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Agency RMBS Prepayment Model

Release of Experimental Model v99 on The Yield Book

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Highlights of Major Model Updates from v21.5 to v99

COVID-19 Impact

- P/S Spread baseline initially 20 bps higher during COVID-19 crisis, normalizing by 2021
- Impact of capacity constraints on impaired collateral increased, slowing refi response to rally
- Turnover assumed 25-30% below normal in Q2/Q3, recovering by year-end
- Cash-outs 10-15% below normal since temporary appraisal flexibilities generally don't apply
- Turnover and cash-out adjustments noted above are on top of HPA/unemployment impact
- HPA base case reduced to 0% in 2020 and 3% thereafter
- Unemployment base case is an increase to 7.5% almost immediately, back down to ~4% in 2022

P/S Spread Model Update

- Spread more sensitive to rally/backup at high media effect levels, reducing primary rate volatility
  - Previously assumed regulator scrutiny and originator pricing power limited movement at these levels
  - Neither seems applicable in current market, so these features have been removed

Recalibrated Refi Response – PIW, Media Effect, Burnout, Spec Category Review

- Conventional/GNMA refi ramps further recalibrated, based on recent major/multi pool speeds
- PIW / media effect recalibrated to reduce extreme rally speeds on highest quality loans
- Most specified pool sectors projected faster ex-COVID-19, in line with recent stronger prepayments
- Incorporate new property valuation method disclosures from GSEs

Introduce Economic Scenarios

- Previous models assumed a single HPA/unemployment scenario across all rate paths
- New model distributes base, downside and upside scenarios across rate paths
- The distribution reflects our view of little correlation between rates and HPA/unemployment

MODEL V99 IS NOT INTENDED FOR PRODUCTION USE. IT IS FOR BETA TESTING PURPOSES ONLY, AND WAS SUBJECT TO ONLY LIMITED TESTING AND REVIEW BY MODEL USERS PRIOR TO RELEASE. IT MAY CONTAIN MATERIAL ERRORS AND MAY NOT BE STABLE. IT IS SUBJECT TO CHANGE WITHOUT NOTICE AND MAY CHANGE SIGNIFICANTLY DURING ITS TESTING PERIOD. COMMENTS ARE WELCOME AND SHOULD BE SENT IN WRITING TO THE YIELD BOOK HELP DESK AT HOWTO@YIELDBOOK.COM. NOT ALL COMMENTS WILL RECEIVE A RESPONSE.

Mortgage Index Comparisons: v99 vs. v21.5

4/1/2020	1-YEAR CPR			Long-Term CPR			OAS			EFF DUR			EFF CONV		
	v99	v21.5	Diff	v99	v21.5	Diff	v99	v21.5	Diff	v99	v21.5	Diff	v99	v21.5	Diff
Total	27.1	30.8	-3.7	21.9	22.5	-0.6	54.4	43.2	11.2	1.7	1.4	0.4	-0.9	-0.7	-0.2
GNMA	31.1	33.8	-2.8	24.0	23.6	0.5	51.0	44.8	6.2	1.7	1.4	0.3	-0.7	-0.6	0.0
FHLM	23.6	27.0	-3.4	20.2	21.0	-0.8	53.6	43.0	10.6	1.8	1.5	0.3	-0.8	-0.6	-0.2
FNMA	25.2	29.3	-4.1	20.9	21.9	-1.0	58.2	45.3	12.9	1.8	1.4	0.4	-0.9	-0.7	-0.2
30 Year	28.0	31.7	-3.8	22.3	22.8	-0.5	55.8	44.4	11.4	1.7	1.4	0.4	-0.9	-0.7	-0.2
GNMA 30 Yr	31.1	33.8	-2.8	24.0	23.6	0.5	51.0	44.8	6.2	1.7	1.4	0.3	-0.7	-0.6	0.0
FNMA 30 Yr	26.2	30.4	-4.2	21.3	22.2	-0.9	60.5	47.3	13.2	1.8	1.4	0.4	-1.0	-0.7	-0.2
FHLM 30 Yr	24.7	28.2	-3.4	20.7	21.3	-0.6	55.7	44.8	10.9	1.8	1.5	0.3	-0.9	-0.7	-0.2
15 Year	18.9	22.3	-3.4	18.2	19.7	-1.5	41.5	31.2	10.3	2.0	1.8	0.2	-0.6	-0.6	-0.1
FHLM 15 Yr	16.5	19.7	-3.3	17.1	18.6	-1.5	41.1	31.7	9.4	2.1	1.9	0.2	-0.5	-0.5	-0.1
FNMA 15 Yr	18.6	22.1	-3.5	18.1	19.6	-1.5	43.1	32.7	10.4	2.0	1.8	0.2	-0.6	-0.6	-0.1

- The updated model projects lower base case speeds based on the impact of COVID-19 on home sales, appraisals and originator capacity, as well as the slower voluntary prepayments that result from higher expected unemployment and reduced home price appreciation.
- Slower speeds in all rate environments result in higher OAS levels; OASs increase further from our introduction of upside and downside HPA scenarios on certain rate paths as described further herein; the positive OAS impact of the downside paths outweighs the negative impact from the upside paths.
- Conventional durations are generally longer on the overall universe as a result of the above changes. Convexity however is slightly more negative at current rate levels.
- GNMA speeds are down less (and OASs up less) than conventionals, resulting from a greater impact of COVID-19 driven defaults, as well as higher peak speeds ex the COVID-19 crisis.
- Changes to 15-year collateral are broadly similar to those for 30-year collateral.

Source: The YieldBook, Citi

TBA and Spec Comparisons: v99 vs. v21.5

v21.5 vs 99			4/1/2020			1 Yr Proj			LT Proj			OAS			Eff Duration			Eff Convexity		
Agency	Coupon	level	Age	Wac		Old	New	Diff	Old	New	Diff	Old	New	Diff	Old	New	Diff	Old	New	Diff
FNMA TBA		2.5	103.29	2	3.54	39.1	27.8	-11.3	24.5	22.5	-2.0	16	33	16	0.5	1.7	1.2	-2.5	-2.8	-0.3
		3.0	104.67	9	3.92	41.9	35.5	-6.4	28.6	26.7	-1.9	22	42	20	0.2	1.1	0.9	-1.2	-1.6	-0.4
		3.5	105.73	7	4.42	49.7	40.6	-9.1	36.2	32.2	-4.0	-4	39	43	-0.5	0.7	1.2	0.4	-0.4	-0.9
		4.0	106.88	7	4.88	49.0	40.2	-8.8	38.2	34.0	-4.2	-11	40	51	-0.1	0.9	1.1	1.1	0.2	-0.9
		4.5	107.69	8	5.37	46.6	37.7	-8.9	37.8	33.3	-4.6	8	63	55	0.6	1.4	0.9	1.1	0.3	-0.8
		5.0	108.01	16	5.78	41.4	33.1	-8.3	34.6	30.9	-3.8	71	116	45	1.3	2.0	0.7	0.7	0.2	-0.5
GNMAII TBA		2.5	104.25	2	3.02	18.8	24.3	5.5	17.5	19.5	2.1	32	25	-8	1.8	1.4	-0.4	-2.7	-2.8	-0.1
		3.0	105.61	4	3.49	34.4	39.6	5.2	23.0	25.9	2.9	27	19	-8	0.7	0.4	-0.3	-1.4	-1.3	0.1
		3.5	105.53	8	4.01	47.0	48.6	1.6	30.7	33.5	2.8	30	31	1	0.1	0.3	0.2	-0.4	-0.3	0.1
		4.0	106.24	8	4.52	52.0	52.6	0.7	35.2	38.3	3.1	20	23	3	0.0	0.3	0.3	0.0	0.0	0.0
		4.5	106.32	8	4.99	51.5	50.1	-1.4	37.7	38.6	0.9	51	63	12	0.3	0.8	0.5	0.3	0.1	-0.2
		5.0	106.16	11	5.54	50.6	45.4	-5.2	39.6	38.8	-0.9	97	110	13	0.6	1.2	0.6	0.7	0.3	-0.4
3's of 19	GEN		104.67	6	3.90	43.5	35.3	-8.2	27.5	24.9	-2.6	23	46	24	0.3	1.3	1.0	-1.2	-1.6	-0.4
	LLB		106.11	5	3.65	6.7	6.0	-0.7	9.8	10.1	0.2	109	105	-4	5.1	4.8	-0.2	-1.2	-1.5	-0.3
	MLB		105.86	5	3.70	9.2	8.3	-0.8	11.5	11.8	0.3	97	94	-3	4.0	3.9	-0.2	-1.8	-2.0	-0.2
	HLB		105.61	5	3.78	12.5	10.6	-1.8	13.5	13.6	0.1	84	85	1	3.1	3.3	0.2	-2.2	-2.1	0.1
	HHLB		105.42	5	3.82	16.8	13.5	-3.3	15.9	15.7	-0.2	69	75	6	2.2	2.7	0.5	-2.4	-2.2	0.2
	MAX200K		105.11	5	3.83	20.1	15.7	-4.3	17.4	16.9	-0.5	65	75	9	1.8	2.5	0.7	-2.4	-2.2	0.2
	NY		105.42	5	3.74	12.6	10.5	-2.1	12.7	12.6	-0.1	84	88	4	3.1	3.6	0.5	-2.8	-2.4	0.4
3.5's of 19	GEN		105.73	8	4.39	42.4	35.7	-6.6	29.7	27.1	-2.6	37	64	27	0.6	1.4	0.9	-0.4	-0.8	-0.4
	LLB		107.98	6	4.04	9.0	8.6	-0.4	11.3	11.8	0.5	119	114	-4	4.3	4.0	-0.3	-1.2	-1.5	-0.3
	MLB		107.61	6	4.10	11.7	11.3	-0.4	13.1	13.8	0.7	105	102	-3	3.3	3.1	-0.2	-1.7	-1.8	-0.1
	HLB		107.05	7	4.21	18.1	16.1	-2.0	16.4	16.7	0.2	88	92	4	2.2	2.4	0.3	-1.6	-1.6	0.0
	HHLB		106.67	8	4.34	24.3	20.3	-4.0	20.2	19.6	-0.6	69	82	13	1.4	2.0	0.6	-1.3	-1.4	-0.1
	MAX200K		106.36	8	4.36	28.6	23.4	-5.2	22.6	21.4	-1.1	62	79	17	1.1	1.8	0.8	-1.1	-1.3	-0.2
	NY		106.80	7	4.17	21.5	18.5	-3.0	16.0	15.7	-0.3	94	102	8	2.3	2.9	0.6	-1.8	-1.7	0.1
4's of 19	GEN		106.88	10	4.84	41.4	34.4	-7.0	30.4	27.6	-2.8	45	80	35	0.6	1.5	0.9	0.1	-0.4	-0.5
	LLB		110.25	8	4.55	12.0	12.4	0.3	13.0	13.8	0.8	115	109	-7	3.6	3.3	-0.3	-1.1	-1.3	-0.2
	MLB		109.69	8	4.60	16.0	16.1	0.1	15.4	16.4	1.0	97	92	-5	2.5	2.3	-0.2	-1.3	-1.3	0.0
	HLB		109.00	9	4.71	23.9	21.3	-2.6	19.5	19.6	0.2	73	81	8	1.5	1.8	0.3	-0.9	-1.0	-0.1
	HHLB		108.38	10	4.82	29.7	25.0	-4.7	23.6	22.7	-0.9	54	73	19	0.8	1.5	0.7	-0.4	-0.7	-0.3
	MAX200K		107.82	10	4.81	33.4	27.5	-5.9	25.8	24.2	-1.6	53	78	25	0.7	1.5	0.8	-0.1	-0.6	-0.5
	NY		108.69	9	4.64	26.4	23.4	-3.0	18.6	18.3	-0.3	91	102	11	1.8	2.4	0.5	-0.8	-0.9	-0.1
4.5's of 19	GEN		107.69	10	5.28	37.5	31.2	-6.4	28.9	26.5	-2.4	81	112	30	1.1	1.8	0.7	0.1	-0.2	-0.4
	LLB		111.38	10	5.08	14.6	14.6	0.0	14.4	15.2	0.8	129	123	-6	3.2	2.9	-0.2	-0.8	-0.9	-0.1
	MLB		110.75	10	5.12	19.2	18.4	-0.9	17.2	17.9	0.7	107	106	-1	2.1	2.2	0.1	-0.8	-0.9	0.0
	HLB		109.44	10	5.20	25.4	21.9	-3.5	20.6	20.5	-0.2	102	113	11	1.5	2.0	0.4	-0.5	-0.7	-0.1
	HHLB		108.94	11	5.29	31.0	25.3	-5.8	25.2	23.7	-1.5	78	101	24	1.1	1.8	0.7	0.0	-0.3	-0.4
	MAX200K		108.44	10	5.29	33.2	26.6	-6.6	26.7	24.7	-2.1	80	108	28	1.0	1.8	0.7	0.2	-0.2	-0.5
	NY		109.50	11	5.09	27.8	24.2	-3.6	20.1	19.6	-0.5	113	127	14	1.9	2.5	0.6	-0.2	-0.4	-0.2

Source: The YieldBook, Citi

COVID-19 Impact – Slower Refis/Turnover; Faster Defaults

Model v99 makes preliminary assumptions about the prepayment impact of the virus:

- Our P/S spread baseline is 20 bps higher during the initial phase of the COVID-19 crisis in March, as market volatility impacts pricing and social distancing impacts capacity; amortizes linearly to zero by the start of 2021. Prepayments on impaired collateral are also assumed to be less responsive initially to the rally, as the environment impacts both the will and ability of originators to refinance "tougher cases".

- Turnover is assumed 25-30% below normal on average in Q2/Q3, recovering by year-end and followed by modest pent-up demand (8-10% above normal) in 2021. May trough assumed 35-40% below normal.

- Cash-outs assumed 10-15% below normal on average, over the same period as turnover. Since full appraisals are generally still required (unlike purchase and rate refinances that benefit from temporary flexiblities offered by the GSEs and FHA/VA), social distancing is likely to dampen cash-out refinancings.

- HPA base case reduced to 0% in 2020 and 3% thereafter, and unemployment base case increased to 7.5% almost immediately, back down to ~4% in 2022. **The turnover and cash-out declines mentioned previously are on top of the impact of these HPA and unemployment assumption changes.**

- While buyouts of delinquent loans will be delayed due to forbearance, no timing changes have yet been implemented; they require more consideration and may be modest relative to overall buyout uncertainty.

- Please see below references for some publicly available forecasts on the expected impact, and some initial data from the MBA purchase applications survey:

  https://www.cnbc.com/2020/03/19/coronavirus-update-home-sales-could-fall-by-35percent-as-spring-market-stalls.html
  https://ihsmarkit.com/research-analysis/covid19-impact-update-us-gdp-to-plunge-to-13-q2.html
  https://www.wsj.com/articles/coronavirus-triggered-downturn-could-cost-5-million-u-s-jobs-11584783001
  https://www.mba.org/2020-press-releases/april/mortgage-applications-increase-in-latest-mba-weekly-survey

Source: CNBC.com, IHS Markit, The Wall Street Journal, MBA

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Model Version 98 = Model Version 99 without COVID-19

- While there will clearly be some impact on HPA, unemployment, home sales, buyouts of defaulted loans, and refinancing capacity from COVID-19, only very early data exists to provide guidance on the magnitude.
- Model version 99 contains our current estimate of the impact, but it is fairly speculative at this early stage of the crisis.
- Model version 98 has been released to The Yield Book concurrently with v99, and is identical to v99 except that all COVID-19 adjustments described on the previous page are removed.
- Therefore, model v98 may represent a preferred starting point for users that wish to overlay their own HPA/unemployment scenarios and prepayment model dials to represent the impact of the virus.
- Model v98 also allows isolation of the COVID-19 impact assumptions of model v99, by comparison of model v99 and model v98 projections.

IMPROVED MODEL PERFORMANCE OF V99 VERSUS V21.5

Model v99 in Line with 12-Month Actuals In-Sample

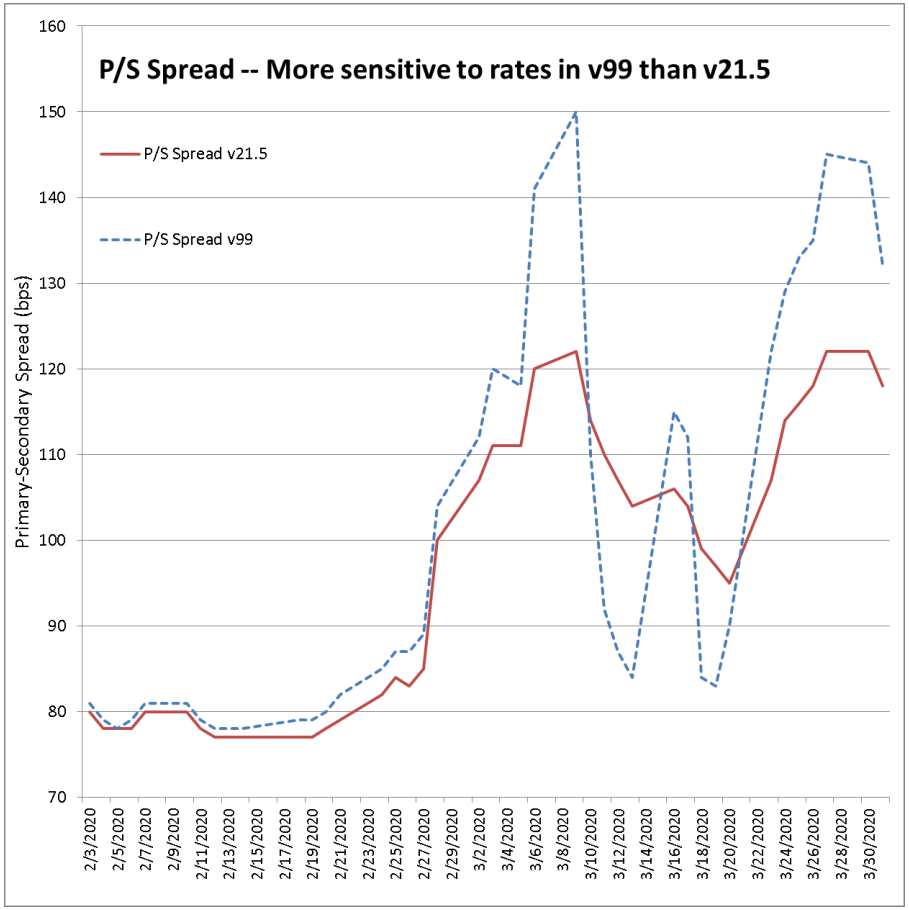
					v21.5				v99			
Asset Class	Balance(mm)	Last Hist Date	3M Hist CPR	12M Hist CPR	3M Proj CPR	3M Ratio	12M Proj CPR	12M Ratio	3M Proj CPR	3M Ratio	12M Proj CPR	12M Ratio
FN30	2161604	202002	15.8	15.4	15.0	1.06	15.0	1.03	15.3	1.04	15.5	1.00
FN30HHLB	100012	202002	12.7	12.8	11.5	1.11	12.3	1.04	12.1	1.05	12.8	1.00
FN30HLB	120334	202002	12.3	12.5	11.0	1.12	12.0	1.04	11.7	1.05	12.5	1.00
FN30LLB	48740	202002	11.1	11.5	9.5	1.17	10.7	1.07	10.2	1.09	11.2	1.02
FN30MLB	69272	202002	11.7	11.9	10.1	1.15	11.3	1.06	10.9	1.07	11.9	1.00
FN30MAX200K	73707	202002	13.4	13.4	12.1	1.11	12.7	1.06	12.6	1.07	13.3	1.01
FN30JUMBO	75136	202002	21.4	18.8	18.1	1.19	17.0	1.10	18.8	1.14	18.0	1.05
FN30INV	30476	202002	16.2	14.5	14.5	1.12	13.9	1.05	15.0	1.08	14.4	1.01
FN30CQ	24273	202002	13.5	13.6	12.6	1.07	13.7	1.00	13.2	1.03	14.3	0.96
FN30CR	21482	202002	13.3	13.3	10.6	1.26	12.2	1.09	11.5	1.16	13.2	1.00
FN30NY	44891	202002	10.6	9.2	8.4	1.26	8.8	1.05	9.1	1.16	9.5	0.97
FN30FICO	121331	202002	18.8	18.2	17.7	1.06	17.7	1.03	18.4	1.02	18.5	0.98
FH30	1471279	202002	16.1	15.7	14.9	1.08	15.0	1.05	15.3	1.05	15.6	1.01
GNII30	1721626	202002	21.4	19.7	17.1	1.25	18.4	1.07	18.5	1.16	19.3	1.02
GNIIMAX200K	15516	202002	17.1	15.4	13.3	1.29	12.9	1.19	15.1	1.13	14.2	1.09
GNII30HHLB	31557	202002	18.2	16.4	15.1	1.20	15.0	1.09	16.9	1.08	16.1	1.02
GNII30HLB	66182	202002	14.7	13.8	13.6	1.08	13.5	1.02	14.1	1.04	14.0	0.99
GNII30MLB	30384	202002	12.3	11.9	10.8	1.14	11.3	1.05	11.4	1.08	11.6	1.03
GNII30LLB	19103	202002	10.3	10.2	9.1	1.13	9.8	1.04	9.7	1.07	10.1	1.01
GNIIJUMBO	53321	202002	29.3	26.8	21.1	1.39	25.0	1.07	24.0	1.22	26.1	1.03
GNIIRH	12785	202002	8.8	9.6	8.4	1.04	10.1	0.94	9.4	0.94	10.7	0.89
GNIINY	3221	202002	12.0	11.3	11.0	1.09	13.1	0.87	12.3	0.98	13.5	0.84
GN30	115288	202002	12.9	13.6	12.7	1.02	13.9	0.98	13.0	0.99	13.8	0.99
FN15	339091	202002	12.7	12.6	11.9	1.07	12.5	1.01	11.8	1.08	12.5	1.01
FH15	232311	202002	12.8	12.8	12.0	1.06	12.7	1.00	12.0	1.06	12.7	1.01
GNII15	30519	202002	17.9	15.9	13.5	1.33	14.4	1.10	15.6	1.15	15.9	1.00
GN15	4651	202002	12.8	13.0	11.4	1.12	12.5	1.04	12.6	1.01	13.3	0.98
FN20	126199	202002	13.3	12.8	11.9	1.12	12.4	1.03	12.2	1.09	12.7	1.00
FH20	77703	202002	12.5	12.4	11.4	1.09	12.3	1.01	11.7	1.06	12.6	0.99
FN10	19146	202002	16.7	16.2	15.2	1.10	15.6	1.04	15.3	1.09	15.6	1.04
FH10	2873	202002	17.6	16.7	16.7	1.05	16.7	1.00	16.9	1.04	16.8	1.00
FN5X1L	12753	202002	26.0	28.4	23.6	1.10	27.8	1.02	24.9	1.05	28.7	0.99
FN7X1L	19486	202002	25.3	25.4	21.2	1.20	23.8	1.06	22.6	1.12	25.0	1.01
FNTX1L	7456	202002	20.4	19.7	16.6	1.23	18.1	1.09	18.1	1.13	19.3	1.02
FH5X1L	7931	202002	29.0	29.9	25.7	1.13	29.8	1.00	26.6	1.09	30.5	0.98
FH7X1L	16739	202002	25.1	24.6	21.6	1.16	23.5	1.04	22.9	1.10	24.5	1.00
FHTX1L	7006	202002	19.4	17.7	16.0	1.22	16.7	1.06	17.2	1.13	17.5	1.01
GN3X1T	6699	202002	30.2	29.8	23.9	1.26	28.3	1.05	25.4	1.19	29.7	1.00
GN5X1T	9501	202002	28.7	28.9	21.9	1.31	26.2	1.10	24.2	1.19	28.6	1.01

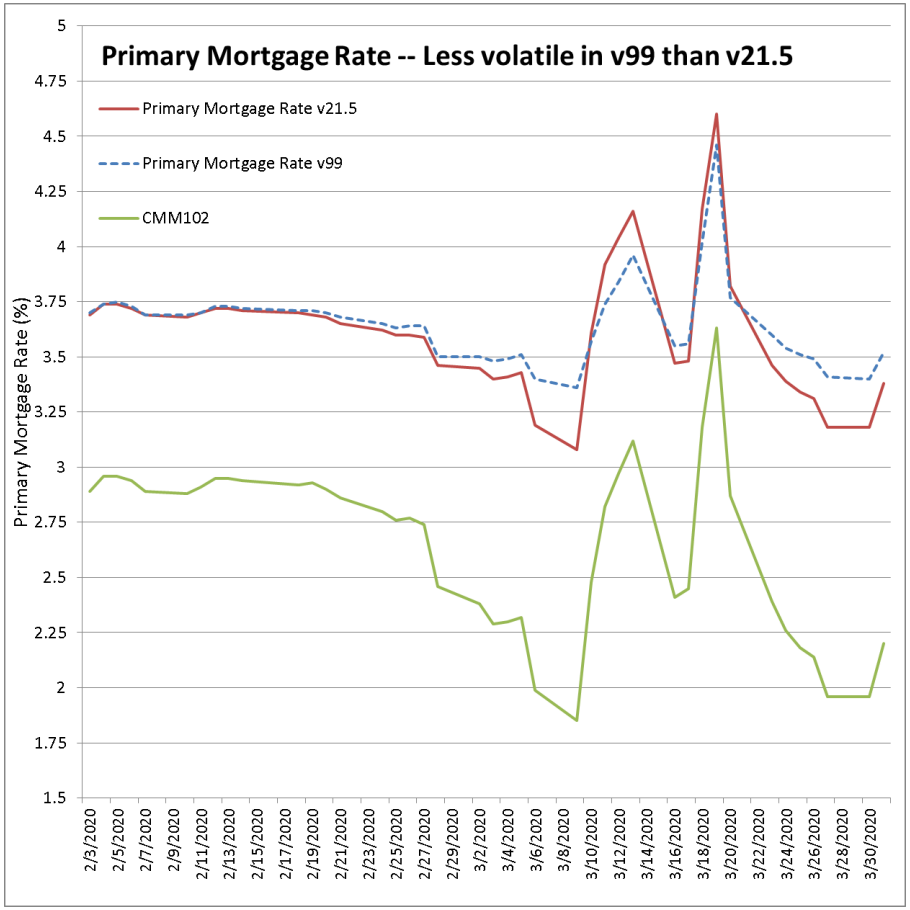
Model version 21.5 has generally projected slower speeds than actuals since it was released. It was particularly slow on GNMA IIs and several conventional spec categories.

Model version 99 actual to projected ratios are very close to 1.0 over the past 12 months for most sectors. But v99 has generally projected slower than actuals over the past three months, mostly driven by surprisingly strong February speeds.

Source: eMBS

P/S Spread More Sensitive to CMM102 Movement in v99



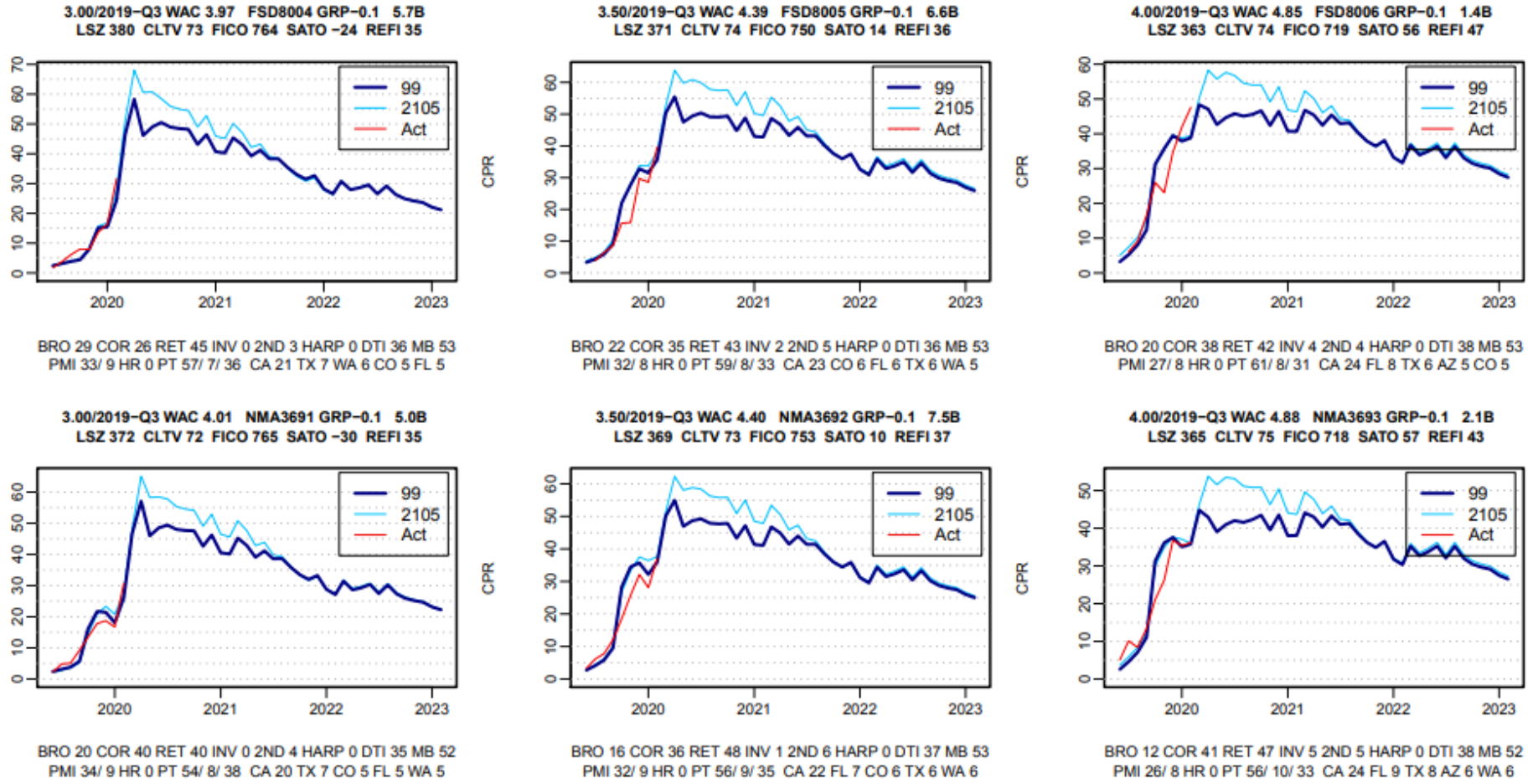


- **The P/S spread behavior in recent models is based on the 2012-2013 experience, when originators were better able to hold margin, but faced scrutiny when the spread was wide. Accordingly model v21.5 had limits on how much and how quickly the spread could rise or fall from elevated levels.**

- **The updated model removes these limits, as the current experience is evidently driven by much different factors, and there little to prevent the spread from reaching very wide levels at extremely low rates, or to collapse from these levels if the rally reverses and significant capacity frees up.**

Source: Citi

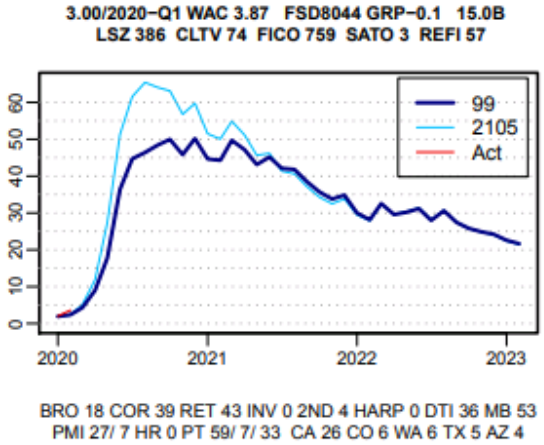
Initial Peak Ramps Lower on Newer FN Majors/FH MLGs…

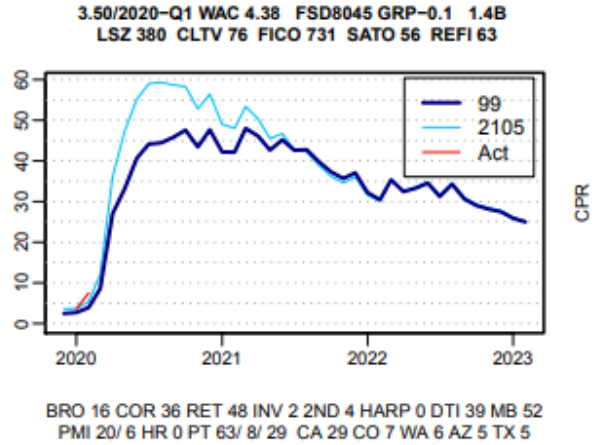


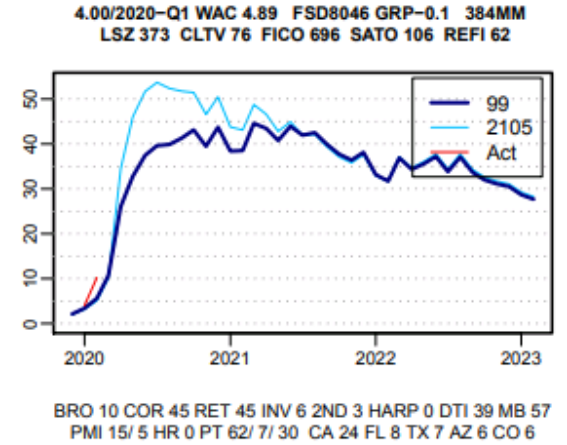
- **Model v21.5 materially increased speeds on new, high quality loans; automated underwriting efficiencies from Day One Certainty and LoanAdvisor (including PIW) have streamlined refinances.**
- **But initial ramps had become more restrained, particularly for lower coupons, even before COVID-19. The S-curve effect in v99 is less steep than in model v21.5, and is of course further restrained by the expected impact of the virus incorporated by v99.**

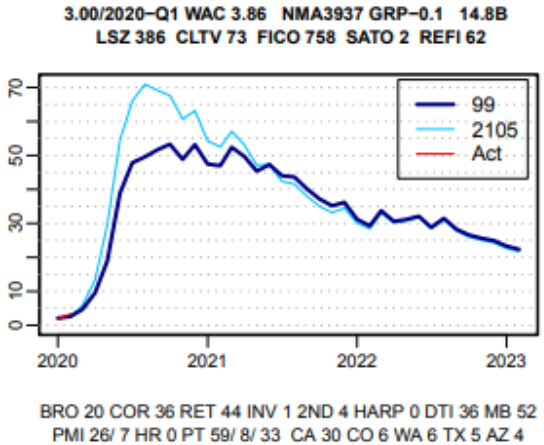
Source: eMBS

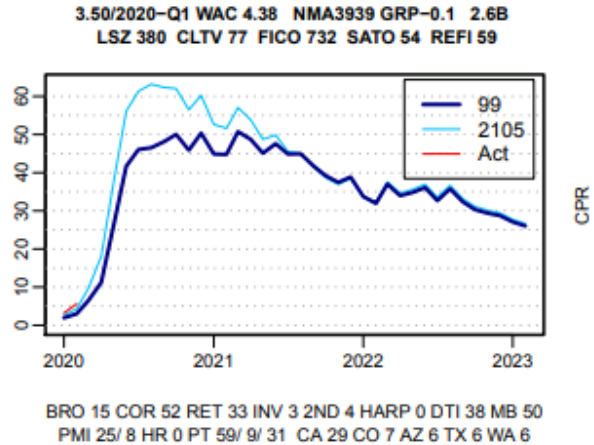
…Particularly on Those Peaking In the Midst of COVID-19…

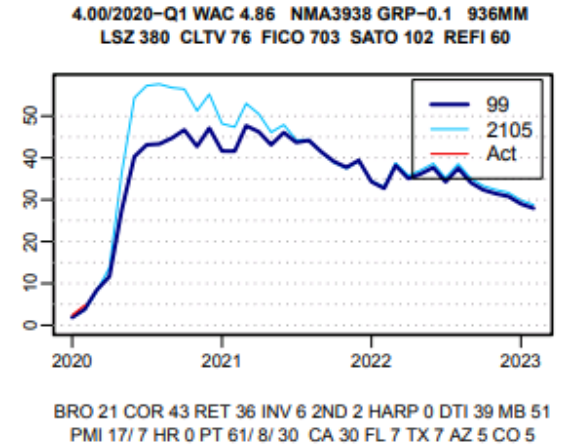








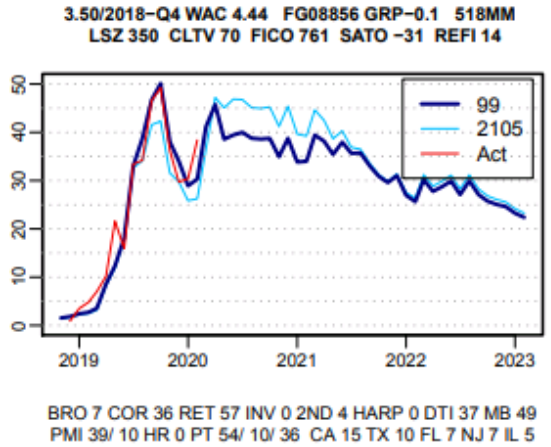


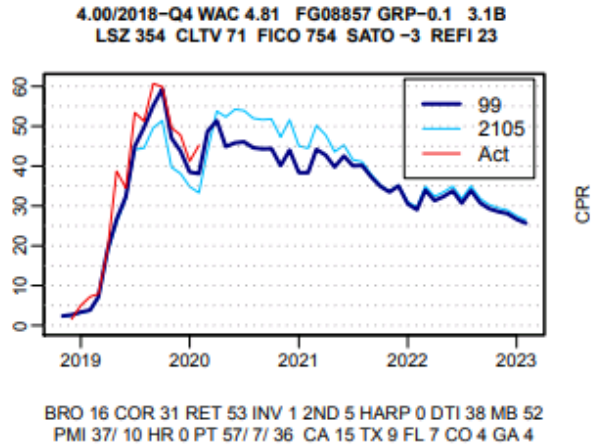


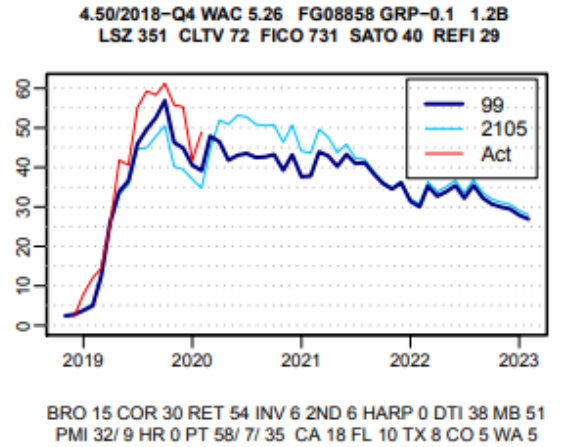
- **We expect refinances to be less affected by COVID-19 than turnover, as borrowers could greatly benefit from any available savings; there is also no new commitment to a large purchase, and social distancing can be maintained more easily than while finding and/or occupying a new home.**
- **But refinances will nevertheless be affected by originator capacity constraints, as well as delays and disruptions in many aspects of the application, underwriting and closing process.**

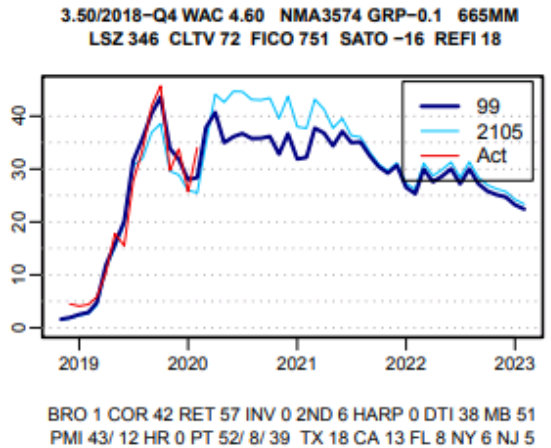
Source: eMBS

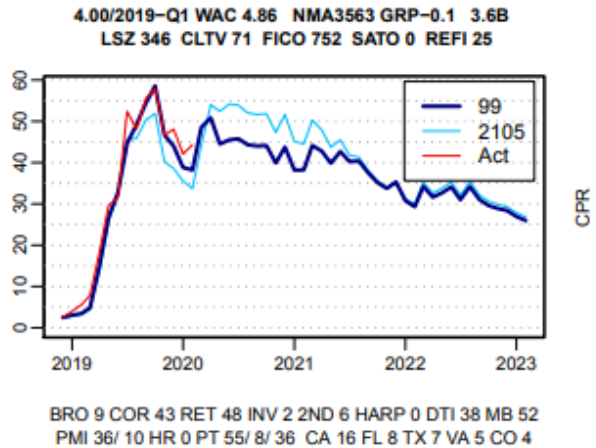
…but Peaks Extended and PIW/Media Effect Recalibrated

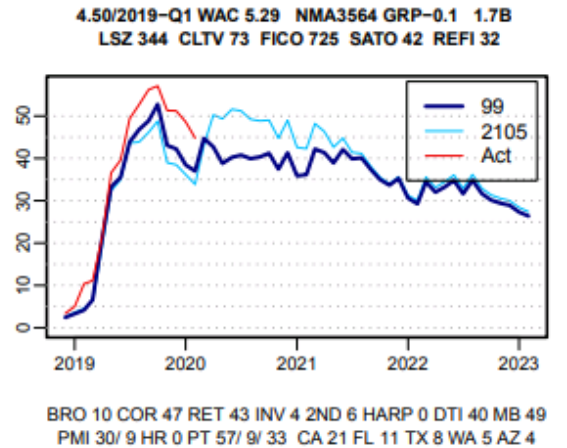








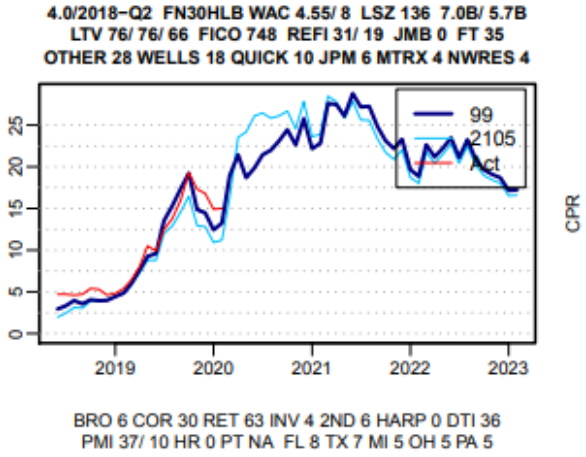


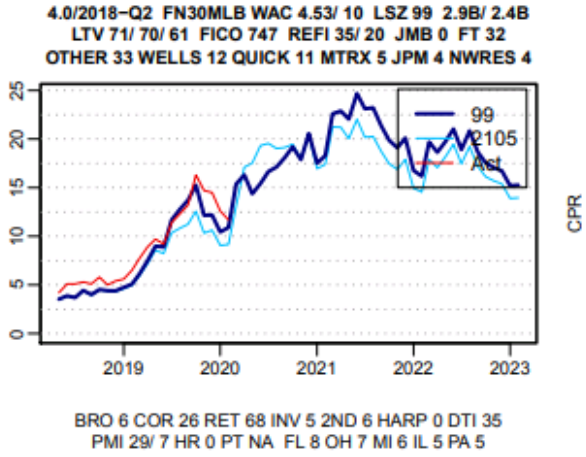


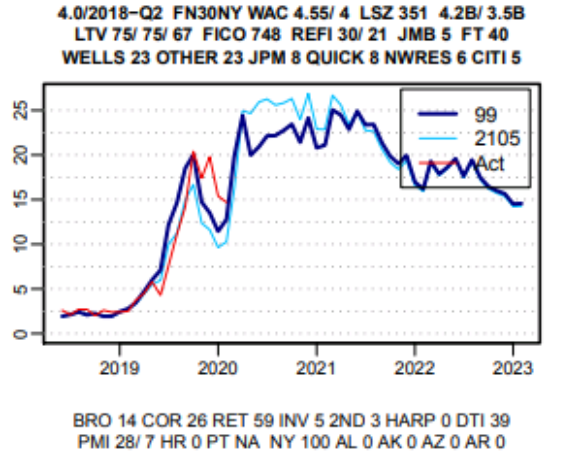
- **PIW-driven peak speeds seem to have persisted longer than v21.5 suggested, and the ramp has therefore been extended in model v99.**
- **Both PIW effect and media effect have been recalibrated to better match peak speeds on pools like these, but at the same time reduce their compounded impact on the cuspiest collateral with more modest incentives, such as 2.5s and 3s in the current rate environment.**

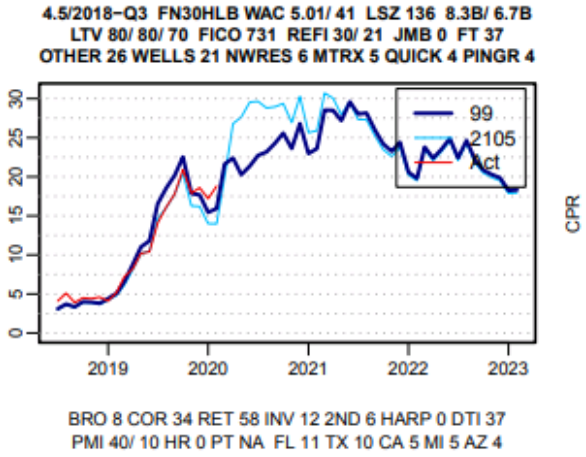
Source: eMBS

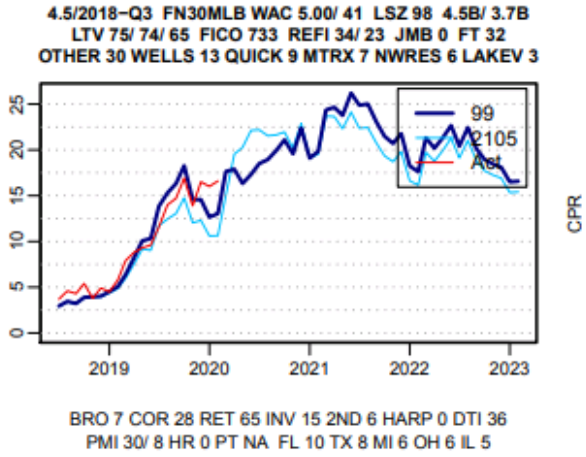
Conventional NY and Loan Balance Faster ex-COVID-19

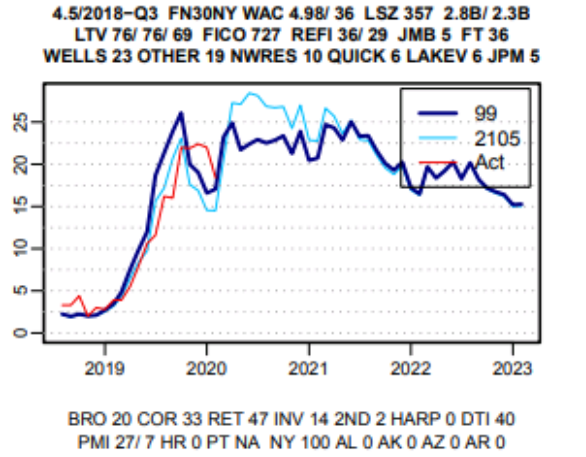








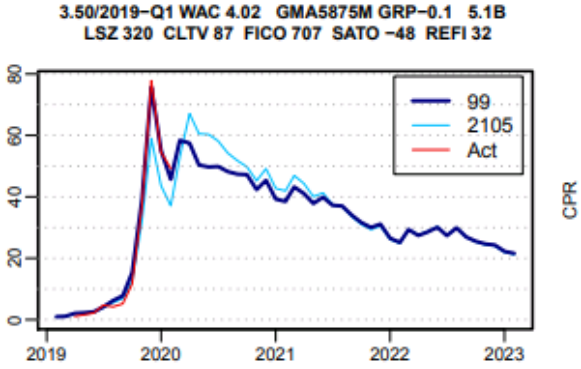


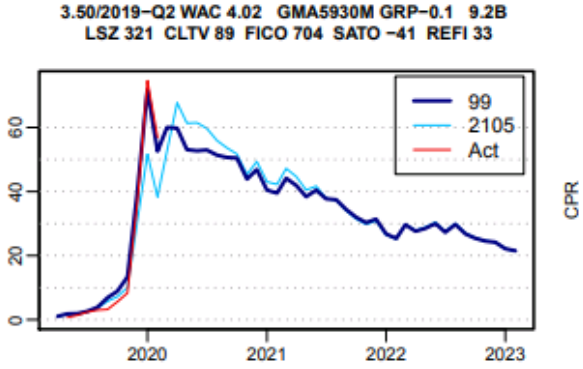


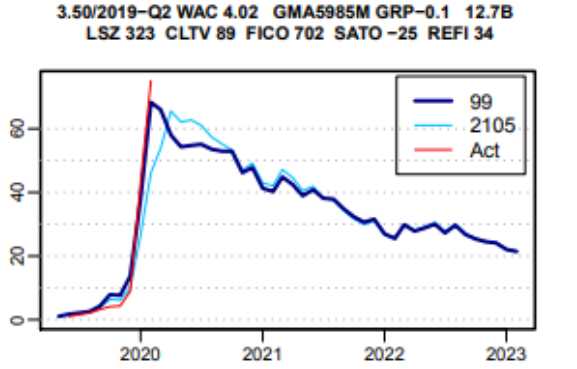
- **Speeds on key conventional specified pool sectors picked up as the rally matured and rates stabilized; while modestly extended lags on this collateral during a sharp rally are normal, the degree to which it occurred in late 2019/early 2020 was very significant.**
- **This may have occurred due to the initial emergence of UMBS and widespread PIW. The lagged response is not as evident on cohorts from 2019, or during rallies between 2010 and 2016.**

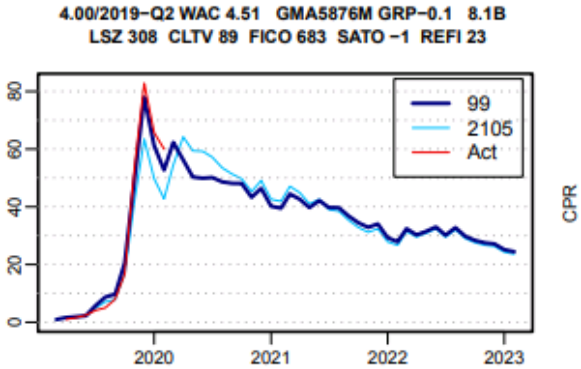
Source: eMBS

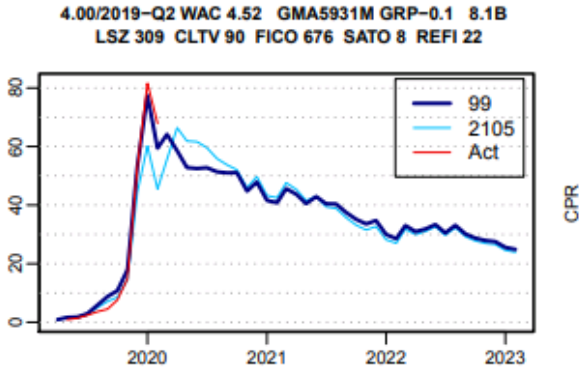
GNMA II Multi Pools Better Match Actuals at Peak in v99

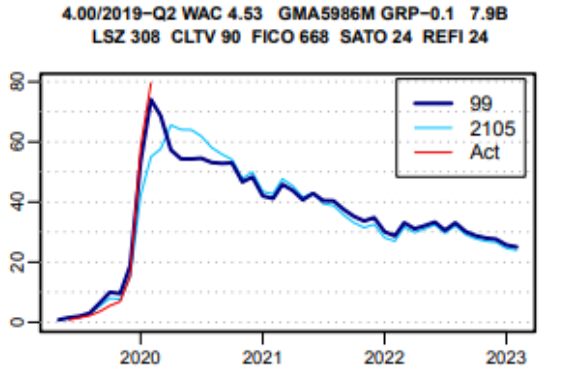








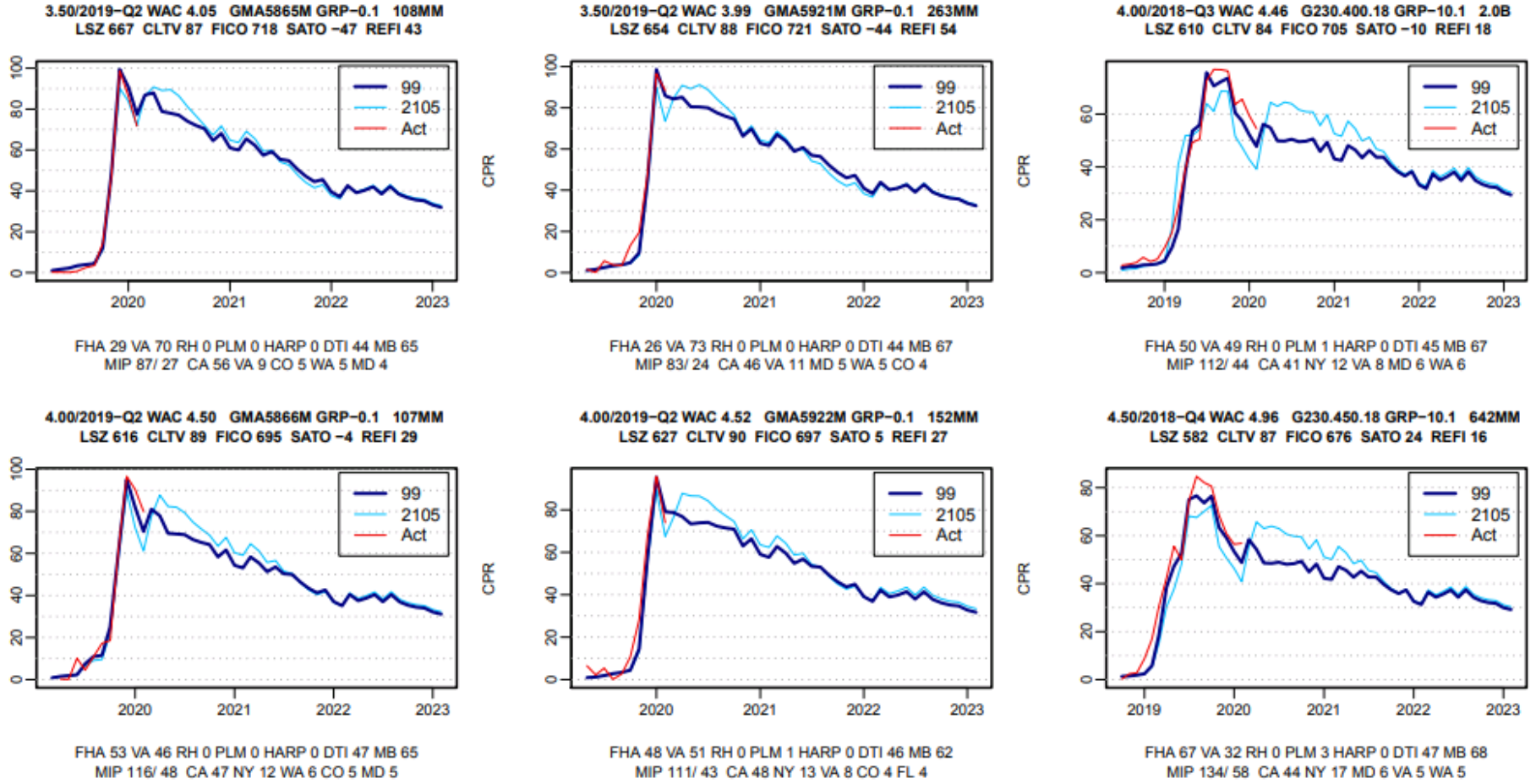




- **Model v21.5 failed to reach the ~80 CPR levels at which many pools printed at their peak, driven by increasingly extreme VA speeds and a recent uptick in FHA speeds.**
- **It has been an ongoing challenge to project peak speeds on GNMA pools. Model v99 has a recalibrated ramp that results in significant improvements, but some pools have still printed faster than model v99.**

Source: eMBS

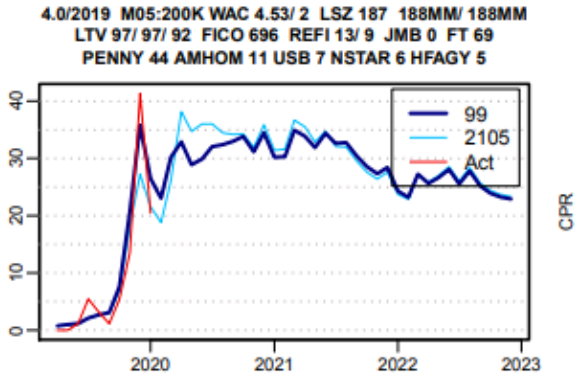
Model v99 Captures Extreme GNMA II New Jumbo Speeds

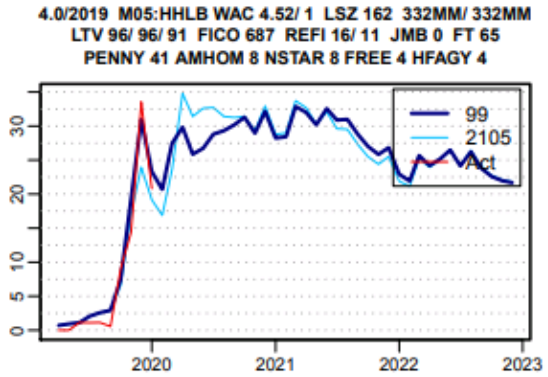


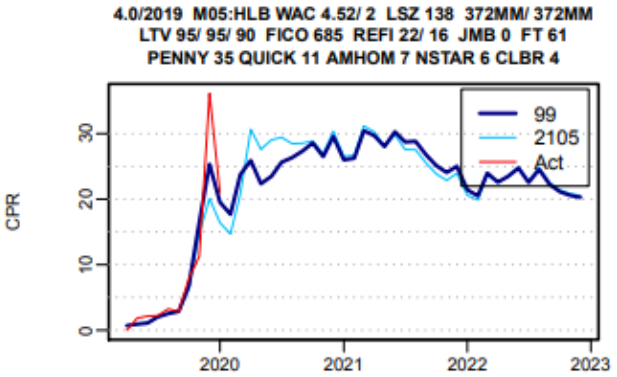
- **Peak ramp speeds on MJMs have been in the very high 90s (meaning about a quarter to a third of the loans pay off in the peak month), with persistent very high speeds for subsequent months.**
- **Peak projection of around 90 CPR appears relatively close, but is actually around 17.5% SMM, well below the 25%-35% SMM actuals and resulting in a substantial projected factor difference. Model v99 is able to reach the high 90s seen on this collateral pre-COVID-19.**

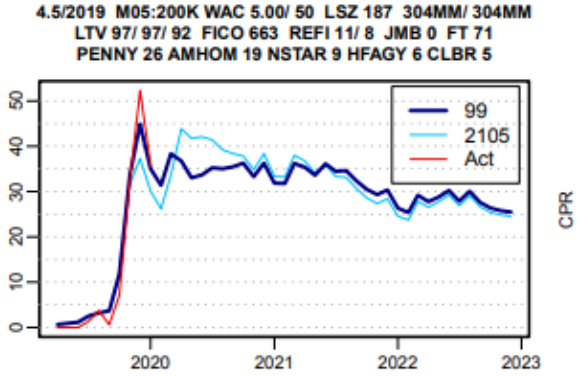
Source: eMBS

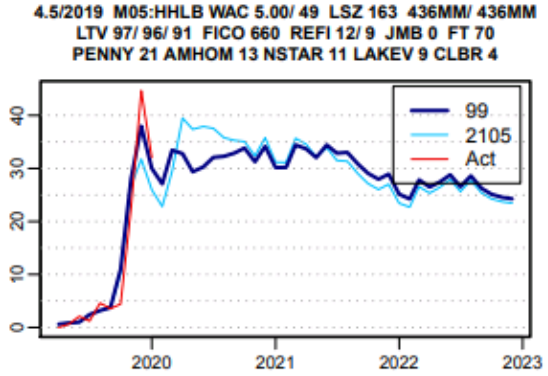
GNMA II Custom LB Ramps Stronger in Model v99

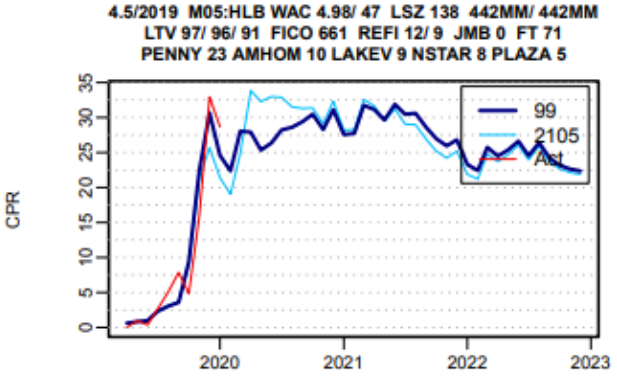








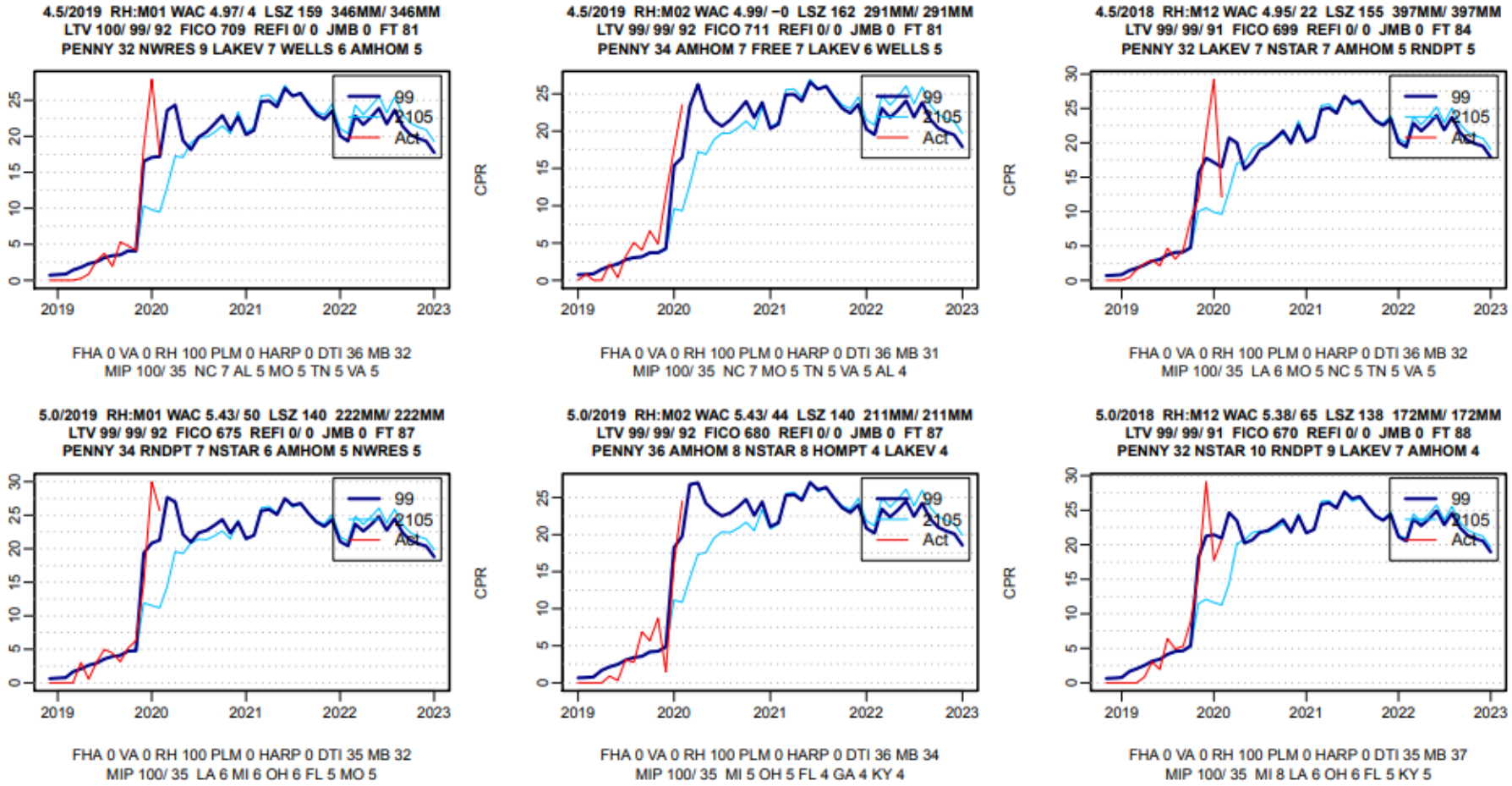




- **Peak speeds on loans in GNMA II custom loan balance pools (loans originated in May 2019 are shown above) have recently outpaced model v21.5.**
- **The VA fractions of these cohorts, while a relatively modest portion, have an outsized effect on peak custom loan balance pool speeds. VA speeds on HLB and higher loan sizes have been peaking at 60-70 CPR during the past few months.**

Source: eMBS

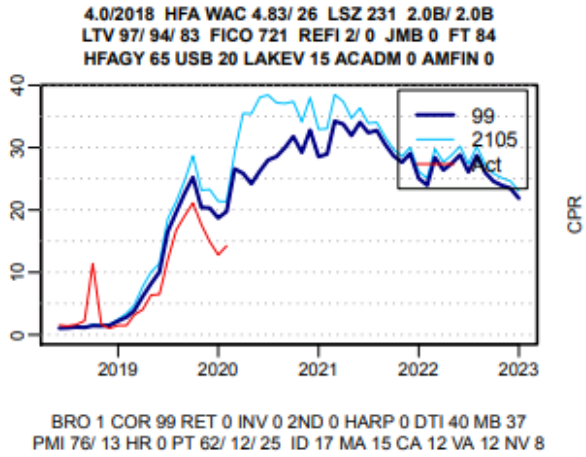
Newly Evident G2 Custom RH Ramps Captured by v99

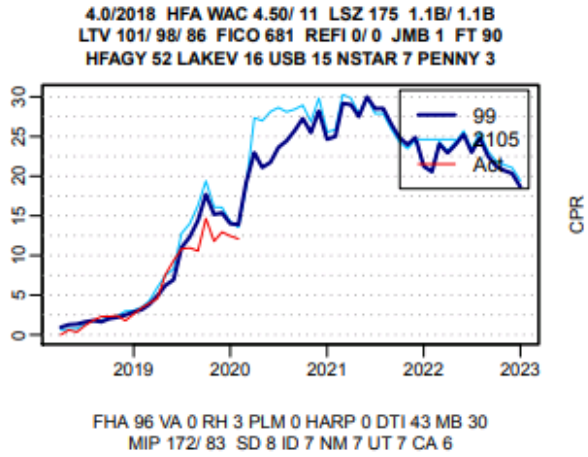


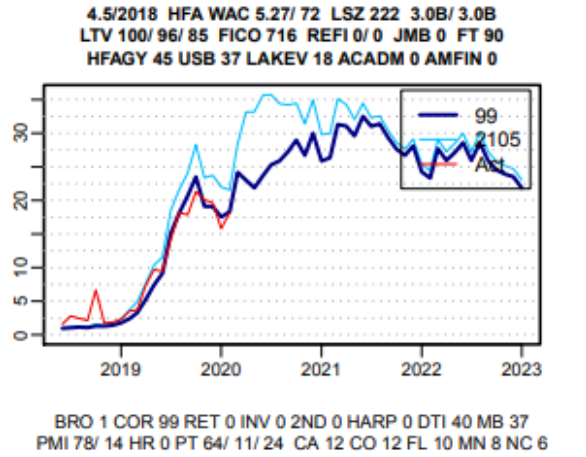
- **Shown above are RH loans in GNMA custom pools originated in Jan/Feb 2019 and Dec 2018.**
- **Recent evidence shows more responsive RH collateral after 12 months of seasoning. Note that streamlined refinances on RH loans generally require 12 timely payments prior to the refinance.**
- **The behavior change may be driven by the RHS Streamline Assist Refinance Program that became effective in 2016, as well as the recent dominance of non-banks in RH servicing that was previously dominated by Chase.**

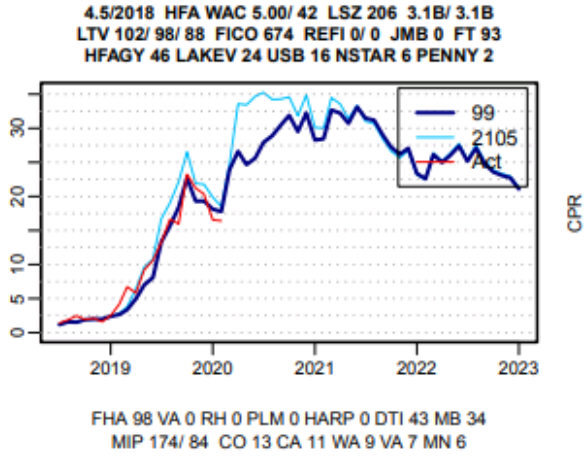
Source: eMBS

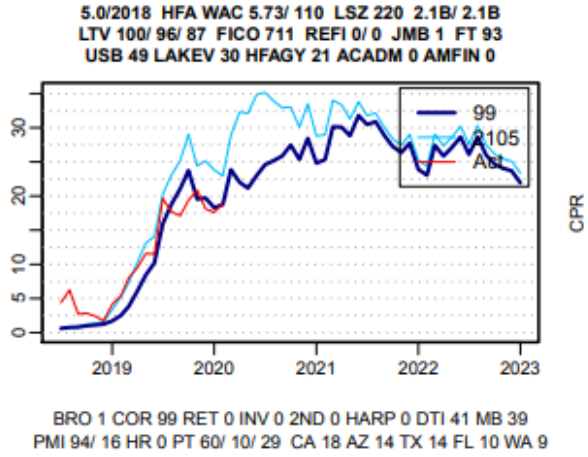
HFA Projections Slowed Further in Model Version v99

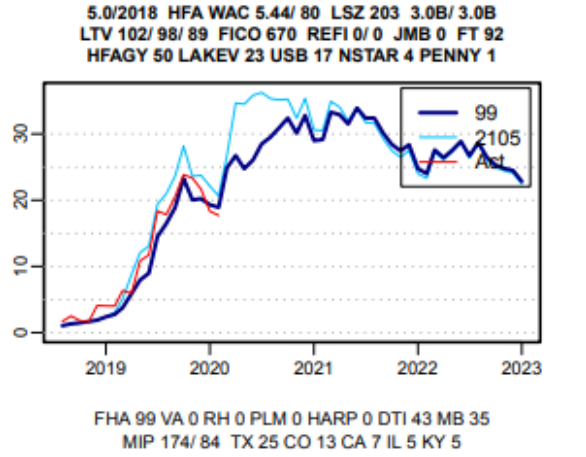








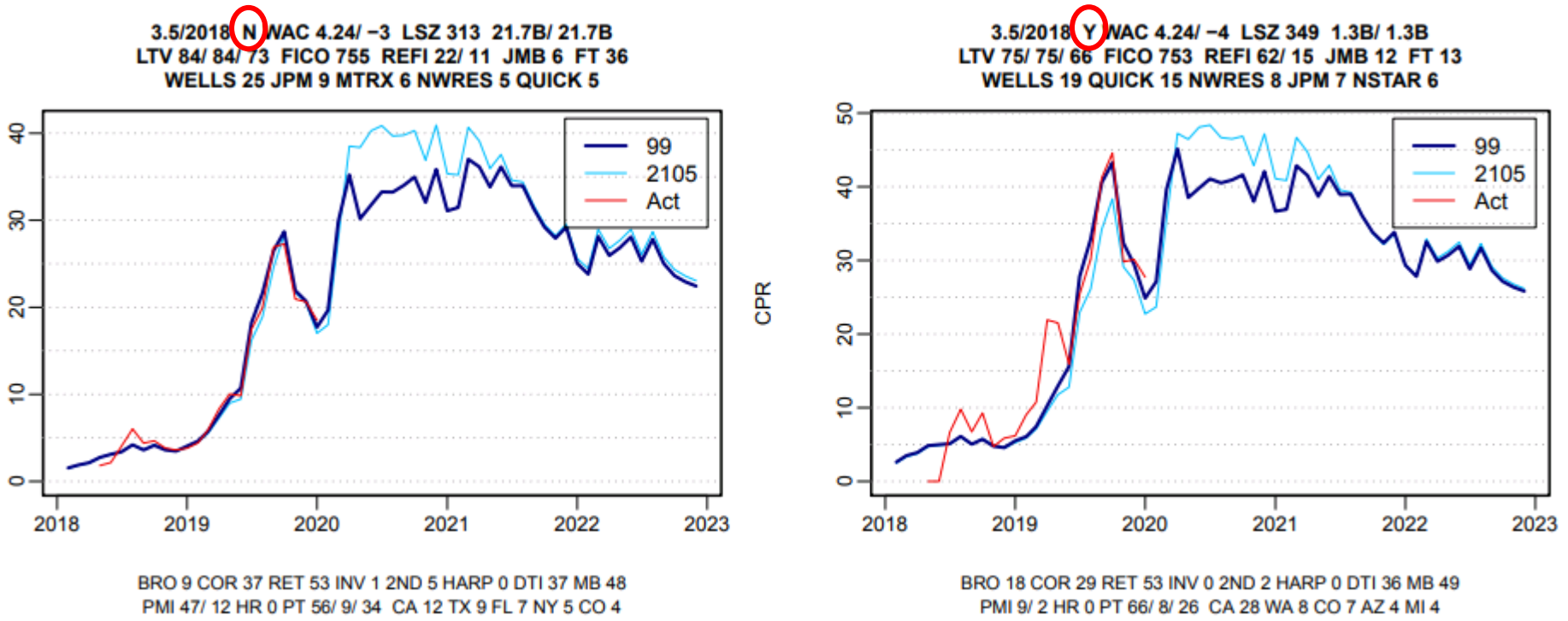




- **Shown above are 2018 HFA loans in FNMA and GNMA II custom pools for large coupon cohorts. Despite material downward adjustments in model version 21.5, actual speeds have remained below projections and therefore have been slowed further in v99.**
- **FHA HFA borrowers may be particularly vulnerable to COVID-19 related delinquency; buyout timing is uncertain, but should become at least a partial offset to voluntary prepayment slowdown.**

Source: eMBS

Model v99 Incorporates Recent GSE PIW Disclosures



- **Above are actual and projected prepayments from CAS transaction loans originated in 2018 with WACs ranging from 4 to 4.5, comparing loans that did not receive a PIW (N) versus those that did (Y).**
- **In model version 21.5, we assume that the impact of PIW is driven by the likelihood of a waiver (and other benefits of automated underwriting) on the refinance, based on loan attributes such as loan age, LTV, occupancy, loan size, and credit score, as opposed to whether PIW applied to the original loan.**
- **This assumption and the typical adjustments by servicer, channel, and other key attributes capture most of the CPR differences between loans that previously received a PIW vs. loans that did not. However, the new data still provide some predictive value, seeming to account for about 3-7 CPR, and have been incorporated into model version 99.**

Source: Fannie Mae

Model v99 Considers a Recession in Stochastic Analysis

HPA Scenarios

Months	Base	Down	Up	Average
1 - 12	0.0%	-10.0%	0.0%	-2.5%
13 - 24	3.0%	-1.0%	7.0%	3.0%
25 - 36	3.0%	3.0%	3.0%	3.0%
37 - 48	3.0%	3.0%	3.0%	3.0%
48 - 60	3.0%	3.0%	3.0%	3.0%

Unemployment Scenarios

Months	Base	Down	Up	Average
1 - 12	7.0%	15.0%	5.0%	8.5%
13 - 24	5.5%	8.5%	4.5%	6.0%
25 - 36	4.4%	5.4%	3.9%	4.5%
37 - 48	4.1%	4.1%	4.1%	4.1%
48 - 60	4.1%	4.1%	4.1%	4.1%

The most severe extension risk in mortgages would be expected to occur in recessionary scenarios when unemployment increases and HPA declines, and when (1) rates are not low enough to trigger a refi wave and/or (2) HPA does not decline enough to trigger widespread use of HLRO.

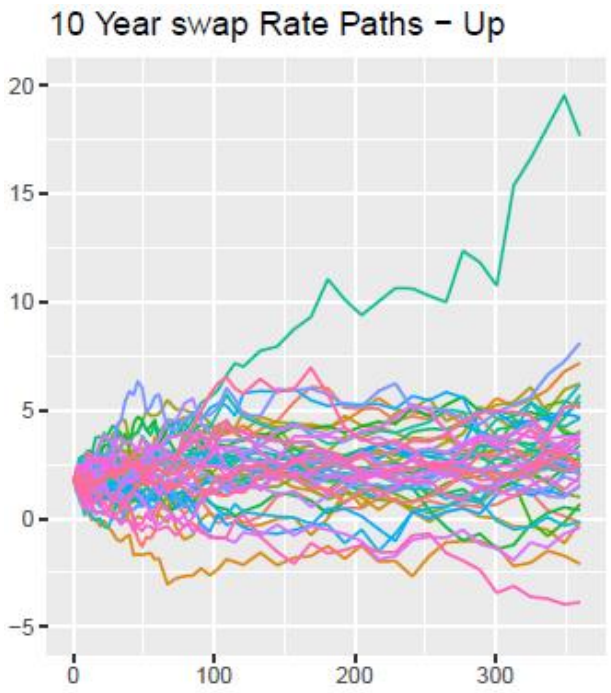
The production model (v21.5) does not capture such scenarios due to benign HPA and unemployment projections.

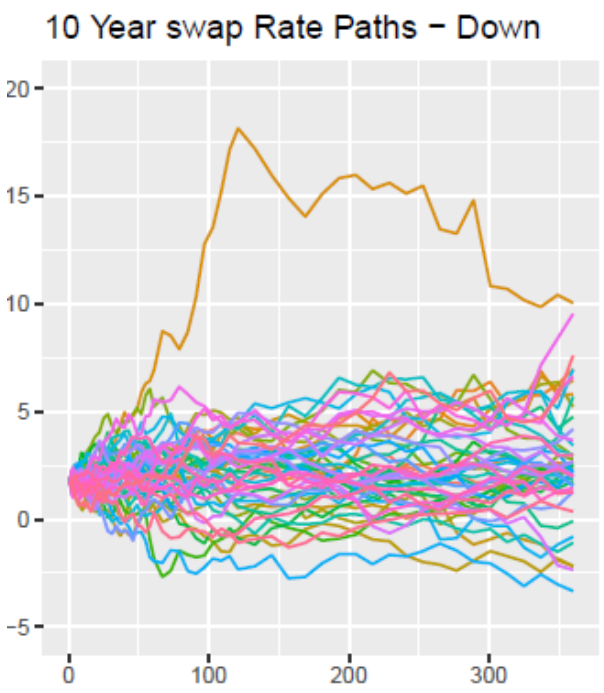
- The weightings have been set to 25% down, 25% up, and 50% base across the 200 rate paths. In effect, we are attempting to represent the worst 25% of outcomes, the middle 50% of outcomes, and the best 25% of outcomes. The blended HPI assumption is below the base case HPI assumption by about 2.5% over a period of 3 years, reflecting the view of Robert Young and others of modest overvaluation of the housing market before the COVID-19 crisis.

- OAS and durations are higher for most MBS if we use these scenarios, reflecting materially reduced cashouts, turnover, and non-streamlined rate refis in the downside HPA/unemployment scenario, partially offset by HLRO streamlined refinances in certain cases and a modest impact from the upside scenario.

- If specific HPA and/or unemployment scenarios are specified on The Yield Book, they will be used on all paths. Thus the multi-scenario feature is disabled by setting the scenarios to our base-case assumptions.

Path-wise HPA and Unemployment Scenario Assignment





- The objective is to assign down, base, and up HPA/unemployment scenarios across the 200 rate paths, such that the rate clouds are largely consistent across the three sets.
- This eliminates any assumed correlation between rates and unemployment. We believe there is little justification for assuming significant correlation. Recessionary scenarios have been associated with both high rate regimes (late 1970s/early 1980s) and low rate regimes (post crisis period following late 2008 housing collapse).
- As shown above, rate clouds for the three sets (shown as of 11/13/2019) are very similar (note that the base case has twice the density of the up and down cases, by design).

Path-wise HPA/Unemployment Scenario Assignment Method

Averages and quartiles of 10-year swap rate at different time points (as of 11/13/2019)

	Mean				25% Quartile				75% Quartile			
Term	Base	Up	Down	Max diff	Base	Up	Down	Max diff	Base	Up	Down	Max diff
12	1.84	1.80	1.82	0.03	1.47	1.32	1.54	0.22	2.25	2.35	2.13	0.22
24	1.89	1.92	1.94	0.03	1.16	1.29	1.23	0.12	2.55	2.55	2.60	0.05
36	2.01	1.94	2.02	0.08	1.35	1.13	1.38	0.25	2.84	2.58	2.60	0.26
60	2.17	2.15	2.14	0.03	1.27	1.22	1.38	0.16	3.03	3.08	2.90	0.18
84	2.29	2.33	2.29	0.05	1.11	1.17	1.26	0.09	3.38	3.67	3.41	0.28
120	2.51	2.49	2.47	0.02	1.25	1.49	1.16	0.33	3.39	3.64	3.34	0.30

Pool pricing using base HPA/unemployment scenario on each set of paths (as of 11/13/2019)

NMA3834 (3% Nov Major)	base (100 paths)	down (50 paths)	up (50 paths)
Average Price	101.11	101.34	101.58
Standard Deviation of Price	5.3	6.0	3.5

- The objective is to assign down, base, and up HPA/unemployment scenarios across the 200 rate paths, such that the rate clouds are largely consistent across the three sets.
- The method we employed was to perform thousands of iterations in order to converge to the closest match for average and 25% and 75% quartiles of 10-year swap rates (the closest proxy to 30-year mortgage rates) across multiple time points; averages turn out within about 5 bps and quartiles within about 25 bps.
- A typical TBA deliverable pool also priced within half a point across the three sets of paths, a far smaller variation than the standard deviations of prices across the paths.

Glossary of Model Changes from v21.5 to v99

* P/S spread model adjusted to increase widening in extreme rate rallies (i.e., if CMM102 more than 1 point below recent average)
* P/S spread model also adjusted to revert more quickly to baseline if rates back up and reverse a rally
* P/S spread baseline increased by 20 bps in light of unique conditions brought on by COVID-19, amortizing back to normal by 2021
* Turnover assumed 25-30% below normal in Q2/Q3 2020 due to COVID-19, with recovery by year end and modest pent-up demand in 2021
* Cashouts down 10-15% from COVID-19 since no temporary appraisal flexibilities generally apply; ultimately rebound like turnover
* COVID-19 impact on turnover/cashouts mentioned above is on top of impact from HPA/unemployment changes
* Stronger impact of capacity constraints on impaired collateral in Q2/Q3 2020, also due to COVID-19, and also normalizing by 2021
* Initial PIW-driven conventional ramp slightly weaker, but peak speeds persist over a longer period
* The propensity of the GSEs to grant PIWs is now a function of HPA; PIWs assumed less likely a down housing market
* Incorporate fraction of loans with PIW (disclosure provided by GSEs in March) as a driver of future refinancings
* Both PIW effect and media effect have been re-parameterized to reduce extreme rally speeds on cuspy collateral
* Lock-in is assumed to be stronger for a given disincentive level if rates back up to levels not seen in a long time
* Recalibration across collateral sectors and attributes, primarily based on v21.5 out-of-sample-performance (from Sep 2019)
* Conventional low loan balance, NY, and CR/U9 collateral projections somewhat higher (ex-COVID-19)
* GNMA II multi pool, jumbo and loan balance peak speeds are higher, particularly for the VA portion, all else being equal
* GNMA RHS premium coupon projections ramp up more sharply after 12 months of seasoning
* Historical FHFA purchase only HPA updated thru Q4 2019; base case projection 0% for 2020 due to COVID-19; 3% for 2021 and beyond
* Unemployment projected to quickly rise to 7.5% driven by COVID-19, gradually falling by 2022 to Fed long-term projection of 4.1%
* Introduce downside (average of worst 25% outcomes) and upside (average of best 25% outcomes) HPA and unemployment assumptions
* Downside HPA assumption (incremental relative to base): -10% 1st year, -4% 2nd year, 0% thereafter
* Upside HPA assumption (incremental relative to base): +0% year 1, +4% year 2, 0% thereafter
* Downside unemployment assumption (incremental relative to base): +8% year 1, +3% year 2, +1% year 3, 0% thereafter
* Upside unemployment assumption (incremental relative to base): -2% year 1, -1% year 2, -0.5% year 3, 0% thereafter
* Rate paths divided into three groups (25% for downside, 50% for upside, 25% for base) to run the three HPA/unemployment scenarios
* Rate paths are assigned to the three groups in a manner designed to minimize correlation between rates and HPA/unemployment

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