Figure 1. FNMA Mortgage Level Counts by Origination PaymentBehaviorSeg and VantageScore 3.0 Bucket, for Origination Years 2016-2019

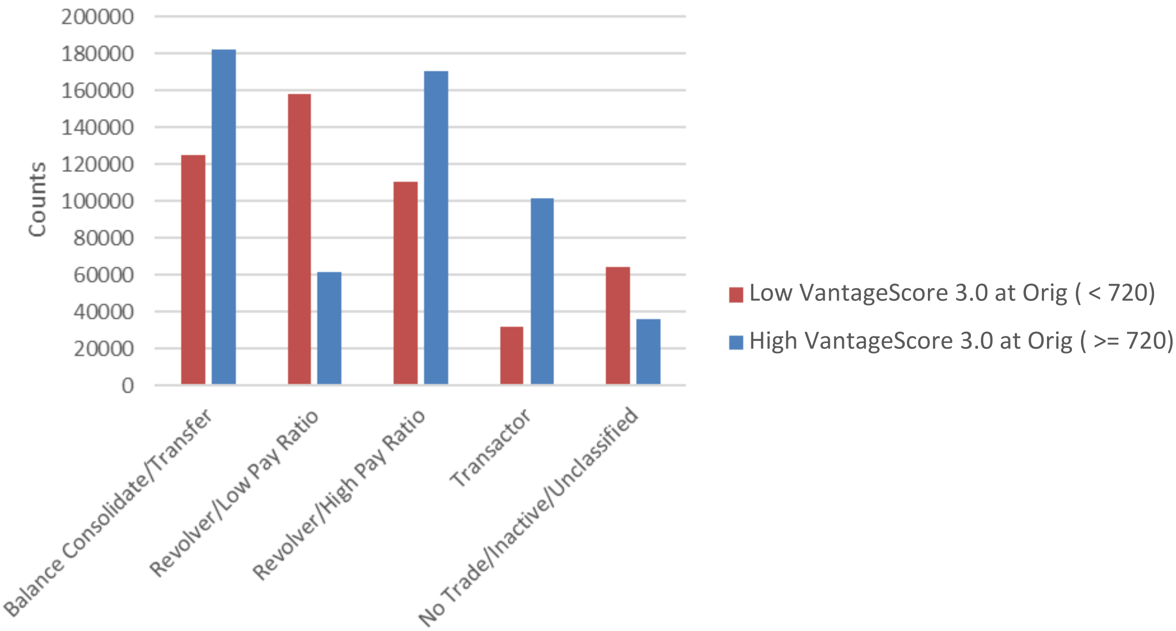

Figure 1. Mortgage Level Counts within our FNMA sample for the four main PaymentBehaviorSeg groups, by Credit Bucket (Low vs. High).

PaymentBehaviorSeg at Origination and its Effect on Delinquencies

Figure 2 below illustrates our first key finding: the PaymentBehaviorSeg attribute increases accuracy in predicting CtoD rates among certain consumer segments when holding credit scores fixed. Each graph in Figure 2 displays CtoD rates for the Balance Consolidate/Transfer segment (in blue), Revolvers with low payment ratios (orange), Revolvers with high payment ratios (green), Transactors (purple), and average over *all* segments (red), while controlling for 20-point VantageScore 3.0 bins (labeled by midpoint) along the X-axis. The charts on the left use a standard Y-axis scale; note that for all mortgage product types (FNMA at the top, VA in the middle, and FHA below), the green curve typically lies above average, and the blue curve below. To demonstrate the magnitude of this effect within the higher credit score bins where the curves appear to merge, the charts on the right use a log scale wherein each Y-axis grid line corresponds to a doubling of the CtoD rate. Since the credit score itself is a logged representation of delinquency rates, this is a natural representation. Here, we can see that the CtoD rate for FNMA consumers in the Balance Consolidate/Transfer group is below average at a roughly similar rate for all credit scores, while the High Paying Revolvers are worse in the lower credit bins than in the higher bins. The trends are similar for VA and FHA consumers.

Figure 2. Current to Delinquent (CtoD) Transition Rate by PaymentBehaviorSeg at Origination, Controlling for Origination Credit Score (VantageScore 3.0)

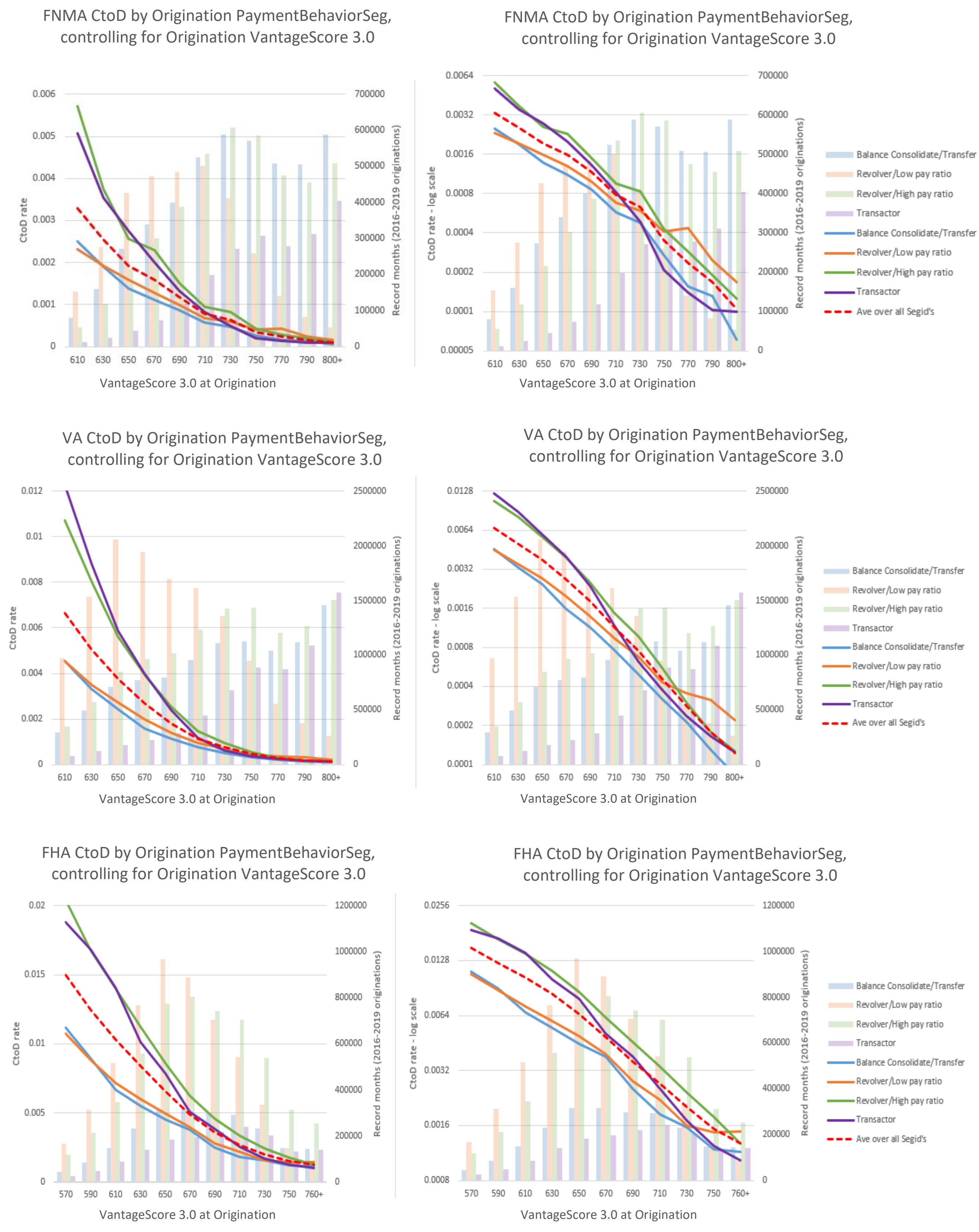

Figure 2. The charts on the left use a standard scale, while those on the right demonstrate the trend on a logarithmic scale, wherein each Y-axis gridline represents doubling of the CtoD rate. Vertical bars illustrate the number of record months for each.

Table 2 below summarizes and quantifies the results found in the graphs above, for two PaymentBehaviorSeg groups (Balance Consolidate/Transfer and High Paying Revolver) and two broad credit buckets: “Low” includes origination VantageScore 3.0 scores between 600 and 699 for FNMA/VA loans and 560–659 for FHA loans, while “High” covers 720–799 for FNMA/VA loans and 680–759 for FHA loans. For each of these credit buckets and loan types, we display the approximate factor by which the CtoD rate for the given PaymentBehaviorSeg group compares to the average within their 20-point VantageScore 3.0 bin. For example, FNMA mortgage consumers in the Low credit bucket had about a 39% higher than average CtoD rate for their 20-point VantageScore 3.0 bin if they were Revolvers with High Pay Ratios at origination; meanwhile, if they were characterized as having Balance Consolidate/Transfer activity then their CtoD rate was 27% lower than average. Overall, within the low credit bucket, the High Pay Ratio Revolvers went delinquent at nearly twice the rate as those who had balance consolidation/transfer activity at origination.

Table 2. Approximate CtoD Multipliers vs. VantageScore 3.0 Bin Average for two PaymentBehaviorSeg Groups

Approximate CtoD factors by two PaymentBehaviorSeg groups at origination, compared with average CtoD within 20-point VantageScore 3.0 bin

	Low credit (FNMA/VA 600–699, FHA 560–659)		High credit (FNMA/VA 720–799, FHA 680–759)	
	Balance Consolidate/Transfer	**Revolver w/High Pay Ratio**	**Balance Consolidate/Transfer**	**Revolver w/High Pay Ratio**
FNMA	0.73	1.39	0.74	1.23
FHA	0.68	1.34	0.72	1.24
VA	0.63	1.50	0.71	1.15

Note that Table 2 does not include the Transactor or Low Pay Ratio Revolver segments, although we can visually examine their CtoD curves in Figure 2. A reasonable hypothesis regarding the CtoD transition might have been that consumers who were Transactors at time of origination have a lower delinquency rate than those who were Revolvers, and moreover, the Revolvers with High Pay Ratios have a lower delinquency rate than those with lower payment ratios. Intuition tells us that Low Pay Ratio Revolvers may be financially stretched and have less flexibility and ability to make their payments when economic circumstances change for the worse. However, in Figure 2, we see that especially among the lower credit score consumers, this reasoning doesn’t bear out: in fact, the CtoD rate for Transactors and High Paying Revolvers is higher than that of Low Paying Revolvers for these consumers. As credit scores increase, the difference between these segments decreases until eventually, around credit scores of 720–730, the curves cross: the CtoD rate for Low Paying Revolvers becomes noticeably higher than that of Transactors, with High Paying Revolvers ultimately lying in between. These observations hold for all three loan types, although the details differ; one implication may be that low credit score revolvers have more experience with managing debt loads and uncertain timing of income and expenses, compared with higher credit score consumers

Figure 2’s solid vertical bars display the total count of “record months” in each VantageScore 3.0/PaymentBehaviorSeg category (i.e., how many data points were available for the calculation of CtoD rate). Despite a clear correlation between PaymentBehaviorSeg and VantageScore 3.0 score, there is enough variation within each VantageScore 3.0 bin to gain a meaningful lift by PaymentBehaviorSeg. That being said, we would first want to conduct further research on the low credit score consumers to fully explain the CtoD trends for

Transactors and Low Pay Ratio Revolvers. Our second key finding, discussed in the next section, is a step in the right direction.

Current PaymentBehaviorSeg and CtoD

For our sample of FNMA mortgages, in addition to collecting several consumer trended 3D attributes at time of loan origination, we also attached the current value of these fields for each month during the two-year period 2018/01–2020/01. Thus, when we refer to a consumer's "current" PaymentBehaviorSeg, we are referring to the real time PaymentBehaviorSeg for the month just before a potential transition may have occurred (i.e., the "C" month for CtoD and CtoT transitions). Given that a consumer is "now" within a given segment and is current on payments, what is the probability of a prepayment or of going delinquent from this month to the next?

Figure 3 below displays the CtoD rates by current PaymentBehaviorSeg, on a log scale and still controlling for the VantageScore 3.0 score at origination. It is not surprising that the *current* PaymentBehaviorSeg provides valuable information above and beyond the credit score at origination since time has passed, and the VantageScore 3.0 score at origination has possibly become stale. As before, the Balance Consolidate/Transfer group has a relatively low delinquency rate across all VantageScore 3.0 scores. Now, however, we observe the behavior we may have expected to see earlier: the Low Pay Ratio Revolvers are delinquent at higher rates than the other segments, across *all* VantageScore 3.0 scores. This is our second key finding: that being a *current* Revolver with a low payment ratio is highly predictive of going delinquent in the subsequent month.

Figure 3. FNMA CtoD by Current PaymentBehaviorSeg, Controlling for Origination VantageScore 3.0

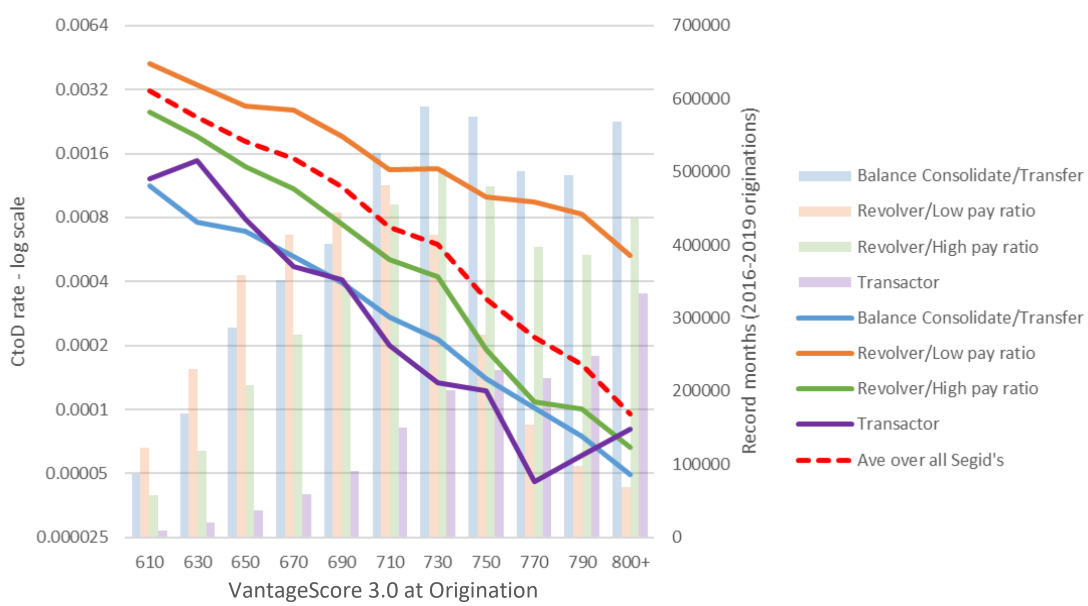

Figure 3. FNMA CtoD transition rate (on a Logarithmic scale) by Current PaymentBehaviorSeg, controlling for Origination VantageScore 3.0 Score; vertical bars illustrate the number of record months for each PaymentBehaviorSeg within each VantageScore 3.0 bin.

This result led us to examine the relationship between a consumer's current PaymentBehaviorSeg and the PaymentBehaviorSeg at origination, in predicting delinquency rates. Consumers move between different PaymentBehaviorSeg classifications over time, and becoming a Low Pay Ratio Revolver sometime after origination is a particularly strong predictor for becoming delinquent. Figure 4 displays the CtoD rate by current PaymentBehaviorSeg, conditional on the origination PaymentBehaviorSeg (along the X-axis), for consumers in the low origination VantageScore 3.0 bucket (< 720); Table 2 displays the matrix of values behind this chart. The very worst delinquency rates are among consumers who were Transactors or High Pay Ratio Revolvers at origination but later became Low Pay Ratio Revolvers. Specifically, looking at the orange bars (the CtoD rates for current Low Pay Ratio Revolvers), we see that High Pay Ratio Revolvers at origination who later became Low Pay Ratio Revolvers have more than twice the CtoD rate as those who were Low Pay Ratio Revolvers and remained low; for those who started as Transactors and became Low Pay Ratio Revolvers, the increase in delinquency is even worse. It seems that among the lower credit score bins, being a Low Pay Ratio Revolver at origination may indicate some resilience and experience managing debt: transitioning to another group later is associated with improved performance and possibly indicates an improvement in circumstances, but starting in any other group and transitioning to Revolver status may indicate a decline in circumstances that is difficult to overcome. These consumers may have experienced a severe setback, or they may simply be unaccustomed to managing unstable incomes or expenses.

Figure 4. FNMA CtoD Rate by Current PaymentBehaviorSeg, Controlling for Origination PaymentBehaviorSeg – Consumers with Origination VantageScore 3.0 < 720

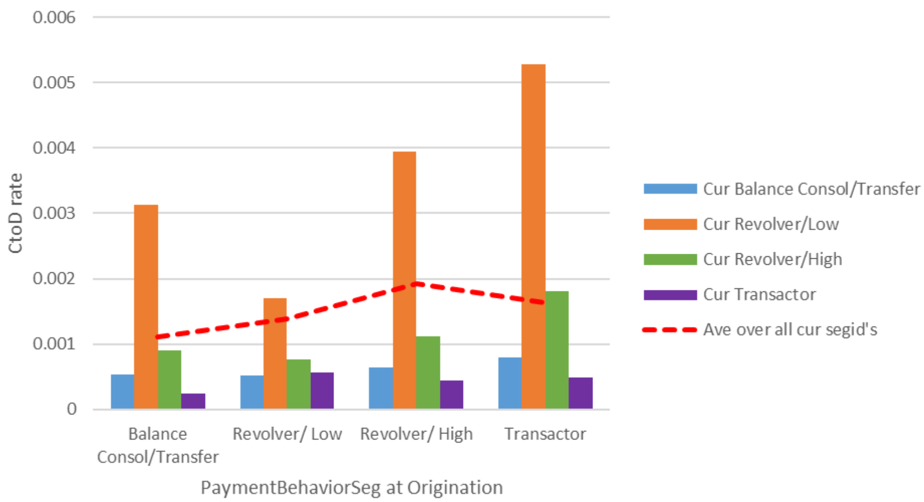

Figure 4. FNMA CtoD transition rate by current PaymentBehaviorSeg, conditional on the origination PaymentBehaviorSeg (along the X axis), for consumers with VantageScore 3.0 scores under 720.

Table 3. Matrix of FNMA CtoD Transition Rates (%) by Origination and Current PaymentBehaviorSeg, for Consumers with Origination VantageScore 3.0 Scores Under 720

	FNMA CtoD Transition Rates (as %) by Origination and Current PaymentBehaviorSeg, for origination years 2016–2019 and consumers with Origination VantageScore 3.0 < 720				
	Cur Balance Consol/Trans	**Cur Revolver/Low**	**Cur Revolver/High**	**Cur Transactor**	**Overall Ave (by orig status)**
Bal Consol/Trans at Orig	0.053	0.313	0.090	0.024	0.106
Revolver/Low Ratio at Orig	0.052	0.170	0.077	0.056	0.128
Revolver/High Ratio at Orig	0.064	0.394	0.112	0.044	0.179
Transactor at Orig	0.079	0.528	0.182	0.048	0.149
Overall Ave (by cur status)	0.055	0.245	0.105	0.046	0.136

For future research, we plan to conduct a more detailed examination of the relationship between a consumer's PaymentBehaviorSeg at various points in time and the CtoD rate during a subsequent mortgage payment performance interval.

PaymentBehaviorSeg at Origination and CtoT

We now move our attention to the relationship between a consumer's PaymentBehaviorSeg and monthly prepayment rate (CtoT). Figure 5 displays the CtoT rate for FNMA and FHA loans by the consumer's PaymentBehaviorSeg at origination, controlling for VantageScore 3.0 score at origination. Note that each of these charts includes just two years of mortgage originations, in order to illustrate the different behavior of seasoned loans (top row) vs. new loans (bottom row). We see a definite signal here, with consumers in the Balance Consolidate/Transfer group prepaying more quickly across all VantageScore 3.0 bins for both types of loans and both origination periods. The result is especially pronounced for FHA loans, and especially for consumers in the lower credit bins.

Table 3 summarizes these results by displaying the approximate CtoT multipliers for the Balance Consolidate/Transfer group as well as the Transactors, for two broad credit buckets: "Low" includes origination VantageScore 3.0 scores between 600 and 699 for FNMA loans and 560–659 for FHA loans, while "High" covers 720–799 for FNMA loans and 680–759 for FHA loans. For each of these credit buckets and loan types, we display the approximate factor by which the CtoT rate for the given PaymentBehaviorSeg group compares to average within their 20-point VantageScore 3.0 bin.

Figure 5. Voluntary Prepayment (CtoT) Rate for FNMA and FHA Mortgages by the Consumer's PaymentBehaviorSeg at Origination, Controlling for VantageScore 3.0 Score at Origination

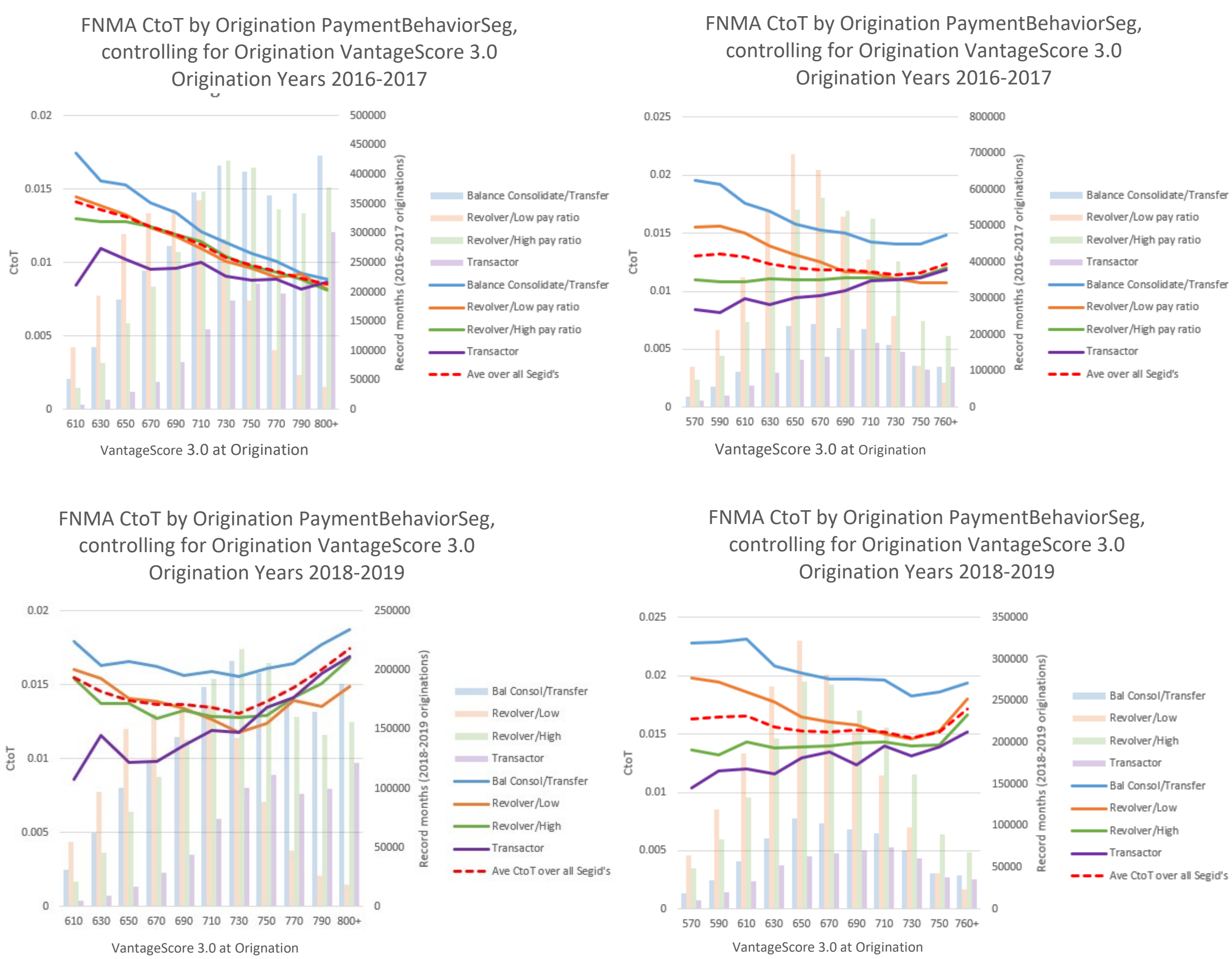

Figure 5. The top row charts include seasoned loans, while the bottom row charts include new loans.

Table 4. Approximate CtoT Multipliers vs. VantageScore 3.0 Bin Average for two PaymentBehaviorSeg Groups

Approximate CtoT factors by two PaymentBehaviorSeg groups at origination, compared with average CtoT within 20 point VantageScore 3.0 bin

	Low credit (FNMA 600–699, FHA 560–659)		High credit (FNMA 720–799, FHA 680–759)	
	Balance Consolidate/Transfer	**Transactor**	**Balance Consolidate/Transfer**	**Transactor**
FNMA Orig 2016-2017	1.14	0.78	1.08	0.91
FNMA Orig 2018-2019	1.16	0.74	1.15	0.95
FHA Orig 2016-2017	1.36	0.73	1.24	0.91
FHA Orig 2018–2019	1.35	0.77	1.27	0.87

That consumers with balance consolidation/transfer activity prepay more quickly than average is not surprising, since presumably some of this activity indicates a tendency to be proactive—by seeking out lower rates and better deals, for example—in the handling of debt. It is perhaps more counterintuitive that Transactors prepay more slowly during the two-year period we studied. However, one big caveat here is that the relative prepayment rate for different groups may vary at different times; during this two-year period (2018–2019), consumers with lower origination credit scores tended to prepay more quickly than those with high scores, possibly due to credit curing; however, during other periods characterized by stronger interest rate incentives and/or stricter underwriting standards, the opposite holds. It stands to reason that Transactors and Revolvers may also display different relative tendencies depending on the economic period. For future research, we would want to consider their behavior in a wider variety of economic conditions.

Conclusion

Typically, the primary measure of borrower credit used to model mortgage performance is the credit score. Additional credit bureau data, such as trended data and segmentation categories reflecting specific borrower behaviors, can provide more accurate models and additional insight into borrower behavior and loan performance. This paper provides examples of this type of analysis and sets the stage for additional research and model development. Specifically, we demonstrate that both origination and current trended consumer segments and their transitions over time have a sizable impact on credit transition and prepayment rates. In our future research we will study additional interactions as well as other trended attributes' predictive power for prepayments and delinquencies.