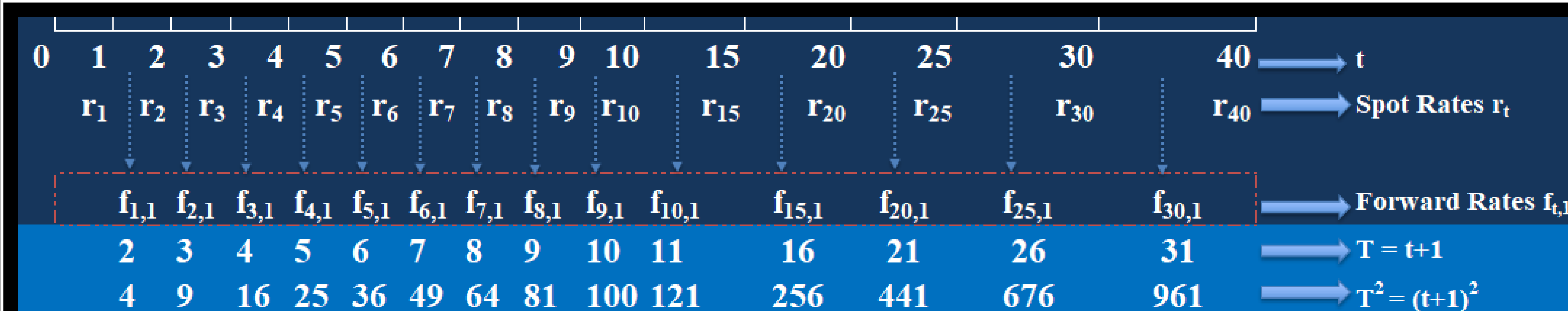


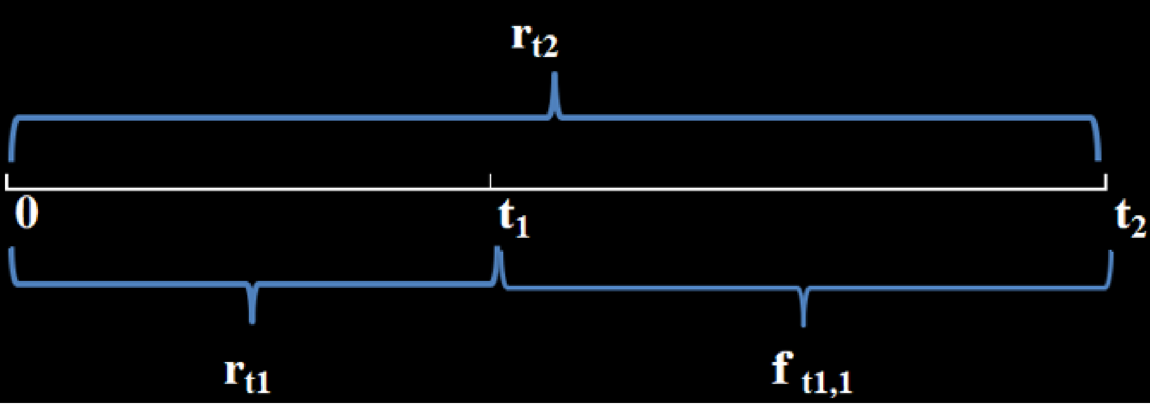
Source: Authors' calculations based on data of JGB daily yields from 1986 to 2017.

Interest Rate Predictions: Two-Step Model

- **Step 1: Utilize the term structure of interest rates to compute 1-year forward rates based on JGB daily yields data from 2007 to 2017.**

Timeline and Key Variables in Interest Rates Estimation Model





$$f_{t1,1} = \left[\frac{(1+r_{t2})^{t_2}}{(1+r_{t1})^{t_1}}\right]^{\frac{1}{t_2-t_1}} - 1$$

Interest Rates Prediction: Two-Steps Model

- **Step 2: Model the constant driving drift and the random component of stochastic interest rates:**

  - First, model the 1-year forward rates computed in Step 1 as a linear function of T and T^2: $\boldsymbol{f_{t,1} = \alpha_0 + \beta_1 T + \beta_2 T^2 + \varepsilon}$
    - Overall constant driving force (the drift): $\boldsymbol{\widehat{\alpha_0} + \widehat{\beta_1} T + \widehat{\beta_2} T^2}$

  - Second, conduct **Monte-Carlo simulation on the error term $\boldsymbol{\varepsilon}$** to obtain the standard deviation of the mean of the residuals. With 1000 replications, the estimated standard deviation of the mean is 0.0036.

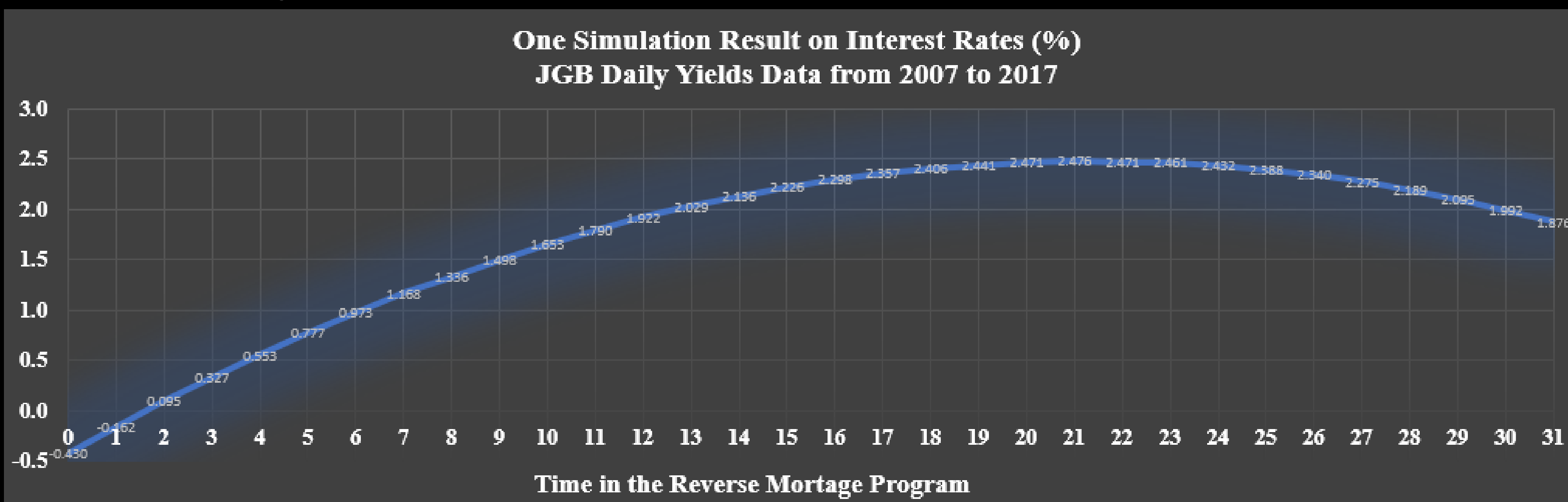
  - Third, combining the estimates from the linear regression and the Monte-Carlo simulation, we model the stochastic 1-Year interest rates in the next 30 years as $\boldsymbol{R_{T,1} = (\widehat{\alpha_0} + \widehat{\beta_1} T + \widehat{\beta_2} T^2) + NORMSINV(RAND())}$, where T =0,1,2, …, 30.

  - Fourth, replicate the entire process with JGB data from 1986 to 2017.

Interest Rates Prediction: One Simulation Result

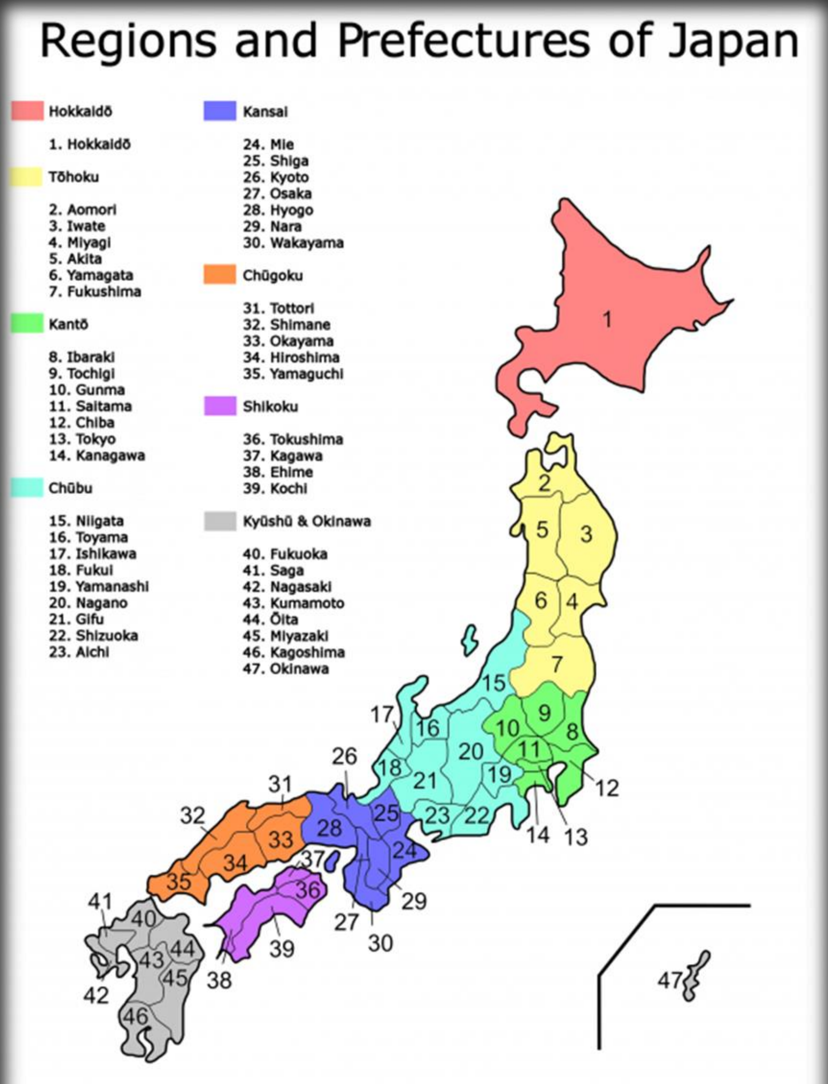
	JGB Daily Yields Data: November 6, 2007 -- March 24, 2017				JGB Daily Yields Data: December 1, 1986 -- March 24, 2017			
Parameters	Estimate	Std Dev	t-value	Prob>|t|	Estimate	Std Dev	t-value	Prob>|t|
α_0	-0.43	0.0102	-42.3	0	1.3712	0.0178	-42.3	0
β_1	0.2728	0.0017	157.71	0	0.2538	0.0032	78.67	0
β_2	-0.0064	0.00005	-120.16	0	-0.008	0.0001	-75.06	0
ε	0	0.6274			0	1.8388		
Adj. R^2	0.5814				0.0651			

Source: Authors' regression results on the drift of 1-Year forward rates.



Source: Authors' simulation result on 1-Year interest rates.

Housing Price Appreciation Rates Prediction



Source: www.japan-guide.com

- Data: Land-based transaction data from MLIT.
- Time: 2006-2016, most recent global housing boom and bust cycle
- Land-only transactions: fundamental driving real changes in house prices.
- 7 Regions: Merge Chugoku and Shikoku regions.
- Estimation Procedures:
  - Hedonic Land Pricing Model on 7 Regions
  - Construct Land Price Index in Japan
  - Compute Land Price Appreciation Rates
  - A Brownian Motion Estimation
  - A Bootstrapping Estimation

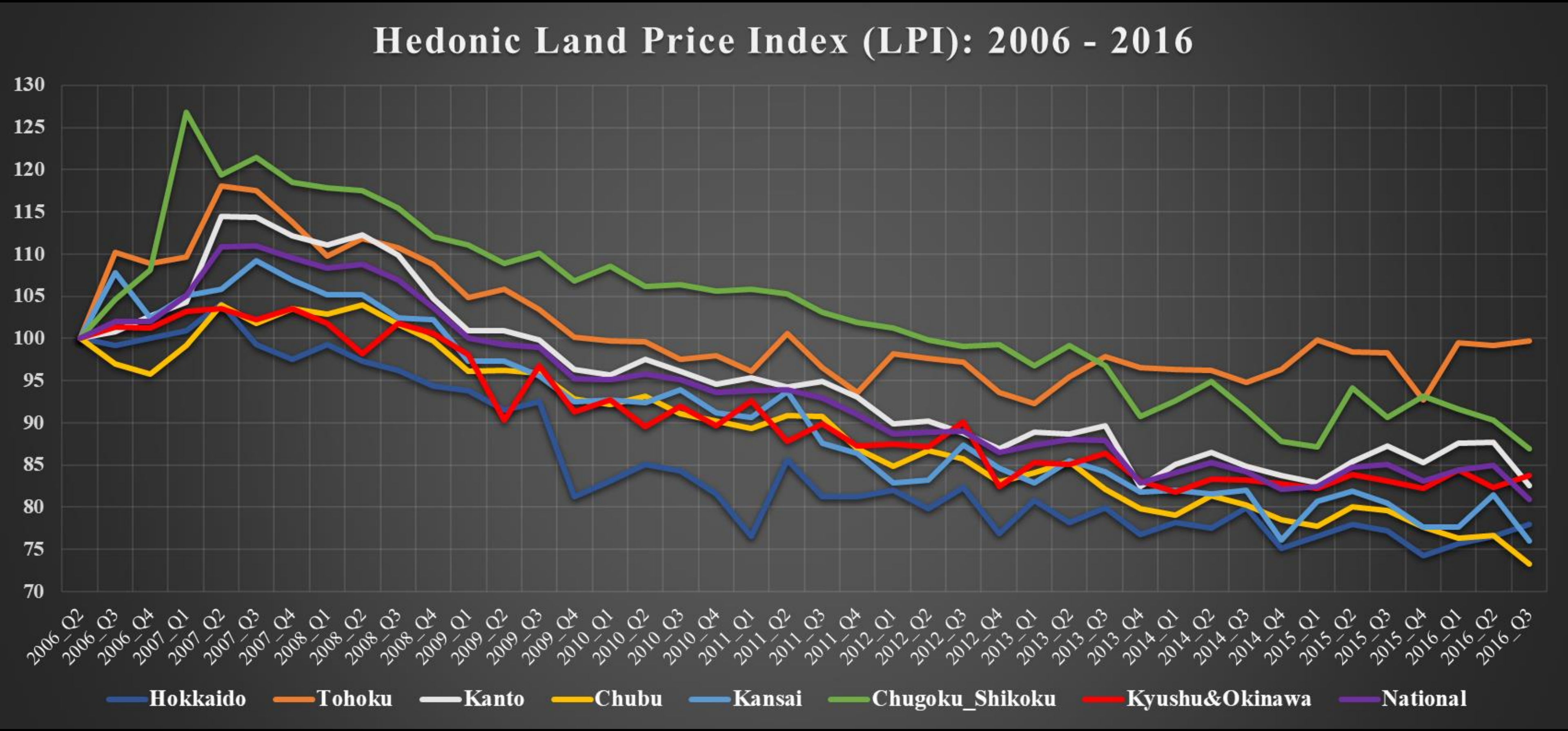
House Price Appreciation Rates Prediction: Hedonic Land Pricing Model

$$Log\_UnitLandPrice_{ijt} = \beta X_i + \delta L_i + \tau A_i + \tau \lambda_t + \pi D_j + \mu_{ijt}$$

Variables	Description	Category	Mean	Standard Deviation
Log_unitprice	Log of unit land price per square meter,price unit in 10,000 yen.	Dependent Variable	10.54	1.40
Landshape	The general shape of the land, such as square, rectangle, trapezoid, irregular, etc.	Fundamental Characteristics	4.08	1.84
Surregion	The characteristics of surrounding area include residential area, commercial area, industrial area or potential residential area.	Fundamental Characteristics	3.64	0.84
Frontrbreath	The width (in meter) of the front raod in contact with the land.	Fundamental Characteristics	6.95	4.78
Frontrtype	Frontage road types, such as prefecrure road, city road, agriculture road, private road, etc.	Fundamental Characteristics	5.48	3.54
Cityplanning	The use districts designated by the City Planning Act	Land Use Regulation	7.31	5.67
Maxbcr	The designated maximum building coverage ratio(%)	Land Use Regulation	59.90	8.98
Maxfar	The designated maximum floor-area ratio (%)	Land Use Regulation	189.57	77.12
Nearestdist	The time distance (minute) from the land location to the nearest train station or ground station.	Location	3.55	2.30
Location	Addresses are shown up to town or ward.	Location		
MergedRegion	7 Regions: Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku_Shikoku, Kyushu_Okinawa.	Location		
Transperiod	The transactin period means the date of contract, displayed on a quarterly basis.	Time		

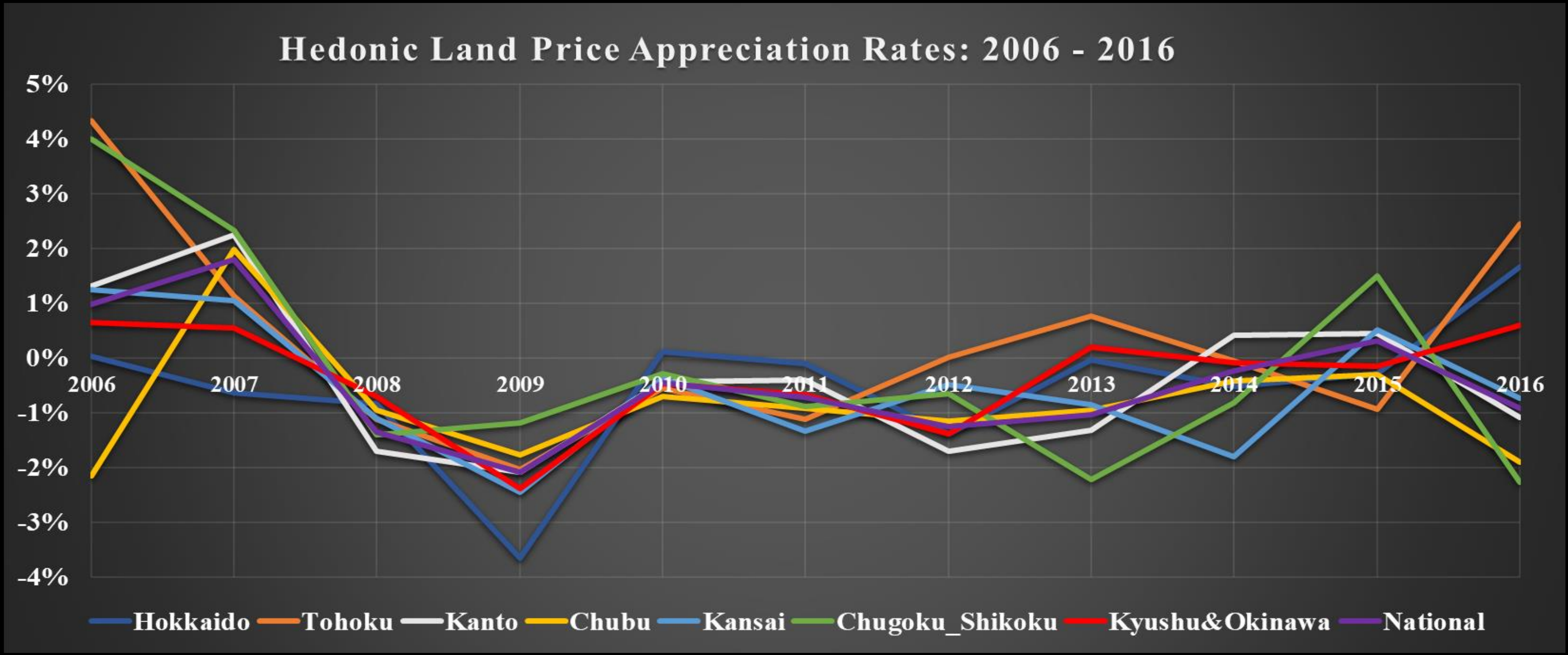
- Fundamental Characteristics, X_i
- Land-Use Regulatory Factors, L_i
- Locational Features, A_i
- Region Dummies, D_j
- Time effects, λ_t

House Price Appreciation Rates Prediction: Land Price Index (LPI)



Source: Authors' calculations on land price index based on the hedonic land pricing model and land-only transaction data from MLIT.

House Price Appreciation Rates Prediction: Land Price Appreciation Rates (LPA)



Source: Authors' calculations on land price appreciation rates based on the constructed LPI.

- **Our constructed hedonic LPA reveals great heterogeneity in Japanese local housing markets.**
- **The severe Great East Japan Earthquake and the tremendous reconstruction afterwards help explain the amplitude of the housing cycle in Tohoku.**
- **The large increase of foreign investors in recent years contributes to house price increases in Hokkaido.**

House Price Appreciation Rates Prediction: Model I: Brownian Motion

- We treat the national housing market as a portfolio of which the overall return depends on the land price returns of the 7 Regions, which capture the fundamental risks and returns of insurance products backed by the housing market.

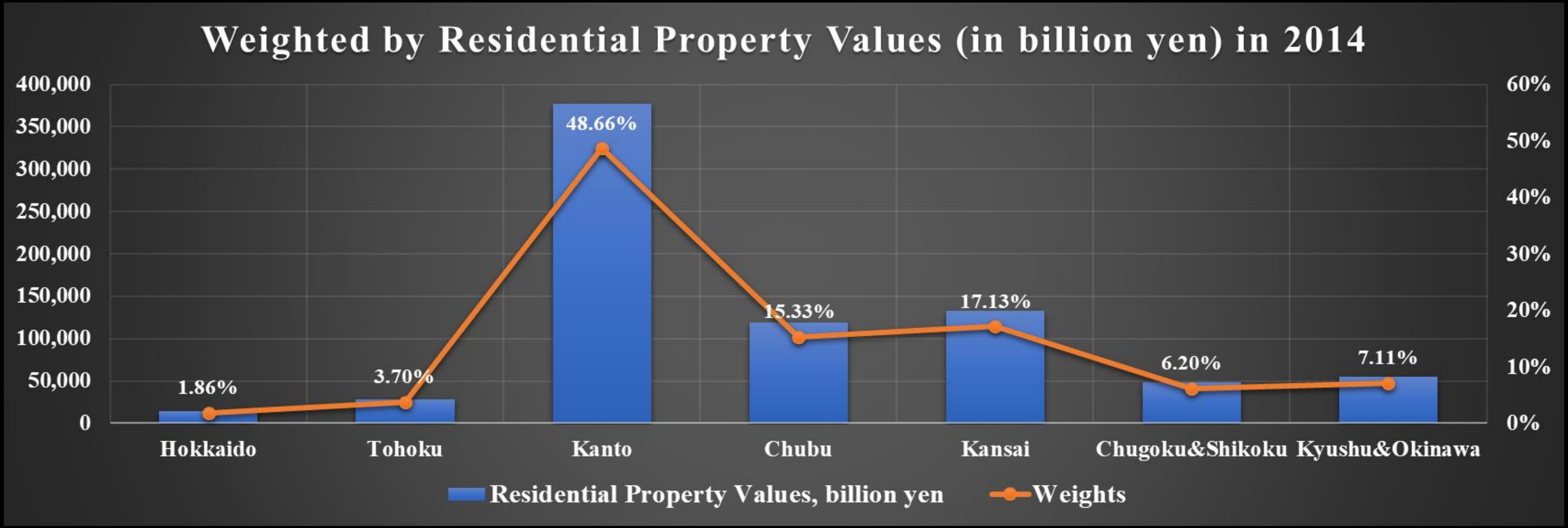
- Brownian Motion: Housing Price $HP_T = HP_{T-1} \times e^r$

- r = Asset Drift + Portfolio Std Dev×NORMSINV(Rand())

- Asset Drift = Portfolio Mean – 1/2×Portfolio Variance

Portfolio	Weighted Average Return	Variance	Standard Deviation	Asset Drift
	-0.464%	0.01246%	1.116%	-0.4699%

Model I: Brownian Motion



Source: Authors' calculations based on residential property values in 2014.

Variance-Covariance Matrix

	Hokkaido	Tohoku	Kanto	Chubu	Kansai	Chugoku_Shikoku	Kyushu&Okinawa	Weights
Hokkaido	0.0166%	0.0137%	0.0057%	0.0000%	0.0064%	0.0005%	0.0100%	1.86%
Tohoku	0.0137%	0.0338%	0.0121%	-0.0036%	0.0133%	0.0169%	0.0128%	3.70%
Kanto	0.0057%	0.0121%	0.0189%	0.0090%	0.0115%	0.0219%	0.0085%	48.66%
Chubu	0.0000%	-0.0036%	0.0090%	0.0122%	0.0044%	0.0060%	0.0026%	15.33%
Kansai	0.0064%	0.0133%	0.0115%	0.0044%	0.0132%	0.0182%	0.0070%	17.13%
Chugoku_Shikoku	0.0005%	0.0169%	0.0219%	0.0060%	0.0182%	0.0386%	0.0067%	6.20%
Kyushu&Okinawa	0.0100%	0.0128%	0.0085%	0.0026%	0.0070%	0.0067%	0.0086%	7.11%
Portfolio Variance	0.01246%							

Source: Authors' calculations based on the estimated LPA.

Model I: Brownian Motion

- Assume a normal-distribution of the housing price returns
- However, given the observed sample period: right-skewed

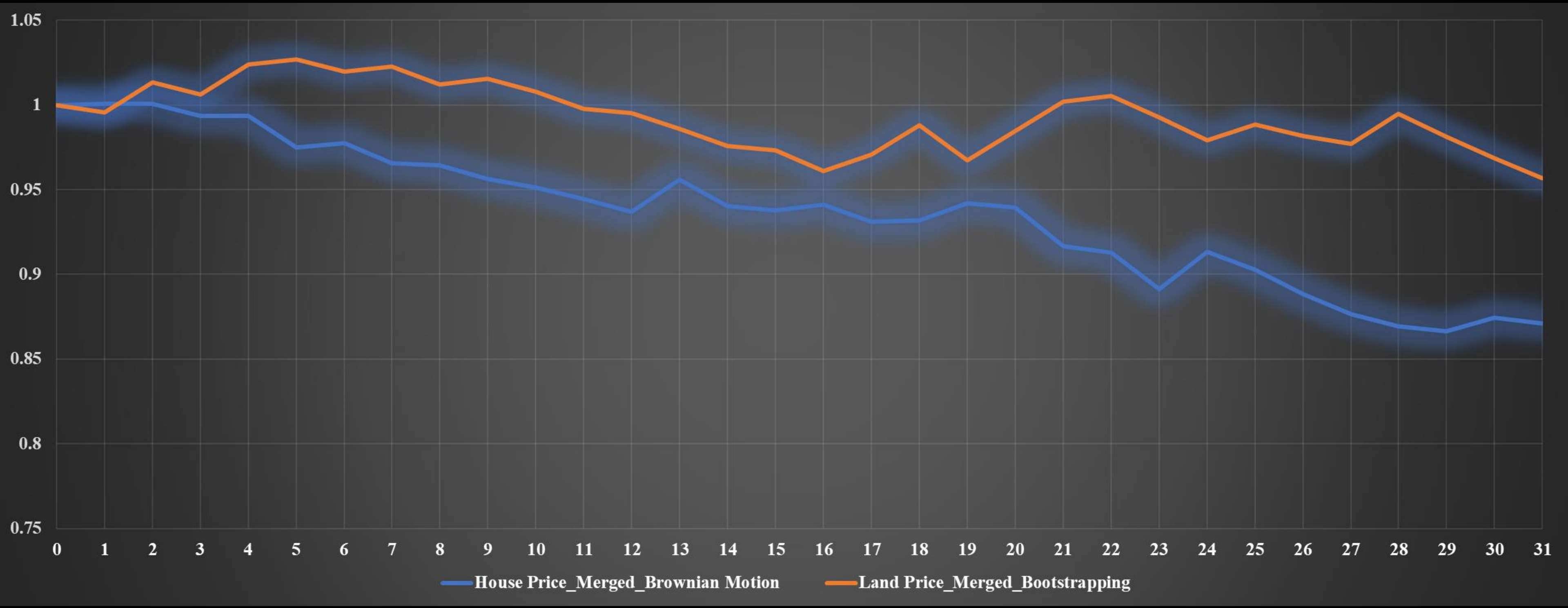
Hedonic Land Price_Annual Growth Rates								
Year	Hokkaido	Tohoku	Kanto	Chubu	Kansai	Chugoku_Shikoku	Kyushu&Okinawa	National
2006	0.03%	4.33%	1.31%	-2.15%	1.24%	3.99%	0.64%	0.974%
2007	-0.63%	1.13%	2.24%	1.97%	1.05%	2.32%	0.54%	1.788%
2008	-0.84%	-1.13%	-1.70%	-0.95%	-1.10%	-1.40%	-0.71%	-1.356%
2009	-3.66%	-2.04%	-2.08%	-1.77%	-2.46%	-1.19%	-2.39%	-2.094%
2010	0.11%	-0.56%	-0.43%	-0.70%	-0.37%	-0.28%	-0.47%	-0.451%
2011	-0.10%	-1.13%	-0.41%	-0.92%	-1.35%	-0.89%	-0.68%	-0.717%
2012	-1.39%	0.01%	-1.70%	-1.15%	-0.50%	-0.65%	-1.40%	-1.253%
2013	-0.04%	0.77%	-1.33%	-0.96%	-0.86%	-2.22%	0.19%	-1.035%
2014	-0.53%	-0.05%	0.41%	-0.42%	-1.80%	-0.82%	-0.09%	-0.241%
2015	-0.29%	-0.94%	0.45%	-0.30%	0.52%	1.49%	-0.15%	0.304%
2016	1.66%	2.44%	-1.09%	-1.90%	-0.74%	-2.28%	0.60%	-0.929%
Skewness	-1.184	1.161	0.660	1.649	0.205	1.140	-1.052	0.765
Kurtosis	3.837	1.238	-0.416	4.134	-0.530	0.596	1.025	0.354
Weights	1.86%	3.70%	48.66%	15.33%	17.13%	6.20%	7.11%	100.00%
Geometric Mean of Growth Rates	-0.524%	0.240%	-0.402%	-0.846%	-0.585%	-0.193%	-0.360%	-0.461%
Standard Deviation	1.230%	1.752%	1.309%	1.055%	1.096%	1.874%	0.882%	1.064%
Variance	0.01663%	0.03375%	0.01886%	0.01225%	0.01320%	0.03862%	0.00855%	0.01246%
Weighted Average Growth Rate	-0.4637%							

Source: Authors' calculations based on the estimated LPA.

- Thus, the Brownian Motion method will underestimate the housing price appreciation rates and overestimate potential default losses.

Model II: Bootstrapping

- **No distributional assumption imposed under the bootstrapping method.**
- **Doesn’t simulate on the error term from a model, but rather on the observed distribution of house price returns**
- **Bootstrapping with replacement give us a less biased estimate of the predicted losses, because it allows for skewness.**



Source: Authors’ simulation results on housing price appreciation rates based on the estimated LPA.

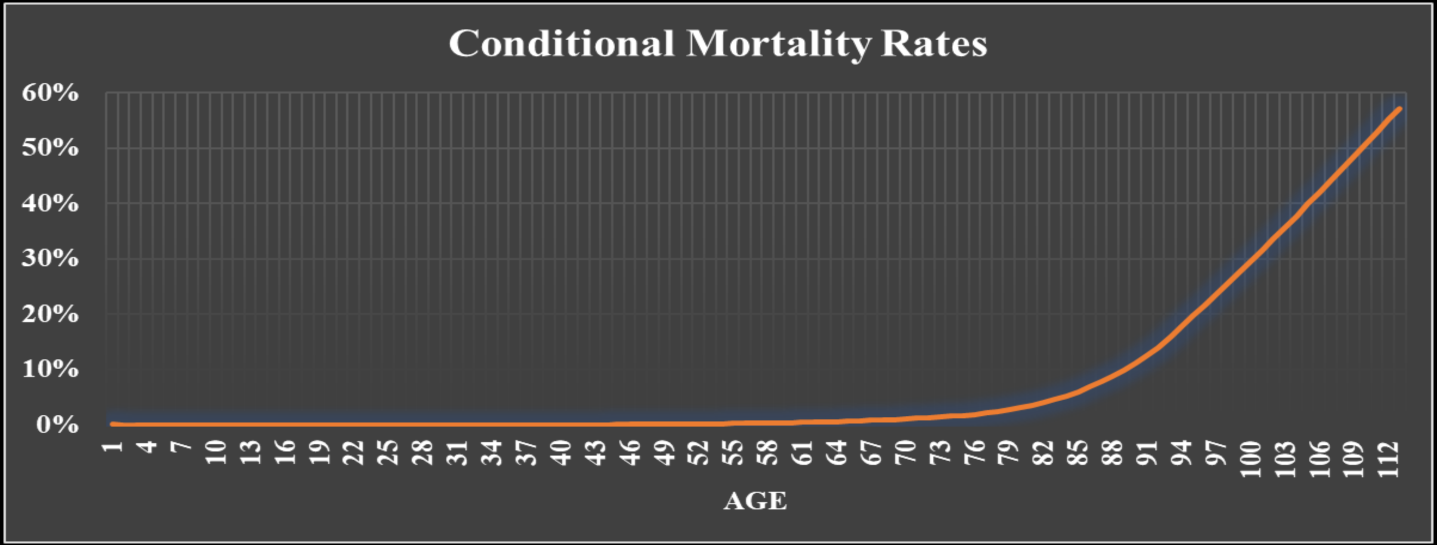
Mortality Rate Predictions

- We assume that mortality of the borrower is the only reason for the termination of reverse mortgage loans.
- We exclude the possibility of refinancing, mobility and co-borrowing (couples) in our model so that the simulation result can provide the lower bound of potential default losses.

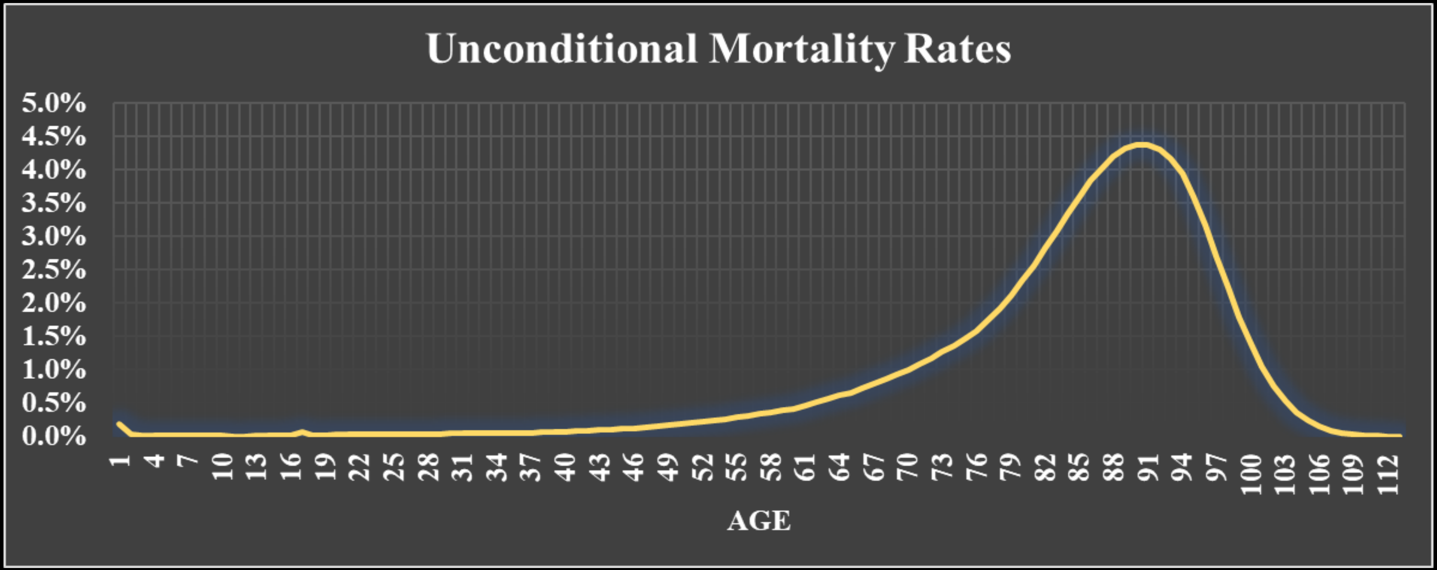
- Data Source: 2015 life table from the Ministry of Health, Labor and Welfare in Japan.
- Data provides conditional probability of death M(T) at each age.
- We compute unconditional probability of death m(T) using:

$$\boldsymbol{m(T) = M(T) \times \left[1 - \sum_{0}^{T} M(T-1)\right]}$$

Mortality Rates Prediction



Source: 2015 life table from the Ministry of Health, Labor and Welfare in Japan.



Source: Authors' calculations based on conditional mortality rates.

Default Risk Modeling Mechanism

1 Interest Rates

- The term structure of interest rates
- Monte-Carlo Simulation

2 House Price Returns

- Hedonic land price index and appreciation rates
- A Brownian Motion Method
- A Bootstrapping Method
- Standardize $H_0 = 1$

3 Mortality Rates

- Conditional mortality rates
- Unconditional mortality rates

4 Potential Losses

- At each period, if $MB_T > HP_T$, then the expected loss equals to $(MB_T - HP_T) \times m(\mathrm{T})$.
- Discounting to obtain the NPV of the potential losses.

Default Risk Estimation Model

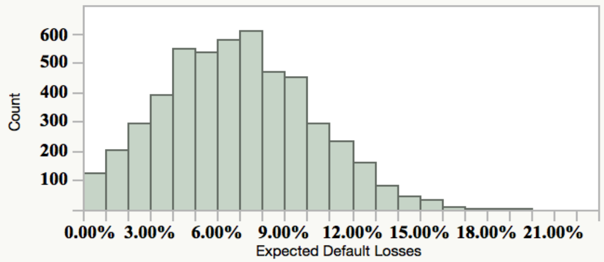
Time	Mortgage Balances	Housing Values	Undiscounted Potential Losses with Default Risk
0	$MB_0 = \gamma_0 \times HP_0$	$HP_0 = 1$	At each stage, if $MB_T > HP_T$, then the expected losses equal to $(MB_T - HP_T) \times \mathrm{m(T)}$
1	$MB_1 = MB_0\ (1 + R_{1,1}) + (\gamma_1 \times H_0)$	$HP_1 = HP_0 \times (1 + g_1)$	
2	$MB_2 = MB_1\ (1 + R_{2,1}) + (\gamma_2 \times H_0)$	$HP_2 = HP_1 \times (1 + g_2)$	
3	$MB_3 = MB_2\ (1 + R_{3,1}) + (\gamma_3 \times H_0)$	$HP_3 = HP_2 \times (1 + g_3)$	
…	…	…	
T	$MB_T = MB_{(T-1)}\ (1 + R_{T,1}) + (\gamma_T \times H_0)$	$HP_T = HP_{T-1} \times (1 + g_T)$	

- Borrowers can choose different kinds of withdrawal plans. For term plan, γ_T is a constant term. For lump-sum plan, $\gamma_T = 0$ for T=1, 2, …, 30. For line of credits plan, γ_T varies as T increases.
- We estimate four alternative scenarios to test the impact of home equity withdrawal rates, mortgage interests spreads and HPA estimation methods.

Alternative Scenarios	Spreads	Home Equity Withdrawal Rates	HPA Estimation Methods
1	50bps	50% at T=0	Bootstrapping
2	50bps	50% at T=0	Brownian Motion
3	100bps	50% at T=0	Bootstrapping
4	50bs	5% per year for the first 10 years	Bootstrapping

Distributions

Scenario 1: 50bps, 50% lump sum and Bootstrapping



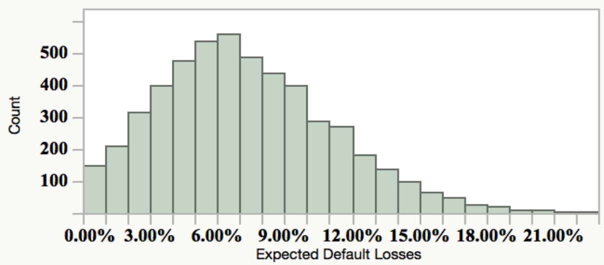
Quantiles

100.0%	maximum	19.79%
99.5%		15.63%
97.5%		13.47%
90.0%		11.22%
75.0%	quartile	9.08%
50.0%	median	6.74%
25.0%	quartile	4.48%
10.0%		2.65%
2.5%		1.00%
0.5%		0.06%
0.0%	minimum	0.00%

Summary Statistics

Mean	0.0684583
Std Dev	0.0324577
Std Err Mean	0.000459
Upper 95% Mean	0.0693582
Lower 95% Mean	0.0675584
N	5000
Skewness	0.2680601
Kurtosis	-0.222073
Median	0.0674

Scenario 2: 50bps, 50% lump sum and Brownian Motion



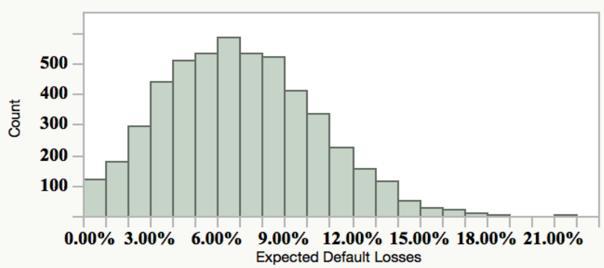
Quantiles

100.0%	maximum	22.73%
99.5%		18.00%
97.5%		15.43%
90.0%		12.29%
75.0%	quartile	9.60%
50.0%	median	6.83%
25.0%	quartile	4.46%
10.0%		2.55%
2.5%		0.90%
0.5%		0.13%
0.0%	minimum	0.00%

Summary Statistics

Mean	0.0720502
Std Dev	0.0376638
Std Err Mean	0.0005326
Upper 95% Mean	0.0730944
Lower 95% Mean	0.071006
N	5000
Skewness	0.4970065
Kurtosis	-0.006975
Median	0.06825

Scenario 3: 100 bps, 50% lump sum and Bootsrapping



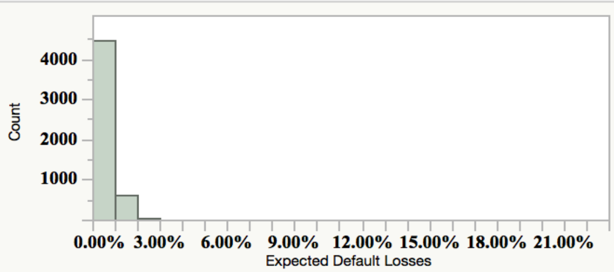
Quantiles

100.0%	maximum	21.71%
99.5%		15.87%
97.5%		13.60%
90.0%		11.32%
75.0%	quartile	9.16%
50.0%	median	6.74%
25.0%	quartile	4.42%
10.0%		2.75%
2.5%		1.09%
0.5%		0.23%
0.0%	minimum	0.00%

Summary Statistics

Mean	0.0691633
Std Dev	0.0328773
Std Err Mean	0.000465
Upper 95% Mean	0.0700748
Lower 95% Mean	0.0682518
N	5000
Skewness	0.2889658
Kurtosis	-0.273469
Median	0.06735

Scenario 4: 50bps, 5% over 10 year and Bootstrapping



Quantiles

100.0%	maximum	2.430%
99.5%		1.950%
97.5%		1.480%
90.0%		1.040%
75.0%	quartile	0.710%
50.0%	median	0.430%
25.0%	quartile	0.210%
10.0%		0.080%
2.5%		0.000%
0.5%		0.000%
0.0%	minimum	0.000%

Summary Statistics

Mean	0.0050904
Std Dev	0.0038983
Std Err Mean	5.513e-5
Upper 95% Mean	0.0051985
Lower 95% Mean	0.0049823
N	5000
Skewness	1.1346479
Kurtosis	1.4717827
Median	0.0043

Interpret Our Simulation Results

- **Scenario 1 vs. Scenario 2:** The Bootstrapping Method performs more accurately and corrects for the overestimation of potential losses associated with the Brownian Motion method.

- **Scenario 2 vs. Scenario 3:** The increase in risk premiums (from 50bps to 100bps) does not significantly increase the default risk.
  - Future study will look at optimal endogenous interest rates.

- **Scenario 1: But even with** the Bootstrapping forecast, the lump sum plan produces not just high tail risk, but high risk period.

- **Scenario 4:** Home equity withdraw rates matter significantly. Tapping on only 5% of home equity each year over the first 10 years decreases the magnitude of potential losses to levels that can be priced.

Policy Implications

- HECMS are particularly difficult to think about in the Japanese context, where house prices are falling.
- This means allowing government guaranteed lump sum withdrawals could be expensive for government.
- Allowing 5 percent draws from initial equity over ten years is, however, quite feasible.
- Mean housing wealth in Japan is about ¥ 320 million (Hori and Niizeki 2017).
- 5 percent is ¥ 16 million per year, which could be helpful in event of, say, medical need.
- Of course, impact will vary by region of the country.

Disclosure

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