Collateral Damage: Low-Income Borrowers Depend on Income-Based Lending

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ABSTRACT

We use negative durability shocks from vehicle discontinuations to study asset-backed lending (ABL) and income-based lending (IBL) in auto finance. Discontinuations lead to increased down payments, higher loan-to-value ratios, and larger post-default personal recoveries. These results all indicate that economically disadvantaged consumers are relatively more reliant on unsecured IBL, in stark contrast to corporate financing patterns. Vehicle recoveries on discontinued cars are lower for borrowers who purchase after discontinuations, implying that depreciation is partially borrower-dependent. Our findings suggest that lower-income borrowers, in particular, benefit from technologies that facilitate IBL such as income monitoring.

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Two key forces animate the auto financing market: asset-backed lending (ABL) linked to the physical collateral value of vehicles (Assunçao et al., 2014; Argyle et al., 2021; Ratnadiwakara, 2021) and income-based lending (IBL) supported by a car buyer's income (Dewatripont and Tirole, 1994; Holmstrom and Tirole, 1997). In this paper, we ask whether lower-income borrowers rely relatively more on ABL or IBL. A clear understanding of the roles ABL and IBL play in facilitating auto financing for economically disadvantaged consumers can provide insight into which financial innovations are likely to aid lower-income borrowers.

It is well understood that low-income consumers face restricted access to all types of financing, including mortgages and credit cards (Mills et al., 2022). What is less clear, however, is whether the form of financing they do receive is more likely to be ABL or IBL. Summary market statistics do not resolve this question. For example, Fulford et al. (2023) show that as of 2019 over the prior six months 4.4% of borrowers made use of an IBL payday loan,[1] while 2.5% relied on an ABL pawn loan and 2.0% took out an ABL title loan. Auto credit has both ABL and IBL components, and we seek to understand which has greater weight in supporting the borrowing of some of the neediest Americans. Access to auto financing is particularly valuable in the U.S., where vehicle ownership is often critical for employment opportunities and mobility (Gurley and Bruce, 2005; Baum, 2009; Gautier and Zenou, 2010; Moody et al., 2021). Recent empirical evidence from Brazil corroborates the finding that vehicular access increases formal employment rates and salaries (Doornik et al., 2021). Ensuring the ability of lower-income consumers to borrow to purchase cars is therefore important for a broad set of policy goals.

We make use of negative durability shocks induced by vehicle discontinuation to assess the relative use of ABL and IBL by disadvantaged auto buyers. Our main finding is that IBL is more impor-

[1] Morse (2011), Gathergood et al. (2019) and Skiba and Tobacman (2019) discuss the payday loan market.

tant for lower-income borrowers. Although these borrowers have limited wages, they nonetheless rely more heavily on IBL than on ABL because they purchase assets with low liquidation values, even compared to their income. This pattern is in stark contrast to that observed in the corporate lending market, in which secured ABL is crucial for the financing of resource-constrained firms (Leeth and Scott, 1989; John et al., 2003; Jimenez et al., 2006; Lian and Ma, 2021).

Car loan contracts do not explicitly assign weights to the ABL and IBL components of financing. ABL and IBL are thus intertwined, which presents challenges when empirically assessing the importance of IBL for auto finance across different types of borrowers. A shock to an asset's economic durability, however, can have a differential impact on lower- and higher-income consumers in a manner that reflects their relative dependence on IBL.[2] Specifically, if lower-income borrowers rely relatively more heavily on IBL than on ABL to finance their purchases, then loan amounts for the less durable assets purchased by these borrowers (largely supported by IBL) should decrease proportionately less than the decline in collateral values. As a result, LTV values may be higher for less durable assets. Under these conditions, disadvantaged borrowers have somewhat less income to pledge, but they purchase assets with dramatically lower collateral values. Consequently, a reduction in durability leads to lower-income borrowers' purchasing the asset; the asset's financing terms then directly depend on the extent to which lower-income borrowers rely on IBL.

An implication of this argument is that if less durable assets have higher LTVs and down payments, then it must be the case that lower-income borrowers depend more heavily than higher-income borrowers on IBL. This prediction allows us to empirically assess the importance of IBL for auto lending for different kinds of borrowers.

Testing this hypothesis requires a shock to economic durability. Although cars can vary in

[2] An asset has declining economic durability if it depreciates faster and has a lower current price.

their durability for a number of reasons (e.g., manufacturer mileage), these sources of variation are also associated with differences along other dimensions (e.g., driving experience). We wish to isolate the pure effect of a change in economic durability by identifying shifts in durability that do not affect current vehicle quality. We utilize model and make discontinuations on existing cars as shocks to durability. We match our data to over two hundred car model discontinuations and eight make discontinuations. Discontinuations may affect economic durability in two ways. First, it is likely that the physical durability of discontinued cars declines. Repair costs relative to vehicle value are of first-order importance in keeping a car on the road (Insurance Networking News, November 15, 2015) and discontinuation plausibly reduces the durability of existing cars due to concerns about future parts and service expertise (Titman, 1984).[3] The inability to get replacement parts and increased servicing costs is frequently cited as a concern following the discontinuation of a car brand or model.[4] Second, discontinued cars may experience a loss of prestige, which should depress their current prices, which is another component of economic durability, though it is less clear whether this effect will also cause quicker value depreciation over time.

We begin our empirical analysis by showing that discontinuations reduce economic durability. Using used car prices from a broad set of wholesale auctions, we find that annual depreciation is 1.2 percentage points per year higher for discontinued vehicles. Six years after discontinuation, the effect grows to 3.3 percentage points per year. We show that after the discontinuation announcement, car values drop by about $1,068, a significant decline from the mean value of $12,493.

[3] While many internal components (e.g., transmission components) can be interchangeable across makes (e.g., a Chevrolet part can be used in a GMC), it is not true for all components and it is especially problematic for external components (e.g., driver's side panels), which are most likely to be damaged in a collision. Even if third-party suppliers provide these non-interchangeable components, they will generally be more expensive due to their specialized nature.

[4] For instance, a *Chicago Tribune*, January 22, 2001 article on the announcement of the discontinuation of Oldsmobile notes "There is no question they're going to take a serious hit in resale value. Anyone who buys an Oldsmobile has to understand that unless they keep it until it's dead, it's not going to be worth much."

We then turn attention to a separate data set of loan originations to consumers and confirm that discontinued vehicles drop in value. We further find that default recoveries (the value the lender receives from the vehicle liquidation after default over the vehicle's wholesale value at origination) decline by roughly 1.4 percentage points after discontinuations. These reduced recoveries are measured relative to the vehicles' already lower post-discontinuation prices. These findings provide clear evidence that discontinued vehicles have reduced economic durability.

Our tests effectively compare the same model x vintage year vehicle before and after a discontinuation, while controlling for changes at the corporate parent. Discontinuation is a choice of the manufacturer, but is not under direct control of other auto market participants. Buyers, sellers, and third-party financiers likely assign some probability to a possible future model discontinuation, but its actual occurrence (i.e., with certainty) must represent adverse news. Moreover, we find no evidence of increasing anticipation before the announcement; there is no observable pre-trend in vehicle values, down payment, or LTV before discontinuation. For used auto buyers, sellers, and lenders, discontinuations appear to cause an unanticipated negative shock to economic durability.

We assess the relative importance of IBL for higher- and lower-income borrowers by tracing the effects of discontinuation-driven durability shocks on down payments, LTVs, and payment-to-income (PTI) ratios. First, we show that down payments are $79 higher after discontinuations (8% relative to mean). A post-discontinuation increase in down payments only occurs if future income is sufficiently pledgeable. Lower-income consumers are forced to purchase the asset with a larger down payment, as their low future income does not allow them to borrow a large amount today. If income is not pledgeable to a meaningful degree, then the lower price of a less durable asset should lead it to be purchased with a lower down payment, which we do not observe.

Second, we show that discontinuation causes a 1.4 percentage points increase in LTV ratios.

This result emerges only if lower-income borrowers make greater use of IBL. If higher-income borrowers rely more heavily on IBL (or if only ABL lending is available), by contrast, the lower liquidation values produced by a discontinuation should lead to lower LTV ratios, which we do not find. It may seem counterintuitive that discontinued vehicles have lower prices and higher down payments, yet still carry higher LTV ratios. This pattern arises when dealers apply non-proportional markups and LTV is calculated relative to book value, as is standard practice in auto lending.[5] Our study of shocks to durability enables us to examine the impact on LTVs of changes at the margin in collateral values such as those that might result from policy reforms.

In a setting that includes IBL, if lower-income borrowers are more reliant on IBL, then discontinued vehicles will be financed at lower PTI ratios. We find that to be true as well. The uniform implication of the down payment, LTV, and PTI results is that in the U.S. auto loan market income is highly pledgeable and lower-income borrowers are relatively more dependent on IBL. A model rationalizing these findings also requires that there be a constant component to dealer markups, and we show that dealer dollar margins, unlike vehicle prices, do indeed not vary with vehicle discontinuation status.

We use data on lender recoveries from vehicle repossessions to distinguish various mechanisms that link discontinuation with collateral value degradation. Although discontinued cars can physically degrade more quickly, they can also attract buyers who do not properly maintain their cars. The average proceeds from the sales of repossessed vehicles are $3,483. We show that borrowers who purchased vehicles after discontinuation have physical collateral recoveries in the event of default that are $356 lower than those of control vehicles. By contrast, borrowers who purchased

[5]For example, suppose that a more durable asset sells for 150, has a book value of 135 and is financed with 145 in debt and a down payment of 5. Suppose the less durable asset sells for 130, has a book value of 115 and is financed with 124 in debt and a down payment of 6. In this case with a constant markup, the less durable asset has a lower price, a higher down payment, and a higher LTV ratio.

vehicles that were subsequently discontinued and who defaulted after discontinuation have collateral recoveries that are \$176 lower than for control cars. The latter result shows that, independent of borrower selection, discontinuation leads to worse recoveries. The difference in recoveries between these two classes of borrowers who both defaulted on loans held against discontinued cars is evidence supporting the argument that depreciation is to some extent borrower-dependent.

When IBL is a component of lending, lenders partially support the debt with a claim on the borrower's future income. In the event of default, do auto lenders actually make recoveries aside from the vehicle repossession? We find that they do. In our defaulted sample, we show that the average cash recovery from the borrower is \$1,171. This indicates that in default, physical assets and personal borrower resources supply 75% and 25%, respectively, of the total recovery proceeds.

We further test the claim that lower-income borrowers rely more on IBL by analyzing recoveries from those who bought discontinued cars and later defaulted. We find that these personal recoveries relative to the defaulted loan balance are 1.8% higher than those arising from non-discontinued cars. Discontinued cars are less expensive and are acquired by lower-income borrowers, and yet we find that their purchasers, in the event of default, supply relatively larger personal recoveries. This perhaps counterintuitive finding is rationalized by by the role of IBL. Lower-income borrowers who acquire less durable assets rely more heavily on IBL; given the low collateral value of these vehicles, if default occurs, lenders seek personal recoveries.[6]

Income pledgeability differs across jurisdictions and economic contexts. New developments such as open banking (He et al., 2023; Babina et al., 2024) and the increased use of digital transactions (Agarwal and Zhang, 2020; Berg et al., 2020; Boot et al., 2021) can help promote IBL, and we show that this may bring special benefits to lower-income consumers. This point may be helpful in

[6]We discuss the related literature on collateral in Section A of the Appendix.

providing guidance to ensure that credit markets serve, to the maximum extent possible, to protect the relative financial access of economically disadvantaged borrowers.

1. Theoretical Framework

To illustrate the effects of a durability shock on the consumer financing of asset purchases, we provide a simple model of financing. In this section, we outline the model and describe the main results. We provide the technical details and further intuition in Section B of the Appendix.

We assume that there are two types of consumers with either higher- or lower-income. Consumers can purchase more durable or less durable assets from sellers (i.e., car dealerships) who charge constant or proportional markups (or both) on sales. Both types of assets have a current period price and a residual value for the next period. Our central interest is in *economic durability*: we define this term to mean that assets with higher economic durability have slower rates of price depreciation over time and higher prices today. Differences in economic durability between assets may arise from variation in either physical durability or intangible quality degradation rates. Formally, we have:

Definition 1.

a) More durable assets have a higher ratio of residual value to current period price than less durable assets.

b) More durable assets have a higher price than less durable assets in the current period.

We also assume that consumers prefer current over delayed consumption, and thus seek to maximize their leverage. Borrowers can access financing from competitive lenders by pledging both the asset's residual value as well as their future income. We refer to the former as asset-based lending (ABL) and the latter as income-based lending (IBL). ABL and IBL are both subject to limited pledgeability constraints, which govern how much financing lenders will provide. For ABL, lenders may be able to seize the collateral at some cost. For IBL, securing future income could include partial wage garnishment or bankruptcy repayment plans (Brown and Jansen, 2020). In our simple setting, there is no uncertainty.

We focus on the interesting region of the parameter space by assuming that higher-income consumers can afford both goods but that lower-income consumers can only afford the less durable asset.[7] We further presume that the more durable asset is more attractive than the less durable asset to unconstrained borrowers.[8] An immediate result of these assumptions is that in equilibrium higher- (lower-) income borrowers purchase the more (less) durable good.[9]

Next, we consider the implications of the model for the contrasting financing patterns of higher- and lower-income borrowers.

Result 1:

a) If income is sufficiently pledgeable, then lower-income borrowers purchasing the less durable asset have higher dollar down payments than higher-income borrowers purchasing the more durable asset.

b) Otherwise, the dollar down payment is lower for lower-income borrowers.

Result 2:

a) If lower-income borrowers are heavily dependent on IBL (implying that they rely relatively

[7] Adams et al. (2009) find that down payments relative to income are often a constraint for vehicle purchases.

[8] In an extension of our model, we consider the possibility of borrower-dependent depreciation. For example, lower-income borrowers may be unable to afford periodic maintenance of the asset resulting in more rapid depreciation. In Section B.4 of the Appendix, we show that the results from the base model hold in this extension as well.

[9] In Section B.5 of the Appendix we consider a model in which borrowers spend a fixed fraction of their income on the value of the asset. This assumption, however, does not well represent the relationship between borrower incomes and vehicle wholesale values that we observe in the data. Moreover, it predicts a relationship between durability and LTVs that contradicts observed data.

more on IBL than higher-income borrowers) and income is sufficiently pledgeable, then the LTV ratio is higher for lower-income borrowers purchasing the less durable asset than for higher-income borrowers purchasing the more durable asset.

b) Otherwise (for example, if higher-income borrowers rely more heavily on IBL or if income is not sufficiently pledgeable), the LTV ratio is lower for lower-income borrowers.

Results 1b and 2b echo the intuitions of Rampini (2019) and Hart and Moore (1994) which do not consider IBL. Result 1b follows from the higher price of the more durable asset not being offset one-for-one with more debt due to limited asset pledgeability and relatively low income pledgeability, leading to higher down payments for the more durable good. Result 2b is due to the more durable asset purchased by higher-income borrowers having a higher collateral value; thus, the component of the LTV ratio due solely to asset-backed lending is higher for higher-income borrowers. If these borrowers also rely more heavily on IBL than lower-income borrowers, then the IBL component of their LTV will also be higher.

Results 1a emerges only if IBL is sufficiently important. Both borrower types reduce their down payments by pledging future income, but lower-income borrowers have less income to pledge. Higher income pledgeability, holding asset values constant, reduces the down payment more for the higher-income borrower. Thus, as long as the difference in income between the two types of borrowers is sufficiently large relative to the pledgeability of income, lower-income borrowers receive smaller IBL amounts and must make larger down payments.

Result 2a emerges only if lower-income borrowers depend relatively more on IBL. Under the assumptions, less durable assets purchased by lower-income borrowers have two features: they are purchased with less debt in dollar terms and they have lower residual values. A comparison of the LTV ratios of more durable and less durable assets therefore depends on the relative strength of these two effects. If lower-income borrowers rely heavily on IBL (implying that they rely more on IBL than do higher-income borrowers), then a greater proportion of their borrowing is based on future income rather than on residual asset value. As a result, as long as income is also sufficiently pledgeable, then lower-income borrowers carry a high level of debt (largely supported by IBL) relative to the low collateral value of their less durable asset.

The model also has implications for borrowers' payment-to-income (PTI) ratios.

Result 3:

a) If lower-income borrowers rely relatively more on IBL than higher-income borrowers, then the PTI ratio is lower for lower-income borrowers purchasing the less durable asset than it is for higher-income borrowers purchasing the more durable asset.

b) Otherwise, the PTI ratio is higher for lower-income borrowers.

Result 3a arises from the fact that the promised payment for the less durable good depends at least in part on its future residual value. If this future residual value for the less durable asset is very low, which is the case when the lower-income borrower is highly dependent on IBL, then the future payment must also be low.

There are parameters that simultaneously satisfy the conditions of Results 1a, 2a and 3a, as well as the other model assumptions. Thus the following implications arise from the model.

Model Implications. If down payments are non-negative,

a) the down payment is higher for the less durable asset, b) the LTV ratio is higher for the less durable asset, and c) the PTI ratio is lower for the less durable asset, then

i) income must be sufficiently pledgeable, ii) lower-income borrowers must rely relatively more heavily than higher-income borrowers on IBL and iii) there must be a constant component of the *markup.*

Figure B.1 in the Appendix presents a graphical illustration of the results. There are six regions that describe the down payment, LTV, and PTI for the less durable asset purchased by the lower-income consumer relative to the more durable asset purchased by the higher-income consumer, with the regions defined by their relationship to three cutoff conditions. First, if the pledgeability of income is above the dark red line, then higher-income borrowers rely more on their future income to cover their obligations and lower-income borrowers make larger down payments. Second, if the durability of the less durable asset is below (i.e., to the left of) the blue curve (and income is sufficiently pledgeable), then lower-income consumers borrow a high level of debt relative to the low collateral value of their asset and have higher LTVs. Third, if durability of the less durable asset is below (i.e., to the left of) the purple line, then lower-income borrowers have lower PTI ratios because they cannot borrow much against the low future value of their asset.

Thus, if lower-income borrowers have higher down payments and LTVs and lower PTIs, then income pledgeability must be high and the economic durability of the lower income asset must be low, with the parameter values residing in light green region I.

1.1. Measuring ABL and IBL

The model implications allow us to assess the relative dependence of higher- and lower-income borrowers on IBL through an analysis relating durability to down payments, LTVs and PTIs. A natural direct alternative would be to measure ABL, perhaps by calculating collateral values, and to view any non-ABL financing as arising from IBL. One could then simply compare in the cross-section the relative use of ABL and IBL by higher- and lower-income borrowers.

The central challenge with this direct approach is that the assets purchased by higher- and lower-income borrowers likely vary significantly in the amenities and features they offer. Consequently, these assets may be sold in different markets and financed by different lenders. In other words, financing choices by consumers of heterogeneous income levels may be driven by complex unobserved variation across multiple characteristics of the assets they purchase. As described in Section 3 below, we instead focus on vehicle discontinuations that generate a pure shock to durability that holds fixed other asset characteristics. We are thereby able to isolate the impact of durability and to trace the effects of a shift in ABL. As in the direct method, we then infer the relative weight of ABL versus IBL by considering the collateral value of the asset relative to the amount of financing. Further, our study of shocks to durability enables us to examine the impact on LTVs of changes at the margin in collateral values such as those that might result from policy reforms.[10]

2. Data

To explore the role of asset durability on consumer financing, we use two data sets. The first data set, supplied by Black Book, provides panel information on 746 vehicle make-models on wholesale values from car auctions of used vehicles.[11] In total, this represents 5,085 make-model-year observations spanning 2001 to 2020 model years.[12] The wholesale values that we use in our analysis cover the period from May 2001 to October 2020 and we compute annual wholesale values by averaging across monthly observations. We use these average wholesale values to calculate year-over-year (YOY) depreciation rates, which we define as the difference between this year's wholesale value and last year's wholesale value, with the difference scaled by the wholesale value

[10]We thank an anonymous referee for this point.

[11]The wholesale values reflect prices paid by dealerships for the purchase of vehicles, and are adjusted for mileage, condition history, and region. The Black Book data cover more than 95% of all auction sales.

[12]In the Black Book data we exclude four luxury brands (Maserati, Porsche, Tesla, and Hummer) because these brands are likely to have different depreciation dynamics and are not representative of our loan data.

last year. Summary statistics are reported in Table 1, Panel A.

The second data set, the loan data, describes loan terms offered by a large independent automotive indirect-finance company.[13] The data include all loans purchased by the firm in 44 states between 1992 and 2021. In total, we observe key features of 326,629 loans that were originated at 4,622 dealerships located in 2,077 U.S. ZIP codes as described in Table 1, Panel B.[14] The lender is one of the top twenty auto finance companies in the United States. Auto buyers can either secure a loan directly from a bank or credit union or finance indirectly through an auto dealership, which then sells the loan to a third-party lender. Our lender originates loans via indirect financing, which accounts for 83% of auto lending in the U.S. (Grunewald et al., 2023).

The breadth and detail of our loan data distinguish our study from previous work. More specifically, we observe loan characteristics (e.g., purchase price and down payment) that are typically unavailable in aggregate data. For example, Experian Autocount data do not measure down payments and sale prices, limiting the construction of collateral measures.[15]

Table 1, Panel B, presents summary statistics from loan data of the buyer, loan, and vehicle characteristics that were observable to the dealer at the time of origination for all loans in our sample, where we observe complete origination data. In our sample, the median vehicle is two years old and has approximately 38,000 miles when sold. The median vehicle has a value of $13,046, and the median down payment is $800 (roughly 6% of the vehicle's value). We find average dealer margins of $4,273 (roughly 25% of the purchase price). The median loan in our sample has a term

[13] This firm is not one of the captive auto lenders studied by Benmelech et al. (2017) and Benetton et al. (2021).

[14] The raw data include approximately 343,000 loans. We exclude loans with incomplete origination data and vehicles older than 7 years. The latter exclusion is because we have limited data on vehicles older than 7 years in our sample (approximately 0.25% of the total sample). We further exclude observations for which the ratio of the retail to wholesale values is in the top or bottom 1%, as these likely reflect data errors; our main results are robust to including these observations.

[15] Argyle et al. (2020, 2023) analyze contract terms in the auto lending market and consider the importance of monthly payment targeting and search frictions.

of 72 months (6 years) and an APR of approximately 19.5%. The high APR reflects the fact that the borrowers in the sample are subprime—the median reported credit score is approximately 530, with approximately 30% of borrowers having a reported bankruptcy (chapter 7 or 13) within seven years of loan origination. The median monthly income is $3,963, so our income comparisons across borrowers are within a set of resource-constrained consumers.

3. Discontinuations

3.1. Background

To causally identify the impact of economic durability on financing, we require a source of exogenous variation in asset economic durability. Moreover, to separate any general effect of durability from other technological shocks in the time series (e.g., financial engineering or digital processing of applications), we require a shock that affects only some vehicles, but that still allows for controls for vehicle age, manufacturer, model, and the year the vehicle was sold. Ideally, we would randomly assign different economic durability to similar vehicles. While this may not be feasible, we can take advantage of shocks to existing vehicles that affect their current and future resale values. Specifically, we utilize discontinuation of vehicles' makes and models as a source of exogenous variation in vehicle economic durability in our data.

This shock does not affect the current quality of a used car because no component of the car changes. In this sense, the shock to quality is only forward looking, although it may be reflected in current prices. Before discontinuation, the car is made in the same factories with the same materials. Moreover, by comparing car prices prior to discontinuation to the same model and year of car post-discontinuation, we can hold constant the car quality and use vehicles that were not shocked to control for the but-for depreciation curve and other time-varying attributes of the market.

One concern with this shock is that the decision to discontinue a make and model of car by the car manufacturer is an endogenous decision and there are many reasons a manufacturer may choose to do so. For instance, a car manufacturer may choose to cut less profitable models during times of financial distress. However, in our specifications we can directly control for the parent car company and thus can compare cars of similar quality within the same car manufacturing family. Thus, any effect on durability due to potential future bankruptcy, as noted in Titman (1984) and shown to be empirically important in Titman and Wessels (1988) and Hortaçsu et al. (2013) among others, should affect all cars made by that manufacturer. Additionally, in several cases, the discontinuation happened when the auto manufacturer was not in financial distress. Moreover, by comparing pre-trends of the vehicles, we can plausibly detect any movements in the resale or depreciation value of the vehicles prior to the shock.

3.2. Discontinuation Shocks

In the last 25 years, 825 car models have been discontinued. Among the 825 discontinued models, we identify 208 instances in which the manufacturer decides to maintain the make of the car (e.g., Chevrolet) but discontinues a specific model (e.g., Chevrolet Monte Carlo), and the model appears in our loan data.[16] We supplement these model discontinuations with eight discontinuations of major US car brands (i.e., makes) during our sample period. A list of discontinued models, discontinued makes and discontinuation years is provided in the Appendix in Table F.3 and Table F.4.

[16]More than half of the discontinued models that are discontinued include low volume production vehicles such as the Aston Martin Vantage GT and the Ferrari 248.

3.3. Empirical Method

We use a difference-in-difference (DiD) approach to test the effect of our shock to depreciation. Specifically, for a transaction i, of model j of vintage v, with parent p and dealer d, during period t, we estimate the following regression:

$$Y_{i,j,d,t,v,p} = \tau_t + \iota_{j,v} + \xi_d + \pi_{p,t} + \beta X_{i,j,d} + \phi_{j,t}\text{Treated}_{j,t} + \epsilon_{i,j,d,t}, \tag{1}$$

where Y is an outcome such as vehicle price or financing term, τ is a transaction year fixed effect, ι is a car model x vintage year fixed effect, ξ is a dealer fixed effect, X are a series of vehicle, borrower, and dealer controls, and Treated is an indicator if the make of model j has been discontinued prior to time t. Thus, in the cross section, we are comparing cars within the same period, absorbing any non-time varying attributes related to the specific model, and dealer, as well as any linear effects of vehicle age. In addition, we also include fixed effects for the interactions of the parent company of the car maker x transaction year fixed effects ($\pi_{p,t}$). Thus, we also absorb any effects related to the financial condition of the parent company at the time of the transaction. Importantly, this isolates general effects that would apply to all makes of a given parent company (e.g., GM during the 2008-2009 Global Financial Crisis). In all specifications, we cluster by make.[17]

[17] Several recent papers raise concerns of differential treatment timing in difference-in-difference regressions and raise the specter of resulting bias when using higher dimensional fixed-effects if there is expected treatment effect heterogeneity (Callaway and Sant'Anna, 2021; Baker et al., 2022). We note several features of our analysis that should alleviate such concerns. First, in the loan sample we drop all observations where the vehicle age exceeds seven years. This reduces the potential for long-run effects to drive the results and for previously discontinued vehicles to act as future controls. Second, we note that 75% of our observations are never treated, reducing the likelihood of negative weights (Goodman-Bacon, 2021). Finally, we repeat our baseline specifications using the stacked regression approach of Gormley and Matsa (2011) and Cengiz et al. (2019), and find similar results.

4. Results

4.1. *Discontinuation Shock and Economic Durability*

We use the discontinuation of models and brands described in Section 3 as a shock to economic durability. Parts availability and servicing expertise for discontinued vehicles are likely to degrade more quickly than for other vehicles. There may also be a loss of prestige that leads to lower current prices. From the perspective of the theoretical framework described in Section 1, this suggests that discontinuation may be viewed as a shock that reduces the economic durability of a car.

We begin by using the Black Book data to empirically assess the impact of discontinuation on economic durability. Definition 1a in Section 1 requires that more durable assets have a higher ratio of residual value to current period price (i.e., lower YOY depreciation), so if discontinuation reduces durability, then it should increase the rate of depreciation. We test this implication by estimating equation (1) and regressing a vehicle's YOY depreciation on a post-discontinuation indicator, model x vintage year fixed effects, and corporate parent x contract year fixed effects. Our use of model x vintage year fixed effects allows us to contrast vehicles of the exact same model and vintage year before and after discontinuation. Corporate parent x contract year fixed effects remove any impacts that influenced the corporate parent. It is plausible that corporations that discontinue a make or model may differ from those that do not. For example, it could be that corporate parents that discontinue a make or model may have weaker balance sheets and may therefore be less capable of guaranteeing future warranties. The corporate parent-contract year fixed effects control for any impacts of this kind. Taken together, this complement of fixed effects isolates the impact of discontinuation itself on the specific model that will no longer be manufactured.

We find (shown in column 1 of Table 2) that discontinued vehicles depreciate by an additional -

1.2% (t-statistic=-2.60) per year. This is a meaningful effect relative to the average depreciation rate of -15%. This finding of more severe depreciation after discontinuation is consistent with the claim that discontinuation reduces economic durability. In the second column of Table 2 we show that vehicles experience sustained rates of elevated annual depreciation after discontinuation, ranging from -0.8% (t-statistic=-2.46) in the first year after discontinuation to -3.3% (t-statistic=-6.17) in the sixth post-discontinuation year. These results are illustrated graphically in Figure 1.

The initial increase in depreciation in the first year after discontinuation likely reflects both the impaired physical durability of discontinued vehicles and the stigma associated with these cars. The fact that the rate of depreciation is greater in subsequent years, however, probably largely arises from a decrease in physical durability, as it seems unlikely that the loss of prestige for discontinued cars would increase over time as a fraction of overall value.

The second key feature of less durable assets, which is highlighted in Definition 1b in Section 1, is that they have lower prices. We show in the third column of Table 2 that discontinuation leads to a \$1068.2 drop (t-statistic=-2.50) in vehicle wholesale values. This is a meaningful decrease compared to the average wholesale value of \$13540. As shown in the fourth column of Table 2, the price effect is substantial in the first year after discontinuation (coefficient= -1055.1 and t-statistic=-3.00) and is larger in subsequent years.[18] Table 2 makes clear that discontinued vehicles are less economically durable, exhibiting both increased rates of annual depreciation and lower prices.

Next we examine the impact of discontinuation on vehicles in our loan data. These data describe sales of individual vehicles, so they can be used to analyze prices, but are not in the form of a panel that allows for the calculation of annual depreciation. We regress the vehicle wholesale value on a post-discontinuation indicator, model x vintage year fixed effects, dealer fixed effects, and

[18] We present the event study plot for the wholesale value in Appendix Figure F.1.

corporate parent x contract year fixed effects, which we refer to as the standard set of fixed effects. We find (shown in column 1 of Table 3) that discontinued vehicles experience a change in wholesale value of -\$262.6 (t-statistic=-2.39). The negative sign of this effect is consistent with the results in Table 2. The magnitude of the drop is smaller than for the vehicles in the Black Book sample, which may arise from the fact that the loan data are generated from subprime borrowers sales, whereas the Black Book data describe a broad cross-section of vehicles.[19]

Including controls for borrower income and credit score, indicators for prior borrower chapter 7 or chapter 13 bankruptcy filings and an indicator for borrower homeowner status leave the qualitative finding unchanged, as shown in the second column of Table 3. Including a control for vehicle mileage and dealer profit yields the result that discontinuation reduces the wholesale value by \$246.35 (t-statistic=-2.33).

We also measure vehicle value using the scaled price, defined as the wholesale value divided by the average wholesale value of the same model and vintage when new. We show in the fourth column of Table 3 that the scaled price is 3.54 percentage points lower (t-statistic=-4.33) post-discontinuation. The results from the specifications including borrower, vehicle mileage and dealer profit controls in the scaled price regressions support the conclusion that discontinuation reduces vehicle value, as shown in the fifth and sixth columns of Table 3.

As an additional test for whether discontinuation can be viewed as a negative durability shock, we study the recovery percent of a vehicle, which we define to be the value the lender receives from the vehicle's liquidation after default divided by the vehicle's wholesale value at origination. We regress the recovery percent on the post-discontinuation dummy and the standard fixed effects. We note here for clarity that we assign the post-discontinuation indicator to a vehicle if it is *purchased*

[19]The autos in the Black Book data also have higher wholesale values when new than the vehicles in the loan data.

after discontinuation. As shown in Tables 2 and 3, these vehicles have lower current period prices when purchased. In the present test, we explore whether their future recovery values are lower, as a fraction of their already reduced prices, relative to other vehicles.

We find, as shown in the first column of Table 4, that the recovery percent is 1.49 percentage points lower (t-statistic=-2.45) for post-discontinuation vehicles. This drop may be compared to the average recovery ratio of 28 percent. In the second column of Table 4, we show that including borrower, vehicle mileage, and dealer profit controls as well as a control for the time to default yields a coefficient of -2.08 percentage points (t-statistic=-3.72) on post-discontinuation. Including an additional fixed effect for the model x year of default as well as controlling for the recovery type results in an estimated coefficient of -1.40 percentage points (t-statistic=-2.20), as shown in the third column of Table 4. These results support the general conclusion that discontinued vehicles have lower residual values, even when viewing these residual values as a fraction of their lower prices at the time of purchase.

Tables 2, 3 and 4 make clear that the discontinuation shock reduces economic durability, as described in Definition 1. Discontinued vehicles have higher depreciation rates, lower prices, and lower residual values, and consequently we view them as less durable assets for the purpose of testing the theoretical predictions outlined in Section 1.

4.2. Durability and Consumer Income

A direct implication from the assumptions of the theoretical framework presented in Section 1 is that higher-income borrowers will purchase more durable assets. The basic intuition is that more economically durable assets are attractive, but expensive. We test this prediction by regressing an indicator for whether a borrower had a bottom-quartile income relative to all borrowers in that year on the post-discontinuation dummy and the standard fixed effects. We find, as shown in the first column of Table 5, that discontinuation increases the probability that the purchaser is in the bottom income quartile by 3.43 percentage points (t-statistic=2.81). This represents a large 13.7 percent increase in the probability that the buyer is lower-income. This finding is consistent with the implication that lower-income borrowers are more likely to buy less durable discontinued vehicles. Including controls yields a similar conclusion, as shown in the second column of Table 5. A regression of the log of borrower income on discontinuation yields a coefficient of -0.014 (t-statistic=-2.21), as displayed in the third column of Table 5; the negative impact of discontinuation on income is evidently strongest in shifting buyers into the lowest quartile. This result is robust to controlling vehicle mileage and dealer profits, and also emerges in specifications using Poisson regressions as suggested by Silva and Tenreyro (2006) and Cohn et al. (2022), as shown in columns four through six of Table 5. Discontinued vehicles are purchased by lower-income borrowers, and the effect is especially pronounced for borrowers in the bottom-income quartile.

4.3. Durability and Down Payments

The results described above in Section 4.1 serve to validate the use of discontinuation as a shock to economic durability, while the results in Sections 4.2 support our assumptions for the relationship between a reduction in durability and borrower income.[20]

The model offers conflicting predictions for the impact of economic durability on the dollar value of the borrower's down payment (i.e., the cash amount paid by the borrower on the transaction date). When income pledgeability is low, more durable assets require larger down payments (Result

[20] We show in the Appendix that discontinued vehicles also have shorter loan maturities (see Appendix Table F.5), consistent with the theory of maturity matching in Hart and Moore (1994) and prior empirical evidence in Argyle et al. (2021).

1b); while when income pledgeability is sufficiently high, borrowers purchase less durable assets with larger down payments (Result 1a).

We regress the down payment on the post-discontinuation indicator and the standard fixed effects. We find that discontinuation leads to larger down payments, as shown in the first column of Table 6. Consistent with the implication in the model when income is sufficiently pledgeable, borrowers supply an additional \$74.02 (t-statistic=3.32) in down payments when purchasing less durable discontinued vehicles. As shown in Figure 2, down payments climb significantly after discontinuation and do not exhibit any apparent pre-trend.

This down payment result is particularly surprising from the perspective of a model with only asset-based collateral, that is, if income was not pledgeable. We showed above in Table 3 that discontinued vehicles are less expensive. This fact, along with the limited pledgeability of collateral emphasized in asset-backed models of lending, should lead discontinued autos to require lower down payments. Moreover, we demonstrate in Table 5 that these vehicles are purchased by lower-income borrowers who presumably have less cash on hand for a down payment. Despite these two compelling intuitions for a prediction that there will be lower down payments for less durable assets, we find the opposite. This finding in the context of the model shows that income-based lending is a relatively important feature of auto lending. Given that lower-income consumers have smaller future incomes against which to borrow, lower-income purchasers of less durable assets need to provide larger down payments to close the transactions.[21]

The positive impact of discontinuation on down payments continues to hold when controlling for borrower and vehicle characteristics, as detailed in the second column of Table 6. We show in

[21] This result aligns with the findings of Adams et al. (2009) and Einav et al. (2012), who show that borrowers that are riskier in observable dimensions make larger down payments, though they do not find an independent effect of income or mileage. Our focus on a shock to durability and our analysis of the ABL-IBL trade-off is not shared by Adams et al. (2009) and Einav et al. (2012).

the third column of Table 6 that in the cross-section more expensive vehicles with elevated book values generally require higher down payments. There are, however, many unobserved differences between vehicles of different prices. Our result that discontinuation shocks lead to higher down payments on vehicles of specific model x vintage years is somewhat stronger when controlling for this vehicle book value effect, as is displayed in the third column. We also find, as described in columns four through six of Table 6, that after discontinuation down payments increase as a fraction of price.

The higher down payments for less durable assets that we find indicate that the empirically relevant regions of Figure B.1 are restricted to region I (light green), region II (orange) or region III (dark pink). Only for the high levels of income pledgeability that hold in those regions will lower-income borrowers make the higher down payments that we observe. The other regions are incompatible with the down payment results in Table 6.

4.4. Durability and LTV ratios

In this section, we consider the implications of the model for the LTV ratio. Specifically, in our model, when IBL is relatively unimportant for lower-income borrowers, LTV increases with durability (Result 2b), but when IBL is relatively important for lower-income borrowers, LTV decreases with durability (Result 2a).

We define the LTV as the ratio of the loan balance to the wholesale value of the auto at the time of origination. We regress LTV on the post-discontinuation indicator and the standard fixed effects, and find a positive and significant coefficient of 0.016 (t-statistic=3.14), as displayed in the first column of Table 7. This result shows that a discontinuation shock reducing vehicle durability leads to higher LTV ratios, which, as we describe in Section 1, arises only in the model when lower-income borrowers are highly dependent on IBL. Figure 3 shows that LTV ratios exhibit no pre-trend before discontinuations and are higher afterward.

It is a general and robust feature of models of asset-backed financing that LTV increases with durability (Hart and Moore, 1994). When the asset constitutes the entire collateral, as in a model without IBL, more durable assets with higher liquidation values support larger loans relative to current values. We also find this implication in our model when IBL is relatively less important for lower-income borrowers (these are regions II, III, IV and V in Figure B.1). Our finding to the contrary indicates that in the auto loan market, income-based lending must play a meaningful role and that it is especially important for lower-income borrowers. Our model describes a setting in which borrowers can rely on their future income to purchase assets. Lower-income borrowers, in particular, use their future income to purchase less durable assets. If the price of the less durable asset is relatively low, then lower-income borrowers will purchase it with a relatively high debt ratio, as the debt is secured by their income, not just by the physical collateral. This mechanism in the model is consistent with the finding that LTV *increases* after a decline in durability.

Including borrower controls has little impact on the estimated effect of the discontinuation shock on LTV, as shown in the second column of Table 7. In the third column of Table 7 we display the similar results when including the full set of vehicle and borrower controls (coefficient=0.014 and t-statistic=6.23). The general conclusion is unchanged: less durable autos are financed with higher LTV ratios, which emerges as a potential outcome in the model only when lower-income borrowers are relatively more dependent on IBL.[22]

We have thus shown in Tables 6 and 7 that less durable assets have both higher down payments

[22] The post-discontinuation increase in LTV ratios does not reflect a shift in default risk; we find in Table F.7 in the Appendix that the latter does not change significantly with the discontinuation shock. We also note that the specifications with borrower characteristics employ a wide set of risk measures such as credit scores, income, and bankruptcy indicators, and the inclusion of these controls has little impact on the estimated coefficient on post-discontinuation.

and higher LTVs than more durable assets. The only region in Figure B.1 for which both of these outcomes hold is region I. The data thus indicate that in the U.S. auto loan market income is quite pledgeable and lower-income borrowers rely relatively more heavily on IBL.[23]

At first glance it may seem surprising that discontinued vehicles have lower prices and higher down payments, yet carry higher LTV ratios. This can occur, however, when dealers charge non-proportional markups[24] and LTVs are calculated relative to the book values of the vehicles. For example, suppose that a more durable asset sells for 150, has a book value of 135 and is financed with 145 in debt and a down payment of 5. Suppose the less durable asset sells for 130, has a book value of 115 and is financed with 124 in debt and a down payment of 6. In this case, the less durable asset has a lower price, a higher down payment, and a higher LTV ratio.

We further comment that the mean LTV for our auto borrowers is 129%.[25] In a model where income pledgeability was low (i.e., little IBL) this high level of debt would be unexpected, as lenders can only seek repayment from the asset value. LTVs of above 100% can be supported, however, when income is sufficiently pledgeable, as the borrower's future income is also used to meet the required debt payments. This is also consistent with parameters in region I of Figure B.1.

4.5. Durability and Payment-to-Income Ratios

Result 3 of the model predicts that the payment-to-income ratio will be lower for less durable assets if lower-income borrowers are more heavily dependent on IBL (as is the case in region I of

[23] In Figures F.4 and F.5 of the Appendix we present permutation tests of the results for year-over-year (YoY) depreciation, Scaled Price, Down Payment, and LTV (Tables 2, 3, and 7, respectively) based on Ganong and J́ager (2018). Using this test, find that our results are significant at the 5% level indicating that they are unlikely to be due to chance or mechanical effects.

[24] In Table F.6 in the Appendix we show that dealer dollar margins do not vary with vehicle discontinuation status.

[25] We further note that the mean LTV for prime auto borrowers (FICO score of 661 to 780) is 131%, while it exceeds 139% for subprime borrowers (Zabritski, 2019).

Figure B.1). This provides an additional model implication that we explore.

We test this prediction by regressing the log of the borrower's payment-to-income (PTI) ratio on the post-discontinuation variable and the standard fixed effects. We find a negative and significant effect of discontinuation on the log of PTI (coefficient=-0.017 and t-statistic=-2.12), as displayed in the first column of Table 8. PTI ratios of the purchasers of these vehicles drop by roughly 2 percent after discontinuation is announced.

Including fixed effects of the borrower income decile has little impact on the estimated negative coefficient on discontinuation, though it does increase the precision of the estimate, as shown in the second column of Table 8. Introducing borrower and vehicle controls, either with or without fixed effects on borrower income decile, also yields similar estimates, as described in columns three and four of Table 8. Using the PTI ratio rather than the log as the dependent variable yields similar directional results and significance but lower magnitudes, as displayed in columns five through eight of Table 8. This is due to a wide distribution in PTI that may skew the results. Figure 4 shows that borrower PTI drops after discontinuation, with no visible pre-trend.

The complete set of empirical findings across down payments, LTVs and PTIs offers consistent support for the argument that income is pledgeable and that lower-income borrowers rely more heavily on IBL, as described in region I of Figure B.1. Moreover, down payments are generally non-negative in our data, so the Model Implications in Section 1 suggest that there is a constant component to the dealer markup.[26] In direct tests, in Table F.6 in the Appendix we show that dealer dollar margins do not vary with vehicle discontinuation status. These results indicate that dealers indeed earn constant margins across more and less durable assets.

[26]Ninety-six percent of down payments are non-negative. Restricting attention to only these observations yields very similar results for Tables 6, 7, and 8.

4.6. *Durability and Recovery in Default*

In the discussion above, we highlight the role of IBL. For IBL to be important, however, it must be that consumers are able to borrow against their future income and need not rely solely on the physical asset to serve as collateral. In this section we discuss the direct evidence on post-default lender collections. In particular, is it the case that lenders actually recover from the personal resources of borrowers?

We have data on the recovery proceeds from 76,638 defaulted loans where we observe both income and vehicle recoveries. For this sample, we find that the average proceeds from the sales of repossessed vehicles are $3,483. The average cash recovery from the borrower is $1,171. We thus find that in default, physical assets and personal borrower resources supply 75% and 25%, respectively, of the total recovery proceeds. These summary statistics show that in the auto loan market, a market in which vehicle collateral is generally deemed to serve a central role, borrower personal income pledges do perform a significant function.

4.7. *Income-based Lending to Lower-Income Consumers—Default Recoveries*

As outlined in the model developed in Section 1, the results in Table 6 showing that a reduction in durability leads to larger down payments demonstrate that income-based lending is important in the auto financing market. The empirical findings on LTV and PTI in Tables 7 and 8 establish that lower-income borrowers are more heavily relying on IBL than higher-income borrowers.

The default recovery data make possible an additional test of these implications. We show in Table 5 that discontinued vehicles tend to be purchased by lower-income consumers. Given the results in Tables 6 to 8, the model's implications are that lower-income borrowers rely relatively more on IBL. We should therefore expect to observe lower vehicle recoveries and higher personal income recoveries from the purchasers of discontinued vehicles who default.

In the extension of the model described in Section 1, we discuss the idea that different borrowers may experience varying levels of asset depreciation for the same vehicle. The recovery data enable us to examine this hypothesis, as we can contrast the outcomes for borrowers who purchased vehicles that were later discontinued with outcomes for borrowers who purchased vehicles after the discontinuation announcement. Both types of borrowers experience the impact on their vehicles of a discontinuation, but the borrowers themselves differ in that only the first group of borrowers chose to purchase what were at the time non-discontinued cars. Any observed differences across the two borrower types in their recovery rates would therefore constitute evidence in favor of borrower-dependent depreciation. In order to ensure that the vehicles of these two borrower groups are comparable, for cars that are discontinued or eventually discontinued, only autos purchased within 2 years of a discontinuation are included.

We begin by analyzing recovery rates for borrowers who purchased their vehicles after a discontinuation announcement. Consistent with our labeling in the previous tables, we describe these as *Post-Discontinuation* transactions. We regress the value of the vehicle recovery on the post-discontinuation indicator, the standard fixed effects and additional fixed effects for the corporate parent x default year, and the form of recovery. We find, as shown in the first column of Table 9, that vehicles purchased post-discontinuation are worth \$239.03 less (t-statistic=-3.37) in repossession. These vehicles are less durable and therefore provide diminished physical recovery proceeds, as expected under the model. It may also be the case that the purchasers of the vehicles are less able to maintain them, resulting in even higher rates of depreciation.

As a point of contrast, we examine vehicle recovery proceeds from cars purchased prior to discontinuation that experienced default after discontinuation. We label these transactions as *Purchase Before, Default After*.[27] In the second column of Table 9 we show that these vehicles have \$205.16 lower (t-statistic=-2.67) recoveries. The purchasers of these cars did not choose to buy a discontinued auto: discontinuation was an ex post shock that they experienced.[28] The drop in vehicle recoveries we find for this group therefore constitutes evidence of higher post-discontinuation depreciation that affects the physical asset independent of the borrower type.

The coefficient on *Post Discontinuation* in this regression is -419.69 (t-statistic=-4.19). This coefficient is larger in magnitude than the coefficient on *Purchase Before, Default After*, with the difference statistically significant at the 5% level. The relatively lower recovery for borrowers who purchased their vehicles after discontinuation, compared to those who experienced discontinuation after purchase, is evidence in favor of borrower-dependent depreciation. This regression includes fixed effects for both model x vintage and parent x default year, so we are comparing outcomes for similar vehicles that defaulted at the same time and that had been discontinued at the time of default. The reduced recovery for post-discontinuation buyers suggests that, perhaps due to financial constraints, these consumers were unable to maintain the values of their vehicles in the same manner as those who purchased them before the discontinuation. Including borrower, vehicle mileage, dealer profit, and time to default controls has little impact on the estimated coefficients on *Purchase Before, Default After* and *Post Discontinuation*, as detailed in the third column of Table 9; both remain significant and statistically distinct from each other at the 5% level. Figure F.6 provides a graphical depiction of vehicle recoveries for both borrowers who experienced a discontinuation

[27] Given our regression specification, model x default year fixed effects would fully absorb the *Purchase Before, Default After* indicator. We therefore employ in Table 9 parent company x default year fixed effects.

[28] Our approach is similar to that of Karlan and Zinman (2009) and Jack et al. (2023) who make use of unexpected ex post variation to distinguish selection and treatment effects.

after purchase and for those who purchased after discontinuation.[29]

A decrease in durability reduces not only the dollar amount recovered from the repossessed asset, but also the percentage of the loan balance recovered through liquidation. We find, as detailed in the fourth column of Table 9, that that the percentage of the loan balance recovered through liquidation of the vehicle is lower for vehicles purchased after discontinuation. In the fifth column of Table 9, we show that the effect of *Post Discontinuation* (coefficient=-2.88 and t-statistic=-5.62) is greater in magnitude than the impact of *Purchase Before, Default After* (coefficient=-1.53 and t-statistic=-2.66), and the difference is statistically significant at the 5% level. The results for the specification including the full set of controls, outlined in the sixth column of Table 9, are quite similar. These findings buttress the argument that asset depreciation varies by borrower type.

Although it is perhaps unsurprising that vehicle recoveries are lower for discontinued vehicles, it is a novel implication of the model that personal income recoveries as a fraction of the loan balance should be higher for these cars, as they are purchased by lower-income borrowers who rely more heavily on IBL.[30] We regress the dollar amount of personal post-default payments on the post-discontinuation indicator and the fixed effects described above. We find, as displayed in the first column of Table 10, that the dollar amount weakly increases (coefficient=104.85 and t-statistic=1.70) after discontinuation. A similar result holds in the specification with borrower, vehicle, and dealer profit controls, as shown in the second column of Table 10. When including the gross default amount as a control, there is somewhat stronger evidence of an increase in income

[29]Figure F.6 is conditional on positive recovery in the vehicle. In Figure F.7 in the Appendix we plot the complete set of recoveries and find similar results. Both borrowers who experienced discontinuation after purchase and those who purchased after discontinuation have a higher likelihood of zero recovery than control borrowers.

[30]The model does not have any implications for the income recoveries of *Purchase Before, Default After* borrowers. Given that the eventual discontinuation experienced by these borrowers was unexpected, their original loan terms should not depend to a greater extent on IBL. As a consequence, we focus in the income recovery analysis on borrowers who purchased their vehicles post-discontinuation, and we do not restrict attention, as we did in Table 9, to vehicles purchased within two years of a discontinuation.

recovery (coefficient=139.42 and t-statistic=2.19), as displayed in the third column of Table 10.

The ratio of personal borrower payments to the defaulted loan balance also weakly increases after discontinuation (coefficient=1.55 and t-statistic=1.75), as we detail in the fourth column of Table 10. Including controls somewhat strengthens this conclusion (coefficient=1.78 and t-statistic=2.00); the results are displayed in the fifth column of the table.

Taken together, the results in Tables 9 and 10 support the contention that lower-income borrowers rely more heavily than higher-income borrowers on their income as a collateral source. It is notable that purchasers of discontinued vehicles make larger personal payments after default. These consumers have lower incomes and buy less expensive vehicles. For both of these reasons, one might have expected them to be supply smaller personal recoveries relative to their loan balances in the event of a default, yet we find the opposite. The model supplies the intuition for our finding: purchasers of discontinued less durable vehicles must pledge their own income, rather than the quickly depreciating physical asset, in order to receive a loan. In the event of default, a lender therefore must have recourse to their income, as the physical collateral does not have much value.[31]

5. Conclusion

We study the roles of asset-backed lending (ABL) and income-based lending (IBL) in the $1.6 trillion U.S. automotive lending market. We show that tracing the effects of a reduction in the economic durability of assets on financing allows us to assess the overall importance of IBL and its relative usage by higher- and lower-income borrowers. We find that model and make discontinu-

[31] In Section D of the Appendix we show that there is little evidence that pre- and post-discontinuation borrowers differ in their sophistication. In Section E of the Appendix we discuss the potential impact of recent changes in securitization markets on lower-income borrowers in the context of our finding that they particularly depend on IBL.

ations generate a negative economic durability shock for used cars: post-discontinuation, holding fixed the model x vintage year, we observe that discontinued vehicles have higher rates of depreciation, lower prices, lower liquidation values, and are purchased by lower-income consumers. After discontinuation, down payments are higher by approximately $79 and LTV ratios increase by 1.4 percentage points. The latter two findings are consistent with a description of the auto market in which IBL plays a meaningful part, lower-income borrowers rely relatively more heavily on it and dealer margins have a constant component.

In a sample of defaulted loans, we find that roughly three-fourths of lender recoveries arise from the vehicle (which serves as the collateral for ABL) and the remaining one-fourth comes from the borrower personally (the source of the guarantee in IBL). For vehicles purchased post-discontinuation, physical collateral recoveries as a percentage of the loan balance are 2.7 percentage points lower, while these recoveries are 1.4 percentage points lower for borrowers who experience discontinuation after purchase. These negative estimates show that discontinuations reduce liquidation values and the gap between the effects is consistent with the claim that depreciation is borrower-dependent. For autos purchased after a discontinuation announcement, the percentage of the loan balance recovered via personal income increases by 1.8 percentage points. The higher personal recoveries on discontinued vehicles may seem surprising given that their purchasers have lower incomes and buy less expensive vehicles. The explanation is that lower-income borrowers make greater use of IBL and must therefore use their personal resources, rather than the collateral value of the vehicle, to cover missing payments in the event of default.

Our theoretical framework draws a sharp contrast between ABL and IBL, but a lender's ability to secure income-based repayment from a borrower may be linked to its power to repossess a vehicle. This argument suggests that the interaction between a lender's capabilities to seize income as opposed to collateral is a topic worthy of further analysis.

In the post-financial crisis period, securitization market issuances have increased relatively more for ABL than for IBL forms of financing. This shift may limit relative credit access for lower-income borrowers who rely on IBL. A resulting restriction on the ability of economically disadvantaged consumers to purchase cars may have wide-ranging implications for their welfare. Our results indicate that innovations that aid lenders in monitoring borrower income are likely to be especially helpful for less wealthy consumers who seek auto financing that often offers a gateway to economic opportunity.

References

Adams, William, Liran Einav, and Jonathan Levin, 2009, Liquidity constraints and imperfect information in subprime lending, *American Economic Review* 99, 49–84.

Agarwal, Sumit, and Jian Zhang, 2020, Fintech, lending and payment innovation: A review, *Asia-Pacific Journal of Financial Studies* 49, 353–367.

Argyle, Bronson, Taylor Nadauld, and Christopher Palmer, 2023, Real effects of search frictions in consumer credit markets, *The Review of Financial Studies* 36, 2685–2720.

Argyle, Bronson, Taylor Nadauld, Christopher Palmer, and Ryan Pratt, 2021, The capitalization of consumer financing into durable goods prices, *Journal of Finance* 76, 169–210.

Argyle, Bronson S, Taylor D Nadauld, and Christopher J Palmer, 2020, Monthly payment targeting and the demand for maturity, *The Review of Financial Studies* 33, 5416–5462.

Assunçao, Juliano J, Efraim Benmelech, and Fernando SS Silva, 2014, Repossession and the democratization of credit, *Review of Financial Studies* 27, 2661–2689.

Babina, Tania, Saleem A Bahaj, Greg Buchak, Filippo De Marco, Angus K Foulis, Will Gornall, Francesco Mazzola, and Tong Yu, 2024, Customer data access and fintech entry: Early evidence from open banking, Technical report, National Bureau of Economic Research.

Baker, Andrew C., David F. Larcker, and Charles C.Y. Wang, 2022, How much should we trust staggered difference-in-differences estimates?, *Journal of Financial Economics* 144, 370–395.

Barbiero, Francesca, Glenn Schepens, and Jean-David Sigaux, 2024, Liquidation value and loan pricing, *Journal of Finance* forthcoming.

Baum, Charles L, 2009, The effects of vehicle ownership on employment, *Journal of Urban Economics* 66, 151–163.

Benetton, Matteo, Sergio Mayordomo, and Daniel Paravisini, 2021, Credit fire sales: Captive lending as liquidity in distress, *Working Paper* .

Benmelech, E., M. J. Garmaise, and T. J. Moskowitz, 2005, Do liquidation values affect financial contracts? Evidence from commercial loan contracts and zoning regulation, *Quarterly Journal of Economics* 120, 1121–1154.

Benmelech, Efraim, 2009, Asset salability and debt maturity: Evidence from nineteenth-century american railroads, *Review of Financial Studies* 22, 1545–1584.

Benmelech, Efraim, Ralf R Meisenzahl, and Rodney Ramcharan, 2017, The real effects of liquidity during the financial crisis: Evidence from automobiles, *Quarterly Journal of Economics* 132, 317–365.

Berg, Tobias, Valentin Burg, Ana Gombović, and Manju Puri, 2020, On the rise of fintechs: Credit scoring using digital footprints, *The Review of Financial Studies* 33, 2845–2897.

Bernanke, Ben, and Mark Gertler, 1989, Agency costs, net worth, and business fluctuations, *American Economic Review* 79, 14–31.

Bernstein, Asaf, 2021, Negative equity, household debt overhang, and labor supply, *Journal of Finance* 76, 2963–2995.

Boot, Arnoud, Peter Hoffmann, Luc Laeven, and Lev Ratnovski, 2021, Fintech: what's old, what's new?, *Journal of financial stability* 53, 100836.

Braucher, Jean, Dov Cohen, and Robert M Lawless, 2012, Race, attorney influence, and bankruptcy chapter choice, *Journal of Empirical Legal Studies* 9, 393–429.

Brown, Jennifer, and Mark Jansen, 2020, Consumer Protection Laws in Auto Lending, working paper.

Callaway, Brantly, and Pedro H.C. Sant'Anna, 2021, Difference-in-differences with multiple time periods, *Journal of Econometrics* 225, 200–230.

Cengiz, Doruk, Arindrajit Dube, Attila Lindner, and Ben Zipperer, 2019, The Effect of Minimum Wages on Low-Wage Jobs, *Quarterly Journal of Economics* 134, 1405–1454.

Cerqueiro, Geraldo, Steven Ongena, and Kasper Roszbach, 2016, Collateralization, bank loan rates, and monitoring, *Journal of Finance* 71, 1295–1322.

Chakrabarti, Rajashri, and Nathaniel Pattison, 2019, Auto credit and the 2005 bankruptcy reform: The impact of eliminating cramdowns, *The Review of Financial Studies* 32, 4734–4766.

Chaney, Thomas, David Sraer, and David Thesmar, 2012, The collateral channel: How real estate shocks affect corporate investment, *American Economic Review* 102, 2381–2409.

Cohn, Jonathan B., Zack Liu, and Malcolm I. Wardlaw, 2022, Count (and count-like) data in finance, *Journal of Financial Economics* 146, 529–551.

Demarzo, Peter M, 2019, Presidential address: Collateral and commitment, *Journal of Finance* 74, 1587–1619.

Dewatripont, Mathias, and Jean Tirole, 1994, A theory of debt and equity: Diversity of securities and manager-shareholder congruence, *Quarterly Journal of Economics* 109, 1027–1054.

Disney, Richard, John Gathergood, and Andrew Henley, 2010, House price shocks, negative equity, and household consumption in the united kingdom, *Journal of the European Economic Association* 8, 1179–1207.

Doornik, Bernardus Ferdinandus Nazar Van, Armando R Gomes, David Schoenherr, and Janis Skrastins, 2021, Financial access and labor market outcomes: Evidence from credit lotteries, *Working Paper* .

Einav, Liran, Mark Jenkins, and Jonathan Levin, 2012, Contract pricing in consumer credit markets, *Econometrica* 80, 1387–1432.

Foote, Christopher L, Kristopher Gerardi, and Paul S Willen, 2008, Negative equity and foreclosure: Theory and evidence, *Journal of urban economics* 64, 234–245.

Fulford, Scott, Eric Wilson, Zoe , Kruse, Emma Kalish, and Isaac Cotter, 2023, Making ends meet in 2023: Insights from the making ends meet survey, *Consumer Financial Protection Bureau Office of Research Reports Series* .

Gan, Jie, 2007, Collateral, debt capacity, and corporate investment: Evidence from a natural experiment, *Journal of Financial Economics* 85, 709–734.

Ganong, Peter, and Simon J́ager, 2018, A permutation test for the regression kink design, *Journal of the American Statistical Association* 113, 494–504.

Gathergood, John, Benedict Guttman-Kenney, and Stefan Hunt, 2019, How do payday loans affect borrowers? evidence from the uk market, *The Review of Financial Studies* 32, 496–523.

Gautier, Pieter A, and Yves Zenou, 2010, Car ownership and the labor market of ethnic minorities, *Journal of Urban Economics* 67, 392–403.

Goodman-Bacon, Andrew, 2021, Difference-in-differences with variation in treatment timing, *Journal of Econometrics* 225, 254–277.

Gormley, Todd A., and David A. Matsa, 2011, Growing out of trouble? Corporate responses to liability risk, *Review of Financial Studies* 24, 2781–2821.

Grunewald, Andreas, Jonathan Lanning, David Low, and Tobias Salz, 2023, Auto dealer loan intermediation: Consumer behavior and competitive effects, Working paper.

Gurley, Tami, and Donald Bruce, 2005, The effects of car access on employment outcomes for welfare recipients, *Journal of Urban Economics* 58, 250–272.

Hart, O., and J. Moore, 1994, A theory of debt based on the inalienability of human capital, *Quarterly Journal of Economics* 109, 841–879.

Hart, Oliver, and John Moore, 1998, Default and renegotiation: A dynamic model of debt, *Quarterly Journal of Economics* 113, 1–41.

Hartman-Glaser, Barney, Simon Mayer, and Konstantin Milbradt, 2023, A theory of asset-and cash flow-based financing, *NBER Working Paper* 29712.

He, Zhiguo, Jing Huang, and Jidong Zhou, 2023, Open banking: Credit market competition when borrowers own the data, *Journal of financial economics* 147, 449–474.

Holmstrom, Bengt, and Jean Tirole, 1997, Financial intermediation, loanable funds, and the real sector, *Quarterly Journal of Economics* 112, 663–691.

Hortaçsu, Ali, Gregor Matvos, Chad Syverson, and Sriram Venkataraman, 2013, Indirect costs of financial distress in durable goods industries: The case of auto manufacturers, *Review of Financial Studies* 26, 1248–1290.

Insurance Networking News, November 15, 2015, What's driving total loss frequency?

Ioannidou, Vasso, Nicola Pavanini, and Yushi Peng, 2022, Collateral and asymmetric information in lending markets, *Journal of Financial Economics* 144, 93–121.

Jack, William, Michael Kremer, Joost De Laat, and Tavneet Suri, 2023, Credit access, selection, and incentives in a market for asset-collateralized loans: Evidence from Kenya, *Review of Economic Studies* .

Jahan, Nusrat, 2020, Does asset durability impede financing? An empirical assessment, Working Paper.

Jimenez, Gabriel, Vicente Salas, and Jesus Saurina, 2006, Determinants of collateral, *Journal of Financial Economics* 81, 255–281.

John, Kose, Anthony W Lynch, and Manju Puri, 2003, Credit ratings, collateral, and loan characteristics: Implications for yield, *Journal of Business* 76, 371–409.

Karlan, Dean, and Jonathan Zinman, 2009, Observing unobservables: Identifying information asymmetries with a consumer credit field experiment, *Econometrica* 77, 1993–2008.

Leeth, John D, and Jonathan A Scott, 1989, The incidence of secured debt: Evidence from the small business community, *Journal of Financial and Quantitative Analysis* 24, 379–394.

Li, Kai, and Chi-Yang Tsou, 2020, The asset durability premium, Working Paper.

Lian, Chen, and Yueran Ma, 2021, Anatomy of corporate borrowing constraints, *Quarterly Journal of Economics* 136, 229–291.

Ma, Song, Justin Murfin, and Ryan Pratt, 2022, Young firms, old capital, *Journal of Financial Economics* 146, 331–356.

McIntyre, Frank, Daniel M Sullivan, and Laura Summers, 2015, Lawyers steer clients toward lucrative filings: Evidence from consumer bankruptcies, *American Law and Economics Review* 17, 245–289.

Melzer, Brian T, 2017, Mortgage debt overhang: Reduced investment by homeowners at risk of default, *The Journal of Finance* 72, 575–612.

Mills, Claire, Rebecca Landau, Belicia Rodriguez, and Joelle Scally, 2022, The state of low-income america: Credit access & debt payment, *Fed. Rsrv. Bank of NY* .

Moody, Joanna, Elizabeth Farr, Marisa Papagelis, and David R Keith, 2021, The value of car ownership and use in the United States, *Nature Sustainability* 4, 769–774.

Morse, Adair, 2011, Payday lenders: Heroes or villains?, *Journal of Financial Economics* 102, 28–44.

Rampini, Adriano A., 2019, Financing durable assets, *American Economic Review* 109, 664–701.

Rampini, Adriano A, and S Viswanathan, 2010, Collateral, risk management, and the distribution of debt capacity, *Journal of Finance* 65, 2293–2322.

Rampini, Adriano A, and S Viswanathan, 2013, Collateral and capital structure, *Journal of Financial Economics* 109, 466–492.

Rampini, Adriano A, and S Viswanathan, 2020, Collateral and secured debt, *Unpublished working paper, Duke University* .

Ratnadiwakara, Dimuthu, 2021, Collateral value and strategic default: Evidence from auto loans, *Journal of Financial Services Research* 59, 209–240.

Silva, J. M. C. Santos, and Silvana Tenreyro, 2006, The log of gravity, *Review of Economics and Statistics* 88, 641–658.

Skiba, Paige Marta, and Jeremy Tobacman, 2019, Do payday loans cause bankruptcy?, *The Journal of Law and Economics* 62, 485–519.

Titman, Sheridan, 1984, The effect of capital structure on a firm's liquidation decision, *Journal of Financial Economics* 13, 137–151.

Titman, Sheridan, and Roberto Wessels, 1988, The determinants of capital structure choice, *Journal of Finance* 43, 1–19.

Zabritski, Melinda, 2019, State of the automotive finance market. Fourth Quarter 2019, Experian.

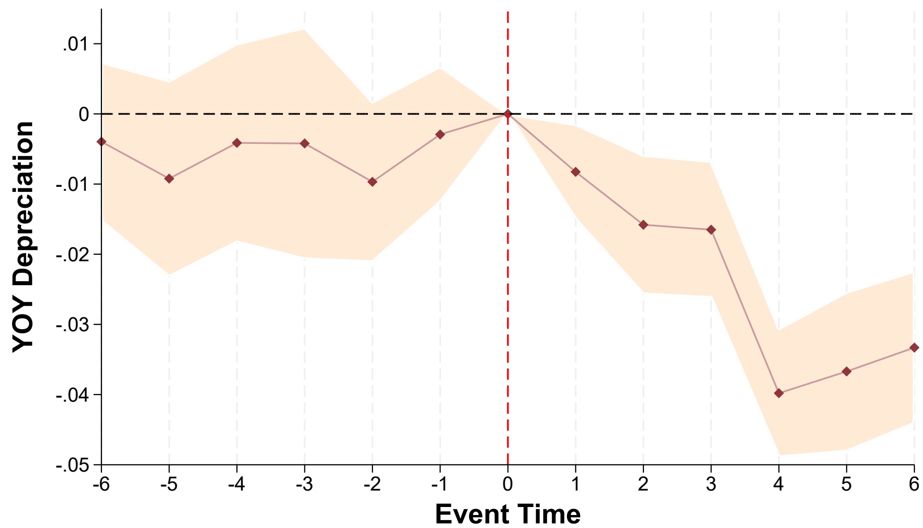

Figure 1: **YoY Depreciation against Event Time.** This figure presents differences in the year-over-year depreciation across vehicles (models & makes) that were discontinued and those that were not. The plot displays the regression coefficients for timing indicators around the year the model was discontinued (discontinuation year=0). The dependent variable is the percentage change in the average annual wholesale value of the vehicle as reported by Black Book. Included fixed effects are Make/Model x Vintage Year and Contract Year x Parent Company.

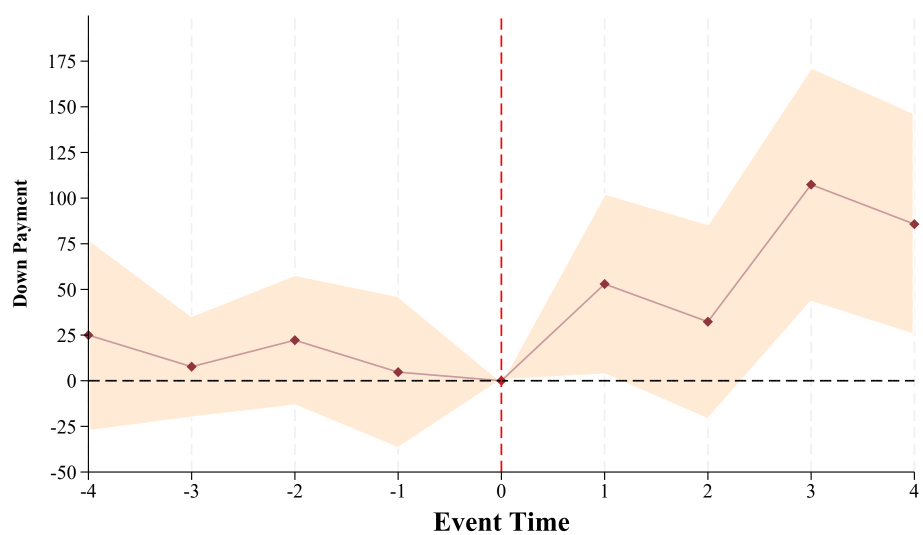

Figure 2: **Down Payment against Event Time.** This figure presents differences in the down payments across vehicles (models & makes) that were discontinued and those that were not. The plot is the regression coefficients for timing indicators around the year the model was discontinued (discontinuation year=0). The dependent variable is the down payment for the vehicle. Included fixed effects are Make/Model x Vintage Year, Dealership, and Contract Year x Parent Company.

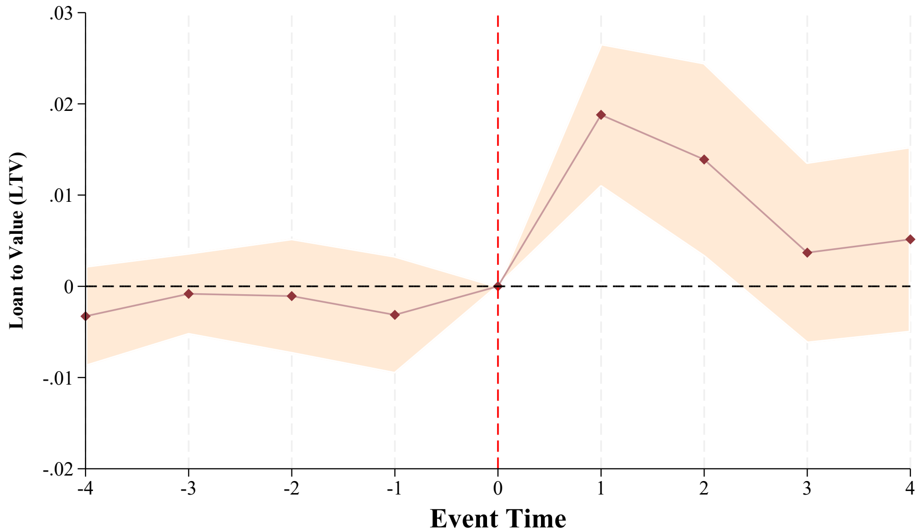

Figure 3: **LTV against Event Time.** This figure presents differences in the loan to value (LTV) across vehicles (models & makes) that were discontinued and those that were not. The plot is the regression coefficients for timing indicators around the year the model was discontinued (discontinuation year=0). The dependent variable is the loan amount divided by the reported vehicle value to the lender for the vehicle. Included fixed effects are Make/Model x Vintage Year, Dealership, and Contract Year x Parent Company.

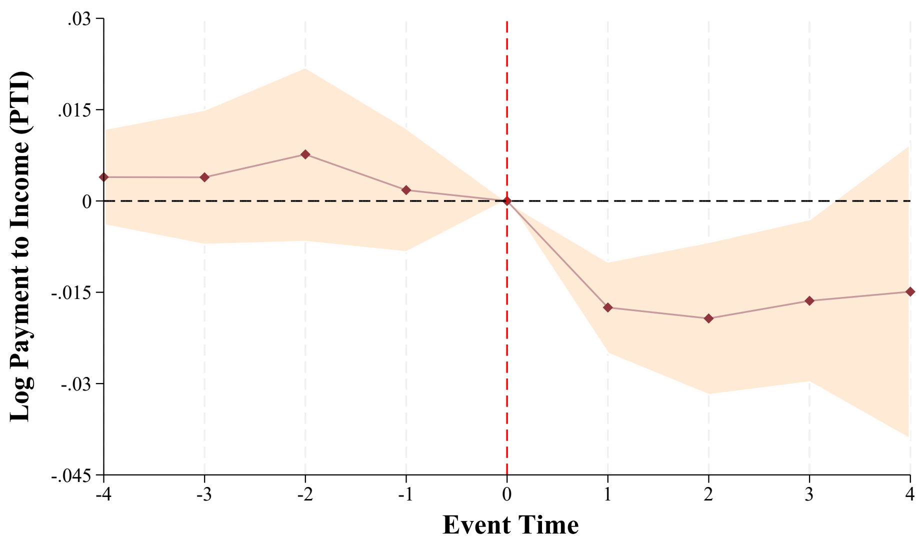

Figure 4: **PTI against Event Time.** This figure presents differences in the log of the payment to income ratio (PTI) across vehicle make-models that were discontinued and those that were not. The plot is the regression coefficients for timing indicators around the year the model was discontinued (discontinuation year=0). The dependent variable is the log of the borrower's monthly payment to the borrower's monthly income. Included fixed effects are Make/Model x Vintage Year, Dealership, borrower income decile, and Contract Year x Parent Company.

Table 1: **Summary Statistics.** This table reports summary statistics for the variables used in the analysis. Panel A provides statistics from Black Book based on annual averages. Panel B provides summary statistics for the loan-level data. Appendix Table F.1 describes the variables. All continuous variables are winsorized at the 1st and 99th percentile.

	Mean	S.D.	25th Pctile	Median	75th Pctile	Obs
Panel A: Black Book Data						
Post Discontinuation (=1)	0.21	0.41	0.00	0.00	0.00	53723
Wholesale Value ($)	12493	10955	4206	9667	17165	53723
YOY Depreciation (%)	-0.15	0.09	-0.20	-0.15	-0.09	48413
Wholesale Value – New ($)	23395	10846	15363	20647	29020	3665
Panel B: Loan Data						
<u>**Borrower**</u>						
Income ($)	4405	1797	3091	3963	5265	286080
Credit Score	531.84	49.94	497.00	531.00	565.33	311007
Chapter 7 Bankruptcy (=1)	0.22	0.41	0.00	0.00	0.00	326629
Chapter 13 Bankruptcy (=1)	0.08	0.28	0.00	0.00	0.00	326629
Homeowner (=1)	0.06	0.23	0.00	0.00	0.00	326629
<u>**Vehicle**</u>						
Post Discontinuation (=1)	0.05	0.22	0.00	0.00	0.00	326629
Vehicle Mileage ('000)	39.21	21.46	25.15	38.29	52.68	323561
Dealer Profit ('000 $)	4.36	2.35	2.66	4.21	6.01	326629
Vehicle Margin ('000$)	4.27	2.26	2.69	4.17	5.77	326629
<u>**Purchase & Loan**</u>						
Wholesale Value ($)	13540	4172	10725	13046	15727	326629
Wholesale Value ($) – When New	18896	4255	15992	18380	21240	284173
Purchase Price ($)	17107	4626	14029	16764	196971	319352
Scaled Price (%)	72.30	17.98	59.79	70.33	82.81	284173
Down Payment ($)	1011	1120	0.00	800	1500	326372
LTV	1.29	0.17	1.18	1.29	1.42	326629
APR (%)	19.34	2.78	17.95	19.49	21.00	326629
Loan Term (months)	67.72	6.88	66.00	72.00	72.00	326622
Payment to Income	0.10	0.03	0.08	0.11	0.13	286082
Default (=1)	0.26	0.44	0.00	0.00	1.00	326629
Time to Default (Months)	30.93	17.52	17.00	28.00	42.00	84344
Gross Default ($)	12436	5827	8668	13070	16552	80803
Vehicle Recovery ($)	3483	3330	0.00	2925	5895	75785
Income Recovery ($)	1171	2512	0.00	0.00	641	79402

Table 2: **Vehicle Depreciation and Model Discontinuation.** This table reports estimates from panel regressions of the average vehicle reported value wholesale value from Black Book on model discontinuation and event time indicators. In columns (1) and (2), the dependent variable is the vehicle *YoY Depreciation*, the percentage change in the average wholesale value as reported by Black Book. In columns (3) and (4), the dependent variable is the vehicle's *wholesale*, the average vehicle wholesale value reported by Black Book. *Post-Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Event time indicators are relative to the discontinuation date, with discontinuation occurring at time 0, as in Figure 1. Fixed effects are as described in the table. Parent fixed effects relate to the parent company of the make and model. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	YoY Depreciation (%)		Wholesale ($)	
	(1)	(2)	(3)	(4)
Post Discontinuation (=1)	-0.012**		-1068.22**	
	(-2.60)		(-2.50)	
Event Time = -6		-0.004		232.73
		(-0.71)		(0.50)
Event Time = -5		-0.009		3.99
		(-1.33)		(0.01)
Event Time = -4		-0.004		100.95
		(-0.59)		(0.24)
Event Time = -3		-0.004		3.21
		(-0.52)		(0.01)
Event Time = -2		-0.010*		-181.96
		(-1.71)		(-0.59)
Event Time = -1		-0.003		-363.17
		(-0.61)		(-1.19)
Event Time = 1		-0.008**		-1055.13***
		(-2.46)		(-3.00)
Event Time = 2		-0.016***		-1544.99***
		(-3.22)		(-4.61)
Event Time = 3		-0.017***		-1860.30***
		(-3.42)		(-5.74)
Event Time = 4		-0.040***		-2035.32***
		(-8.74)		(-6.80)
Event Time = 5		-0.037***		-1959.30***
		(-6.51)		(-7.32)
Event Time = 6		-0.033***		-1943.10***
		(-6.17)		(-7.22)
Vehicle Model x Vintage FEs	Yes	Yes	Yes	Yes
Parent x Contract Year FEs	Yes	Yes	Yes	Yes
Observations	48086	48086	53496	53496
Adjusted R^2	0.369	0.375	0.887	0.888

Table 3: **Vehicle Wholesale Value and Model Discontinuation.** This table reports estimates from panel regressions of the vehicle's reported value on model discontinuation. In columns (1) to (3), the dependent variable is the vehicle *Wholesale Value*, the wholesale value of the vehicle reported to the lender at loan origination. In columns (4) and (5), the dependent variable is the vehicle's *Scaled Price*, the vehicle wholesale value reported to the lender at origination over the average of the given vehicle model and year wholesale value when new. *Post-Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Wholesale Value ($)			Scaled Price (%)		
	(1)	(2)	(3)	(4)	(5)	(6)
Post Discontinuation (=1)	-262.60**	-319.35***	-246.35**	-3.54***	-3.47***	-2.85***
	(-2.39)	(-3.14)	(-2.33)	(-4.33)	(-4.31)	(-5.79)
Log Income		1219.56***	1143.55***		6.09***	5.48***
		(27.41)	(24.42)		(28.37)	(26.59)
Credit Score		1.20***	1.22***		0.01***	0.01***
		(6.31)	(5.99)		(5.26)	(4.88)
Ch. 7 Bankruptcy (=1)		130.06***	161.74***		0.61***	0.78***
		(8.97)	(15.07)		(8.49)	(14.89)
Ch. 13 Bankruptcy (=1)		-130.53***	-150.95***		-0.66***	-0.70***
		(-4.44)	(-4.60)		(-4.74)	(-4.28)
Homeowner (=1)		-44.31**	-28.31*		-0.36***	-0.27***
		(-2.54)	(-1.77)		(-3.79)	(-3.06)
Log Mileage			-638.25***			-3.55***
			(-22.05)			(-23.30)
Dealer Profit ('000 $)			-96.89***			-0.46***
			(-13.05)			(-10.36)
Veh. Model x Vintage FEs	Yes	Yes	Yes	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Contract Yr. FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	324823	273365	272725	283515	247874	247350
Adjusted R^2	0.773	0.761	0.816	0.676	0.686	0.777

Table 4: **Default Recovery and Model Discontinuation.** This table reports estimates from panel regressions of proxies of the vehicle's residual value. The dependent variables is the *Vehicle Recovery* represents the recovery value that the lender receives from the vehicle liquidation after default over the vehicle's wholesale value at origination. All observations are conditional on default. Columns (3) contains additional fixed effects for both the year of the default interacted with the vehicle model as well as the recovery type. *Post-Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Vehicle Recovery (%)	(1)	(2)	(3)
Post Discontinuation (=1)	-1.49**	-2.08***	-1.40**
	(-2.45)	(-3.72)	(-2.20)
Vehicle Model x Vintage FE	Yes	Yes	Yes
Parent x Contract Year FE	Yes	Yes	Yes
Dealership FE	Yes	Yes	Yes
Model x Default Year FE	No	No	Yes
Recovery Type FE	No	No	Yes
Borrower Controls	No	Yes	Yes
Vehicle Controls	No	Yes	Yes
Time to Default Control	No	Yes	Yes
Observations	73986	64634	63823
Adjusted R^2	0.087	0.272	0.581

Table 5: **Borrower Income and Model Discontinuation.** This table reports estimates from panel regressions of borrower income. The dependent variable in columns (1-2) is *Low Income* $= 1$ an indicator for whether the borrower was in the bottom quartile of income for borrowers in that year. The dependent variable in columns (3-4) is the *Log Income* of the borrower reported to the lender at the time of the origination. The dependent variable in columns (5-6) is the borrower income, and the regression is estimated via Poisson pseudo-likelihood regression. *Post Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The reported R^2 in columns (5-6) is the pseudo-R^2 from the Poisson regression. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Dep. Var.	Low Income (=1)		Log Income		Income (Poisson)	
	(1)	(2)	(3)	(4)	(5)	(6)
Post Discontinuation (=1)	3.43^{***}	3.31^{***}	-0.014^{**}	-0.013^{*}	-0.018^{***}	-0.016^{**}
	(2.81)	(2.73)	(-2.21)	(-1.85)	(-2.80)	(-2.50)
Vehicle Model x Vintage FE	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Contract Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Dealership FE	Yes	Yes	Yes	Yes	Yes	Yes
Vehicle Controls	No	Yes	No	Yes	No	Yes
Observations	284573	283928	284573	283928	284573	283928
Adjusted R^2	0.142	0.184	0.242	0.282	0.252	0.283

Table 6: **Down payment and Model Discontinuation.** This table reports estimates from panel regressions of the vehicle's down payment at origination and the vehicle's down payment over the purchase price. The dependent variable in columns (1) to (3) is the winsorized vehicle's *Down Payment*, the cash amount that the borrower pays at loan origination. The dependent variable in columns (4) to (6) is the *Down payment to Price* ratio, the down payment divided by the purchase price at origination in %. *Post Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Down Payment ($)			Down Payment / Price (%)		
	(1)	(2)	(3)	(4)	(5)	(6)
Post Discontinuation (=1)	74.02***	60.94**	78.55***	0.60***	0.47***	0.49***
	(3.32)	(2.05)	(2.97)	(4.85)	(3.35)	(3.59)
Wholesale Value ($)			0.07***			0.00***
			(27.57)			(10.09)
Vehicle Model x Vintage FEs	Yes	Yes	Yes	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Transaction Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Borrower Controls	No	Yes	Yes	No	Yes	Yes
Vehicle Controls	No	Yes	Yes	No	Yes	Yes
Observations	324567	272472	272472	317555	265708	265708
Adjusted R^2	0.216	0.226	0.239	0.267	0.199	0.200

Table 7: **Loan to Value (LTV) and Model Discontinuation.** This table reports estimates from panel regressions of the loan to value (LTV) ratio. The dependent variable in columns (1) to (3) is the *Loan-to-Value* (LTV) ratio, which is the amount financed over the reported wholesale vehicle value. *Post Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Loan-to-Value (LTV)	(1)	(2)	(3)
Post Discontinuation (=1)	0.016***	0.018***	0.014***
	(3.14)	(3.53)	(6.23)
Vehicle Model x Vintage FEs	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes
Parent x Contract Year FEs	Yes	Yes	Yes
Borrower Controls	No	Yes	Yes
Vehicle Controls	No	No	Yes
Observations	324823	273365	272725
Adjusted R^2	0.345	0.339	0.709

Table 8: **Payment to Income (PTI) and Model Discontinuation.** This table reports estimates from panel regressions of the payment to income ratio of the borrower. The dependent variable is the natural log of the *Payment-to-Income* ratio (PTI) in columns (1-4), which the is borrower's estimated monthly payment over the borrower's reported monthly income, and the PTI ratio in columns (5-8), multiplied by 100 for readability. *Post Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Log(PTI)				PTI			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post Discontinuation (=1)	-0.017**	-0.023***	-0.027***	-0.023***	-0.163**	-0.241***	-0.255***	-0.229***
	(-2.12)	(-5.43)	(-6.19)	(-5.38)	(-2.39)	(-6.31)	(-7.66)	(-6.56)
Vehicle Model x Vintage FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Contract Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dealership FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income Decile FE	No	Yes	No	Yes	No	Yes	No	Yes
Borrower Controls	No	No	Yes	Yes	No	No	Yes	Yes
Vehicle Controls	No	No	Yes	Yes	No	No	Yes	Yes
Observations	284575	284573	272725	272725	284575	284573	272725	272725
Adjusted R^2	0.041	0.527	0.566	0.546	0.053	0.639	0.673	0.661

Table 9: **Vehicle Recovery and Purchase Timing.** This table reports estimates from panel regressions of the vehicle based recovery on defaulted loans. For vehicles that are discontinued or eventually discontinued only vehicles purchased within +/- 2 years of discontinuation are included. In columns (1) to (3), the dependent variable is the *Vehicle Recovery* value. In columns (4) to (6), the dependent variable is the percent of the vehicle's original wholesale value recovered via vehicle recovery. In columns (7) to (9), the dependent variable is the percent of the balance of a defaulted loan recovered via vehicle recovery. All recovery values are net of fees. *Post-Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. *Purchased Pre., Default Post* is an indicator for if the vehicle was purchased prior to discontinuation but the loan defaulted after discontinuation. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. The F-statistic and associated p-values for whether *Post-Discontinuation* is equal to *Post-Discontinuation* is reported in the bottom row. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Veh. Rec. ($)			Veh. Rec./Default (%)		
	(1)	(2)	(3)	(4)	(5)	(6)
Post Discontinuation (=1)	-239.03***	-419.69***	-355.86***	-1.54***	-2.88***	-2.66***
	(-3.37)	(-4.19)	(-3.71)	(-5.06)	(-5.62)	(-4.91)
Purchased Before, Defaulted After (=1)		-205.16**	-175.59**		-1.53**	-1.40**
		(-2.67)	(-2.35)		(-2.66)	(-2.33)
F-Stat (Post Disc. = Purch. Before, Def. After)		8.33	7.45		15.87	18.75
		(0.0064)	(0.0096)		(0.0003)	(0.0001)
Vehicle Model x Vintage FE	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Contract Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Dealership FE	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Default Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Recovery Type FE	Yes	Yes	Yes	Yes	Yes	Yes
Borrower Controls	No	No	Yes	No	No	Yes
Vehicle Controls	No	No	Yes	No	No	Yes
Time to Default Control	No	No	Yes	No	No	Yes
Observations	57521	57521	55747	57510	57510	55738
Adjusted R^2	0.566	0.566	0.578	0.502	0.503	0.508

Table 10: **Income Recovery and Model Discontinuation.** This table reports estimates from panel regressions of the income based recovery on defaulted loans. In columns (1) to (3), the dependent variable is the dollar value of the *Income Recovery* amount net of fees. In columns (4) and (5), the dependent variables is the percent of the balance of a defaulted loan recovered via the income of the borrower net of fees. *Post-Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. *Gross Default* is the remaining portion of the loan outstanding at default. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Inc. Rec. ($)			Inc. Rec./Default (%)	
	(1)	(2)	(3)	(4)	(5)
Post Discontinuation (=1)	104.85*	112.86*	139.42**	1.55*	1.78*
	(1.70)	(1.77)	(2.19)	(1.75)	(2.00)
Gross Default Amount ('000 $)			51.86***		
			(10.54)		
Vehicle Model x Vintage FE	Yes	Yes	Yes	Yes	Yes
Parent x Contract Year FE	Yes	Yes	Yes	Yes	Yes
Dealership FE	Yes	Yes	Yes	Yes	Yes
Model x Default Year FE	Yes	Yes	Yes	Yes	Yes
Recovery Type FE	Yes	Yes	Yes	Yes	Yes
Borrower Controls	No	Yes	Yes	No	Yes
Vehicle Controls	No	Yes	Yes	No	Yes
Time to Default Control	No	Yes	Yes	No	Yes
Observations	70030	67962	67961	70017	67951
Adjusted R^2	0.102	0.107	0.113	0.111	0.114

Internet Appendix for: "Collateral Damage: Low-Income Borrowers Depend on Income-Based Lending"

Appendix A. Related Literature

It is clear that collateral is valuable because it allows lenders to recover potential losses in the event of a default. This theme has been explored in an influential theoretical literature (Bernanke and Gertler, 1989; Hart and Moore, 1994, 1998; Rampini and Viswanathan, 2010, 2013; Rampini, 2019; Demarzo, 2019) and has been extensively validated in empirical tests (Benmelech et al., 2005; Benmelech, 2009; Gan, 2007; Chaney et al., 2012; Cerqueiro et al., 2016; Jahan, 2020; Li and Tsou, 2020; Ioannidou et al., 2022; Barbiero et al., 2024). The IBL-specific component of lending, by contrast, is tied to the profit or income generated by the borrower (Dewatripont and Tirole, 1994; Holmstrom and Tirole, 1997).

Chakrabarti and Pattison (2019) study the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA) and point out that it made it harder for bankrupt auto borrowers to discharge debt in excess of the collateral value of their vehicles. In the context of our setting, BAPCPA essentially raised the IBL component of borrowing. Chakrabarti and Pattison (2019) show that BAPCPA led to lower rates and perhaps larger loans for subprime borrowers. The discontinuations we analyze, by contrast, reduce the ABL element of borrowing. Despite the reduction in ABL, we find that discontinuations lead to an increase in LTVs, due to a selection effect within the borrower group. We find only a very small positive impact on interest rates.

In the corporate setting, large and profitable borrowing firms make extensive use of unsecured lending (also called cash flow-based lending), while small and less profitable lending firms depend almost exclusively on asset-based lending supported by specific collateral (Leeth and Scott, 1989; John et al., 2003; Jimenez et al., 2006; Lian and Ma, 2021; Ma et al., 2022; Hartman-Glaser et al., 2023). That is, resource-constrained firms are more likely to use secured borrowing. By contrast, we show in the consumer auto loan market that IBL, an unsecured form of lending, is especially important for low-income borrowers. These divergent findings may arise from the fact that in the corporate market firms mainly choose between secured and unsecured business financing; the owner's personal capacity for IBL is generally of too small scale to support a firm's borrowing. Constrained companies use secured business borrowing, despite its costs, because it gives them access to more financing than unsecured business lending (Rampini and Viswanathan, 2020). However, in the consumer market, borrowers have the option of using IBL that is large enough to support their purchases. We find that low-income borrowers make particular use of this type of unsecured borrowing.

Studies on the impact of shifting collateral values have found that negative housing equity leads to reduced investment (Melzer, 2017), higher default risk (Foote et al., 2008), lower labor supply (Bernstein, 2021) and diminished consumption (Disney et al., 2010).[32] We show that the reduced collateral value of discontinued cars leads to a selection effect in the types of buyer. As a consequence, for autos, in contrast to the dynamic in housing markets, we find that investment is higher for borrowers who personally experience a negative collateral shock than for those who purchase after the shock (i.e., borrower-dependent depreciation is lower for those who purchased before the shock). For houses, an ex post drop in collateral value has a negative treatment effect on owners' incentives to invest in their assets. In the auto market, however, the negatively selected post-discontinuation buyers appear not to have the resources to maintain their vehicles; this mechanism is stronger than the negative effect of a discontinuation shock on the investment incentives of current owners. As a result, investment is higher for those whose collateral drops unexpectedly in value.

Appendix B. Theoretical Setup

To illustrate the effects of a durability shock on consumer financing of asset purchases, we provide a simple model of financing. The key difference between our model and others that examine the effects of durability (e.g., Rampini, 2019), is that we allow for asset-based lending (ABL) and income-based lending (IBL). We show that the addition of a sufficient level of IBL combined with lower income borrowers that depend relatively more on IBL is central to explaining our empirical results. The model consists of two periods and three agents (consumers, sellers, and lenders). All agents are risk-neutral and there is no uncertainty.

[32] In the housing context, equity is typically positive at origination and may be subject to ex post negative shocks. Our setting differs in that most borrowers have negative equity when initially financing their vehicles.

Appendix B.1. Consumers and Goods

There are two types of consumers (lower and higher income) $i \in \{L, H\}$. Both types of consumers have income I_i in each period, but differ in the level of their income, where $I_H > I_L > 0$. We also assume that the difference in income is not too large, so $2I_L > I_H$. Consumers can purchase one of two types of goods $G \in \{MD, LD\}$, which we denote more durable and less durable. In our baseline model, we assume more durable goods have value $2\gamma > 0$ in the first period and value γ in the second period. Less durable goods have value $(1+\delta)\gamma$ in the first period and value $\delta\gamma$ in the second period, where $\delta \in (0, 1)$ represents the residual value of the less durable good relative to the more durable good. The central difference between goods is their degree of depreciation. The seller (e.g., a car dealership) of the good charges a constant markup κ and a proportional markup μ on the value of the good, where $\kappa \geq 0$ and $\mu \geq 1$ and at least one of these inequalities is strict, meaning the combined price of a good is

$$\kappa + \mu 2\gamma \text{ if } G = MD$$

$$\kappa + \mu(1+\delta)\gamma \text{ if } G = LD$$

Consumers do not face shocks, information is full, and consumers prefer current consumption over delayed consumption. Note that the latter assumption is valid if, for example, the lender is more patient than the consumer or if the lender has more diversified income. Moreover, we assume that both types of consumers would always prefer the more durable product if they could afford it. We further presume that purchasing the less durable good is attractive relative to purchasing nothing, even accounting for consumers' subjective preference for first-period consumption.

Appendix B.2. Pledgeability of Assets and Income

Consumers can borrow from a competitive set of lenders to finance their purchase. As in Rampini (2019), due to the limited pledgeability of the assets, lenders require collateral. The consumer can pledge the good's residual value in the second period (i.e., ABL) as well as their income in the second period (i.e., IBL). The pledgeability of assets and income is denoted by $\{\theta_G, \theta_I\}$, where both are bounded between $[0, 1)$, which represent the fraction of the asset and income, respectively, that can be pledged as collateral. Naturally, as the pledgeability of income θ_I (assets θ_G) tends toward 0, the financing will increasingly consist of ABL (IBL). The pledgeability of income reflects the potential for the lender to recover the remaining portion of the loan in default from sources of income (e.g., wage garnishment): a fraction up to θ_I of the borrower's second-period income may be seized by the lender. The pledgeability of assets reflects the lender's claim on the assets. In the second period, the lender may repossess the asset and receive a fraction θ_G of its residual value. In equilibrium, the borrower will instead sell the asset for its residual value and make the pledged payment. For simplicity, we assume that the risk-free rate is 0. Consumers face no sanction or cost from defaulting other than the loss of any pledged income or the good.

To examine the interesting parameter space of the model, we assume that high (low)-income consumers can (cannot) afford the more durable good if they borrow their maximum feasible limit.

$$\theta_I I_L + \theta_G \gamma + I_L < \mu 2\gamma + \kappa < \theta_I I_H + \theta_G \gamma + I_H. \tag{B1}$$

Lower-income consumers, however, can afford the less durable good,

$$\theta_G \delta\gamma + \theta_I I_L + I_L > \mu(1+\delta)\gamma + \kappa. \tag{B2}$$

We assume that κ and μ are such that equations B1 and B2 hold.

Appendix B.3. Analysis

We now solve for the loan characteristics of lower income and higher income consumers. Specifically, we examine (1) down payments, (2) loan-to-value ratios, and (3) payment-to-income ratios of the two types of consumers and then examine the effects of allowing the pledgeability of income θ_I and the degree of depreciation δ to vary.

Appendix B.3.1. Down Payments

Given the pledgeability constraints and the markup, consumers need to pay for some portion of the good in period 1 using their first period income I_i. Under the assumption that consumers prefer to maximize first period consumption, the consumer will seek to minimize their down payment and maximize their borrowing. We examine the down payments for consumers who purchase the more durable and less durable good separately.

The down payment for the consumer who purchases the more durable good is

$$\kappa + \mu 2\gamma - \gamma\theta_G - I_i\theta_I. \tag{B3}$$

The down payment for the consumer who purchases the less durable good is

$$\kappa + \mu(1+\delta)\gamma - \gamma\delta\theta_G - I_i\theta_I. \tag{B4}$$

If income is sufficiently pledgeable, specifically if

$$\theta_I > \frac{\gamma(1-\delta)(\mu-\theta_G)}{I_H - I_L}, \tag{B5}$$

then the down payment is greater for the less durable good purchased by the lower-income consumer, otherwise the down payment will be greater for the more durable good. This condition states that the income pledgeability constraint weakens when the difference between the non-pledgeable value of the assets is smaller than the difference in the borrower incomes. As the residual value of the less durable good, δ increases, it becomes relatively more expensive and thus requires a higher down payment, which matches the intuition of Rampini (2019). In addition, an increase in the proportional markup will also cause a relatively larger increase in the down payment of the higher-income borrower, since it is applied to a higher asset value. However, holding the residual value constant, when income pledgeability is high, the down payment of the higher-income borrower is lower, since they can pledge more of their income when borrowing. Thus, whether the down payment of the less durable good is higher depends on the relative difference in the non-pledgeable portion of the assets to the difference in the incomes.

The intuition is that if the residual value is too small, then the *price effect* (i.e., the lower price and down payment from the difference in depreciation) will dominate *the income pledgeability effect* (i.e., lower income supporting smaller income-based loan and therefore a higher down payment).

Appendix B.3.2. Loan-to-Value (LTV) Ratio

We now turn to the loan-to-value (LTV) ratios. The amount of the loan relative to the collateral value of the more durable and less durable good to the lender at origination, that is, 2γ or $(1+\delta)\gamma$.

Again, we examine the LTVs for the purchase of the more durable and less durable goods when both ABL and IBL are available. The LTV for the higher-income consumer who purchases the more durable good is

$$\frac{\gamma\theta_G + I_H\theta_I}{2\gamma}. \tag{B6}$$

The LTV for the low-income consumer who purchases the less durable good is

$$\frac{\gamma\delta\theta_G + I_L\theta_I}{(1+\delta)\gamma}. \tag{B7}$$

If low-income borrowers are heavily dependent on income-based lending, specifically if

$$\delta < \frac{2I_L}{I_H} - 1, \tag{B8}$$

and if

$$\theta_I > \frac{\gamma\theta_G(1-\delta)}{2I_L - (1+\delta)I_H}, \tag{B9}$$

then the LTV is higher for the less durable good, otherwise the LTV is higher for the more durable good. The first condition is stronger than requiring the ratio of IBL to ABL for lower-income borrowers to be higher than that for higher-income borrowers, i.e.,

$$\frac{\theta_I I_L}{\theta_G\delta\gamma} > \frac{\theta_I I_H}{\theta_G\gamma}. \tag{B10}$$

Thus, greater reliance on IBL relative to ABL for lower-income borrowers relative to higher-income borrowers is a necessary condition for the less durable good to have a higher LTV. The second condition is a restriction on the minimal pledgeability of income. Similar to B5, a higher δ, so less difference in durability, or a higher θ_G, the pledgeability of the asset, would require a higher pledgeability of income since the lower-income borrower gets more of their loan from the asset based borrowing.

The intuition is that the income portion of the financing must be more important for the lower-income borrower. If IBL is relatively more important to the lower-income borrower, then their higher dependence on IBL will outweigh the relatively smaller amount they get from borrowing against a lower value asset.

Appendix B.3.3. Payment-to-Income (PTI) Ratio

The payment to income ratio is always lower for the lower-income purchaser as long as the low-income purchases are more dependent on income-based lending, which is satisfied by equation B10 above. It does not depend on the degree of the pledgeability constraints.[33]

Appendix B.3.4. Joint conditions and varying markups

Suppose a) the down payment is higher for the less durable asset, b) the LTV ratio is higher for the less durable asset, and c) the PTI ratio is lower for the less durable asset. The overall restrictions for δ and θ_I for the down payment, LTV, and PTI results are then

$$1 > \theta_I > \frac{\gamma(1-\delta)(\mu-\theta_G)}{I_H - I_L}, \tag{B11}$$

$$1 > \theta_I > \frac{\gamma\theta_G(1-\delta)}{2I_L - (1+\delta)I_H}, \tag{B12}$$

$$\frac{2I_L}{I_H} - 1 > \delta, \tag{B13}$$

$$\frac{I_L}{I_H} > \delta > 0. \tag{B14}$$

Again, note that the fourth condition is equivalent to equation B10, and that it is a weaker condition than the third. Thus, for the LTV to be relatively higher and the PTI to be relatively lower for the less durable good purchased by the lower-income consumer, it must be that the lower-income consumer is more reliant on IBL.

For the conditions on the down payment (first condition) and the LTV conditions (second and third) to hold simultaneously, we need to consider the role of the proportional markup μ. We will consider two extreme cases. First,

[33] Note that the payment to income ratio for both types of consumers will be higher with more IBL (higher θ_I), but since income is in the numerator and denominator of the ratio, the relative level of PTI only depends on the degree of residual value relative to the ratio of incomes.

assume that there is only a proportional markup (i.e., $\kappa = 0$). Then, as long as we restrict down payments to be non-negative, as we generally observe in the data, the three conditions cannot jointly hold.

Lemma B.1: *If $\kappa = 0$, $\mu \geq 1$ and borrowers have non-negative down payments, then it cannot be that the joint restrictions for down payment, LTV, and PTI hold.*

Proof. Since the restrictions imply the down payment of the lower-income borrowers are higher, it must be that the joint conditions hold and the down payment of the higher-income borrower is non-negative

$$\kappa + \mu 2\gamma - \gamma\theta_G - I_H\theta_I \geq 0.$$

Restricting attention to $\kappa = 0$, the above can be rewritten as a restriction on the upper bound of θ_I,

$$\bar{\theta}_I = \frac{\gamma(2\mu - \theta_G)}{I_H} \geq \theta_I.$$

We can now compare this to the two restrictions on θ_I. The restrictions on θ_I for the LTV and down payment imply that $\theta_I > \max\left\{\frac{\gamma(1-\delta)(\mu-\theta_G)}{I_H - I_L}, \frac{\gamma\theta_G(1-\delta)}{2I_L-(1+\delta)I_H}\right\} = \underline{\theta}_I$. Thus, to demonstrate that the conditions cannot hold simultaneously, it is sufficient to show that for all $\theta_G \in (0, 1)$ either the first or second restriction in the brackets is weakly greater than $\bar{\theta}_I$. Focusing on the LTV restriction (the second term in the brackets) yields

$$\frac{\gamma(2\mu - \theta_G)}{I_H} \leq \frac{\gamma(1-\delta)\theta_G}{2I_L - (1+\delta)I_H}.$$

Simplifying and rearranging, using that both denominators are positive (due to the LTV and PTI restrictions on δ), yields

$$(2\mu - \theta_G)(2I_L - (1+\delta)I_H) \leq (1-\delta)\theta_G I_H$$

Denoting $2I_L - (1+\delta)I_H$ as D, we can rewrite this as a restriction on θ_G

$$\theta_G \geq \frac{\mu D}{I_L - \delta I_H}. \tag{B15}$$

Focusing on the down payment restriction (the first term in the brackets above) yields

$$\frac{\gamma(2\mu - \theta_G)}{I_H} \leq \frac{\gamma(1-\delta)(\mu - \theta_G)}{I_H - I_L}.$$

Rearranging and simplifying, using that both denominators are positive (due to the LTV and PTI restrictions on δ) yields

$$(2\mu - \theta_G)(I_H - I_L) \leq (1-\delta)(\mu - \theta_G)I_H,$$

which we can rewrite in terms of restriction on θ_G

$$\theta_G \leq \frac{\mu D}{I_L - \delta I_H}. \quad \text{(B16)}$$

Either equation (B15) or equation (B16) must hold. Thus, either the first or second strict restriction on θ_I will always be violated when down payments are positive, $k = 0$, and $\mu \geq 1$.

□

Second, assume the opposite case that there is only a non-proportional markup (i.e., $\kappa > 0$ and $\mu = 1$). Then there exist parameters such that the three conditions can jointly hold. Thus, for the lower-income borrower to have a relatively higher LTV and down payment, it must be that some non-proportional markup (i.e., $\kappa > 0$) exists.

Appendix B.3.5. Discussion

The existence of constraints on both the pledgeability of income and the importance of income-based lending provide key implications for empirical tests. Specifically, if less durable goods have higher LTVs, higher downpayments, lower PTIs, and are purchased by lower-income consumers, then a key implication of the model is that the lower-income consumers are more dependent on income-based lending, that it must be relatively important for autolending, and that some non-proportional markups exist.[34]

[34] If parameters are chosen such that the higher- and lower-income borrowers both purchase the same asset, unlike in our main model, then lower-income borrowers will have higher down payments and lower LTVs, as they can borrow less against their future income.

Figure B.1 presents a graphical illustration of the results. There are six regions that relate to where the down payment, LTV, and PTI for the least durable good purchased by the lower-income consumer are relative to the more durable good purchased by the higher-income consumer. As the pledgeability of income θ_I increases, IBL becomes a relatively large portion of financing to purchase the asset. As δ decreases, IBL becomes relatively more important for the lower-income borrower, as the residual value of the less durable asset is decreasing, reducing the ability to rely on ABL. When θ_I is relatively high and δ is low, the light green region (I), the LTV and down payment are higher for the less durable asset, and the PTI is lower. The level of θ_I to support higher down payments for the less durable asset, dark red line, must increase to offset the lower price of the less durable asset, otherwise the down payment, LTV, and PTI is lower, the light blue region (V). If δ is above a certain level, then lower-income consumers rely relatively more on ABL and, in return, the LTV is lower and the PTI is higher, the dark and light pink regions (III and IV). If the pledgeability of income is too low relative to the durability of the asset, then the LTV is lower but the down payment is higher, the orange region (II).

The down payment, LTV and PTI conditions do not depend explicitly on κ. Equations (B1) and (B2), however, place restrictions on the values that κ may take. For example, given the baseline parameters for the figure ($I_H = 2.15$, $I_L = 1.8$, $\theta_G = 0.75$, $\mu = 1$, and $\gamma = 1$), assuming $\theta_I = 0.65$ and $\delta = 0.25$, and a value of 1.75 for κ, the equilibrium will reside in region I of the figure.

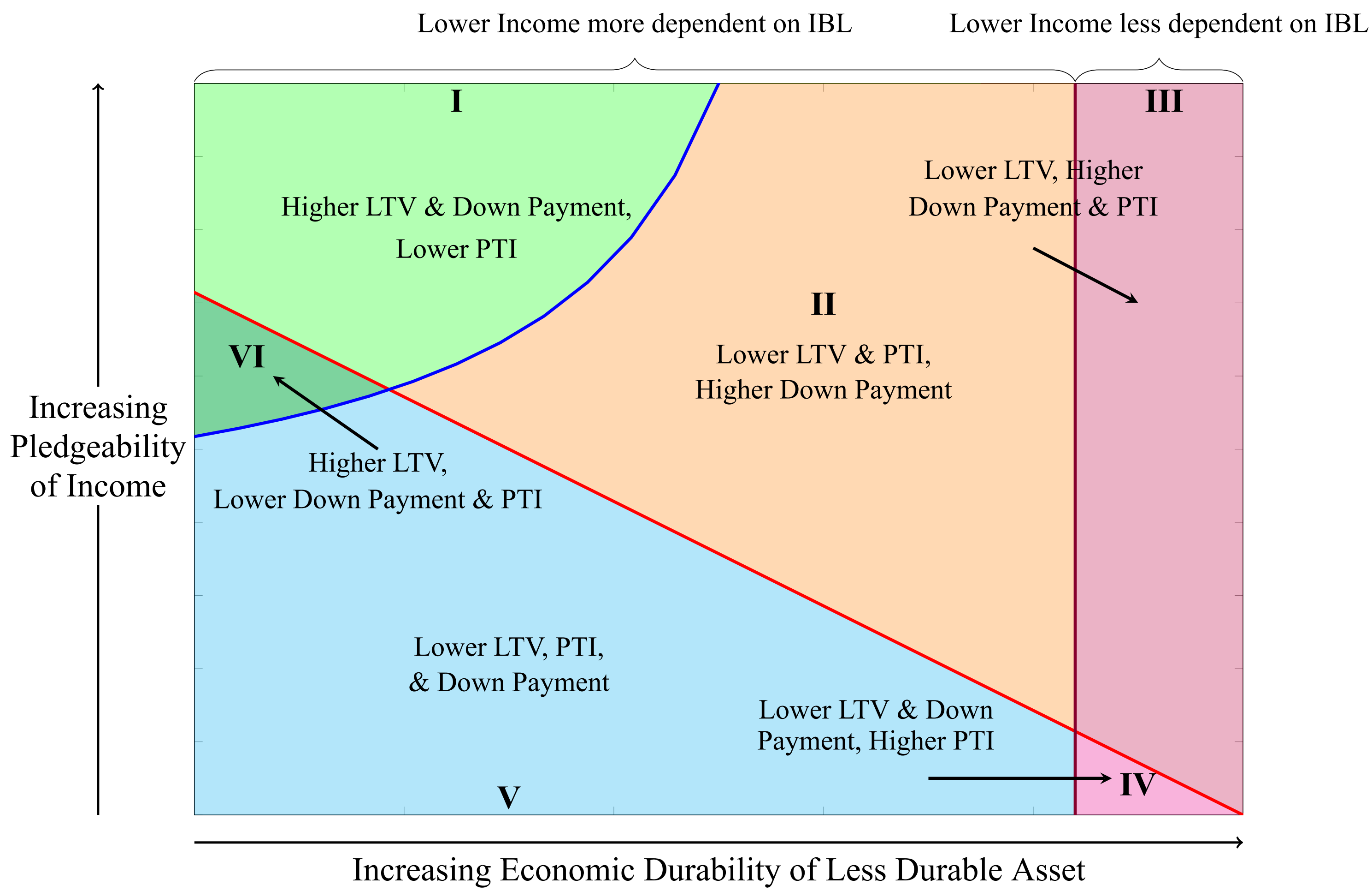

Figure B.1: **Visualization of model equilibria - Less Durable relative to More Durable Asset.** This figure presents four potential equilibrium outcomes of the LTV, down payment, and PTI of the less durable asset relative to the more durable asset. The y-axis is income pledgeability (θ_I), the x-axis is the economic durability of the less durable asset (δ). Model parameters are: $I_H = 2.15$, $I_L = 1.8$, $\theta_G = 0.75$, $\mu = 1$, and $\gamma = 1$.

Appendix B.4. Extension to Include Borrower-Dependent Depreciation

We can extend the model to consider how differences in borrower income affect the depreciation of the asset. For instance, borrowers who are liquidity constrained due to lower income may forgo periodic maintenance of the asset, resulting in more rapid depreciation, and thus a lower residual value.

We make the following additional assumptions. First, the depreciation due to the attributes of the borrower (higher or lower income) is represented in a reduced form by $\psi_i \geq 0$ for $i \in \{L, H\}$. Second, the depreciation is additive and independent of the asset type, such that the asset value in the second period (the residual value) is $\gamma(\delta_G - \psi_i)$ for $G \in \{MD, LD\}$ and $i \in \{L, H\}$. Third, the borrower-based depreciation is not so high that the asset has a non-positive recovery value ($\delta_G - \psi_i > 0$). Finally, we assume that the borrower's type does not affect the purchase price of the asset but only its residual value (i.e., all buyers face the same sticker price for a given asset). We maintain all other assumptions from the baseline model.

Given the above, we can now rewrite equations (B3)-(B4) and (B6)-(B7), for the down payment and LTV equations, respectively, for the different assets and borrower types. The down payment for the consumer who purchases the more durable good is

$$\kappa + \mu 2\gamma - \gamma(1 - \psi_i)\theta_G - I_i\theta_I. \tag{B17}$$

The down payment for the consumer who purchases the less durable good is

$$\kappa + \mu(1 + \delta)\gamma - \gamma(\delta - \psi_i)\theta_G - I_i\theta_I. \tag{B18}$$

The LTV for the consumer who purchases the more durable good is

$$\frac{(1 - \psi_i)\gamma\theta_G + I_i\theta_I}{2\gamma - \psi_i\gamma}. \tag{B19}$$

The LTV for the consumer who purchases the less durable good is

$$\frac{\gamma(\delta - \psi_i)\theta_G + I_i\theta_I}{(1 + \delta - \psi_i)\gamma}. \tag{B20}$$

Assuming that the borrower-dependent depreciation is higher for L-type borrowers (i.e., $\psi_L > \psi_H \geq 0$), we can reformulate equations (B5) and (B8), the conditions on income pledgeability (θ_I) and asset-based depreciation (δ). Specifically, if income is sufficiently pledgeable,

$$\theta_I > \frac{\gamma[(1-\delta)(\mu-\theta_G) - \theta_G(\psi_L - \psi_H)]}{I_H - I_L}, \tag{B21}$$

then the down payment is greater for the less durable good purchased by the lower-income consumer, otherwise the down payment will be greater for the more durable good. Relative to equation (B5), we can see that the income level of the pledgeability condition is now lower (setting $\psi_L = \psi_H = 0$ reproduces equation B5). The intuition is that the additional gap between depreciation due to borrower types increases the depreciation differential between the equilibrium asset purchases of the borrower types, further reducing the size of the asset-based portion of the loan for lower-income borrowers. Consequentially, either lower-income borrowers must make even higher down payments, or the degree that income pledgeability matters for down payment differentials is smaller, relative to the base case without borrower-dependent depreciation.

In addition, if lower-income borrowers are more dependent on income-based lending, specifically if

$$\delta < \frac{I_L(2-\psi_H)}{I_H} - (1-\psi_L), \tag{B22}$$

and income is sufficiently pledgeable,

$$\theta_I > \frac{\theta_G(1-\delta+\psi_L-\psi_H)}{I_L(2-\psi_H)-(1+\delta)I_H} \tag{B23}$$

then the LTV is higher for the less durable good, otherwise the LTV is higher for the more durable good. Note that when $\psi_L > \psi_H \geq 0$, the degree of asset-based depreciation difference necessary to induce high LTVs for less durable goods purchased by lower-income borrowers is smaller relative to the baseline model (or equivalently the δ that satisfies this equation is closer to 1). Moreover, the condition for the pledgeability of income is also weaker (so the θ_I that satisfies this equation is closer to 0). However, the former condition is still equivalent to saying that the ratio of IBL to ABL for lower-income borrowers is higher than that for high-income borrowers, i.e.,

$$\frac{\theta_I I_L}{\theta_G(\delta - \psi_L)\gamma} > \frac{\theta_I I_H}{\theta_G(1 - \psi_H)\gamma}. \tag{B24}$$

The intuition for this result is similar to the baseline model: the income portion of the financing remains more important for the lower-income borrower. If IBL is relatively more important for the lower-income borrower, then their higher IBL dependence still outweighs the comparatively smaller amount of financing they derive from borrowing against a lower-valued asset. In this extension, the collateral value of the asset is even lower for lower-income borrower, which further reduces the ABL portion of the loan, and thus all else equal increases the importance of IBL for the lower-income borrower. Thus, similar to the down payment, this condition is more easily satisfied when there is also a depreciation differential due to the borrower type.

By similar logic, the payment-to-income (PTI) ratio is also lower for the lower-income purchaser with borrower-dependent depreciation as long as the lower-income purchases are more dependent on income-based lending, which is satisfied by equation B22 above and if the lower-income borrower-dependent depreciation is higher ($\psi_L > \psi_H$). Relative to the baseline model, the denominator is the same, but the numerator for the lower-income borrower is further reduced by the additional greater depreciation due to the borrower-based depreciation. Therefore, if the PTI is lower for the lower-income borrower in the baseline model, *ceteris paribus*, it will be even further reduced if the lower-income borrower-dependent depreciation is higher ($\psi_L > \psi_H$).

Appendix B.5. Proportional Purchases Assumption

We consider an alternative formulation of the model that imposes an additional assumption: Borrowers spend a fixed proportion ρ of their income on the value of the asset. In this section, we consider two implications of this model. First, we consider the direct evidence on the relationship between borrower incomes and the value of the assets they purchase. Second, we examine the theoretical prediction for the relationship between LTVs and durability that follows from this assumption.

First, from an empirical perspective, an assumption of proportional purchases implies that a regression of the log of wholesale values on the log of borrower incomes should yield a coefficient of one on the latter variable. In

Table F.8 we show that the estimated coefficient is approximately 0.27 and is significantly different from one. The 95% confidence intervals for the estimated coefficients on borrower income are $(0.248, 0.310)$ and $(0.239, 0.303)$ in the first and second columns, respectively, of Table F.8.

Second, the proportional assumption also generates a prediction about relative LTVs. In Result 2 of the baseline model we provide conditions under which the the LTV ratio is higher for lower-income borrowers purchasing the less durable asset than for higher-income borrowers purchasing the more durable asset. In Table 7, we show that LTVs are indeed higher for less durable assets.

Under the proportional assumption the income and purchase price of the higher-income borrower purchasing the more durable asset satisfy the following equation

$$\rho = \frac{2\gamma}{I_H}. \tag{B25}$$

We can solve for the δ of the asset purchased by the lower-income borrower such that the lower-income borrower spends the same proportion ρ of her income on the value of the asset:

$$\rho = \frac{(1+\delta)\gamma}{I_L}. \tag{B26}$$

Solving for δ yields

$$\delta = \frac{2I_L}{I_H} - 1. \tag{B27}$$

The rest of the model is the same as in our baseline formulation, so we can immediately compare (B27) to inequality (B8) and see that with the proportionality assumption it cannot be that the lower-income borrower has a higher LTV, as inequality (B8) is strict. The intuition is that as value is directly proportional to income, the lower-income borrower cannot have a higher LTV, even if income is highly pledgeable. If income is not highly pledgeable (i.e., if inequality (B9) does not hold), then the lower-income borrower will have a lower LTV, as borrowing will depend more on the future value of the collateral, which is low for the less durable asset.

Instead of fixing δ, alternatively we could assume that the less-durable asset also has a lower consumption value, denoted γ_l. If we maintain the proportionality assumption, then we can solve for γ_l as a function of the income and δ as follows

$$\gamma_l = \frac{2\gamma I_L}{I_H(1+\delta)}. \tag{B28}$$

This then implies that the LTV of the lower-income borrower purchasing the less durable asset is

$$\frac{\theta_G \delta \gamma_l + \theta_I I_L}{(1+\delta)\gamma_l}. \tag{B29}$$

The LTV of the higher-income borrower purchasing the more durable asset is the same as in the baseline model. Comparing the LTVs of the lower-income and higher-income borrowers, for the lower-income borrower to have a higher LTV would require that $\delta > 1$. This would violate our fundamental assumption that $\delta \in (0, 1)$: We presume that the asset purchased by the lower-income borrower has lower durability (i.e., lower residual value). Therefore, under either form of modeling, the lower-income borrower cannot have a higher LTV if the value of the asset is a fixed proportion of the borrower's income.

Appendix C. Additional Empirical Tests and Robustness

Appendix C.1. Durability and Loan Maturity

The model we consider in our theoretical framework involves one-period loan repayments, so it does not generate formal predictions for the impact of durability on loan maturity. It is intuitive, however, that less durable assets will be financed with shorter-term asset-backed debt, and this implication arises, for example, in the model of Hart and Moore (1994). Hart and Moore (1994) also argue that human capital cannot support long-term debt as it belongs only to its owner and can be withdrawn from use at any time. A reduction in durability that leads to a greater use of income-based financing should thus lead to shorter-term financing. Both asset-backed and income-based models of financing therefore suggest that a decrease in asset durability will result in shorter-maturity debt.

We test this hypothesis by regressing the observed maturity in months of the auto loan on the post-discontinuation dummy and the standard fixed effects. We find that discontinuation reduces the maturity of the loan (coefficient=-0.75 and t-statistic=-5.22), as displayed in the first column of Table F.5. The reduction of 0.75 months in loan maturity after discontinuation is a meaningful effect, though perhaps not very large compared to the mean loan maturity of 67.72 months. Overall, however, there is little observed variation in loan maturities (the interquartile range is 66 to 72 months), so it is notable that we find an effect of reasonable magnitude. As in Argyle et al. (2021), we find that cars with shorter expected life expectancies receive loans with shorter maturities. Including borrower, vehicle, and dealer profit controls has little impact on the estimated coefficient, as we show in the second and third columns of Table F.5.

Appendix C.2. Mechanical Correlations and Robustness

Our empirical tests examine the impact of vehicle discontinuations on various price, financing, borrower characteristic, and recovery outcomes. Some of these variables are likely linked (e.g., a borrower seeking a larger loan amount may require a longer maturity to service the debt), which raises a question about the extent to which these findings are independent. We show that there are some results that are inconsistent with mechanical correlations and others that are consistent. It is clearly not the case that all of the findings are driven by mechanical correlations.

In our main specification we group together model and make discontinuations. As a robustness test, in Table F.10 in the appendix we provide results separately for model and make discontinuations. The results for the two types of discontinuations are broadly consistent. In unreported results, we also examine the effects of discontinuation shock within vintage x contract years (i.e., including vintage x contract year fixed effects) to address concerns about potential changes in the relative stock of vehicles for sale after discontinuation. We find that our main results remain similar.

Our empirical tests examine the impact of vehicle discontinuations on various price, financing, borrower characteristic, and recovery outcomes. Some of these variables are likely linked (e.g., a borrower seeking a larger loan amount may require a longer maturity to service the debt), which raises a question about the extent to which these findings are independent. To explore this issue, we present in Table F.9 correlations between our central outcome variables. (We focus on the raw correlations, but the residual correlations after removing the baseline fixed effects are generally similar.)

Our main tests show that vehicle discontinuations result in higher down payments, LTVs, and income recoveries, and lower wholesale values, borrower incomes, maturities, PTIs, and vehicle recoveries. To assess the independence of these findings, one can compare them to the correlations in the data. For example, we find that discontinuations led to higher down payments. Based on the mechanical correlations in Table F.9 alone, discontinuations could be expected to result in greater wholesale values (false), lower LTVs (false), shorter maturities (true), higher borrower income (false), lower PTI (true), higher vehicle recoveries (false) and higher personal recoveries (true). Broadly speaking, across various outcomes, there are thus some results that are inconsistent with mechanical correlations and others that are consistent. It is clearly not the case that all of the findings are driven by mechanical correlations.

Appendix D. Unsophisticated Post-Discontinuation Borrowers?

Our empirical tests have explored and provided support for the theory that vehicles that are discontinued and therefore experience a negative durability shock are more likely to be purchased by lower-income consumers. One alternative theory is that, controlling for income, post-discontinuation buyers are more sophisticated in that they are less disturbed by the reduced prestige of discontinued vehicles. These sophisticated borrowers may have greater personal resources to supply the larger down payments and the greater post-default personal recoveries that we observe. In a second alternative theory, post-discontinuation borrowers are less sophisticated and supply larger down payments simply due to overpaying. Under both alternative theories, discontinuation may result in selection effects on borrower income, as emphasized in our model, and on sophistication.[35]

Three pieces of evidence, however, do not support the shared premise of both alternative theories that there is a change in borrower sophistication post-discontinuation. First, in Table F.6 in the Appendix, we show that pre- and post-discontinuation consumers do not differ in the frequency with which they are highly educated. Second, it is sometimes argued that bankrupt borrowers who select a Chapter 13, rather than a Chapter 7, bankruptcy are less sophisticated (Braucher et al., 2012; McIntyre et al., 2015). In Table F.6 we show that the borrower's propensity to enter Chapter 13 bankruptcy (either unconditionally or conditional on having experienced some form of bankruptcy) is not related to whether the consumer purchases a post-discontinuation vehicle. Third, as displayed in Table F.6, pre- and post-discontinuation buyers do not pay different dealer dollar margins. There is thus no direct evidence of any change in the sophistication of post-discontinuation buyers.

[35] In our model and under both these alternative theories, discontinuation is a supply-side shock to the nature of the asset that results in demand-side selection in the types of buyers.

We do find (Appendix Table F.7) a small (6 basis point) and marginally significant post-discontinuation increase in interest rates. This might be regarded as weak indirect evidence that post-discontinuation buyers are less sophisticated. Default rates, however, as described in Table F.7 are not significantly different after discontinuation; unsophisticated buyers would likely be anticipated to default more frequently, which we do not observe. In summary, our results are consistent with post-discontinuation selection in borrower income, but the weight of the evidence across various tests is that pre- and post-discontinuation do not differ in their sophistication.

Appendix E. Securitization

The dependence of low-income borrowers on IBL that we document suggests that recent changes in securitization markets have potentially broad implications for the relative access to auto credit of poor consumers. Specifically, Figure F.8 displays total annual securitization issuances for autos, equipment, student loans, and credit cards. As is clear from the figure, in the post-financial crisis period (i.e., since 2008) there has been a significant increase in the securitization of ABL such as equipment relative to IBL such as student loans and credit cards.

A rise in ABL securitization relative to that of IBL is likely to facilitate the availability of the former type of financing at lower prices. Given the importance of the IBL component of auto debt to low-income borrowers, this suggests that an increasing fraction of vehicle lending will be directed to wealthier consumers. To explore the effects of changing market conditions, we examine the relationship between auto financing of consumers and the securitization of ABL relative to securitization of IBL. Specifically, each year we calculate the ratio of securitized equipment lending, which is almost entirely ABL, to the sum of equipment, credit card, and student loan lending, where the latter two are almost entirely IBL.[36] We then plot the relationship across the highest and lowest income quartiles since the onset of the financial crisis in Figure F.9.[37] As the ratio of equipment to total securitization increases, borrowers in the highest income quartile experience an increase in auto financing, while borrowers in the lowest income quartile experience a decrease. Although this figure depicts an association rather than a causal connection, it is consistent with the argument that the importance to low-income borrowers of IBL, which has been relatively disfavored by securitization markets, may be acting to reduce their ability to purchase vehicles.

[36] To avoid any mechanical relationship, we exclude securitized auto lending.
[37] We present the regression underlying this analysis in appendix Table F.11.

Appendix F. Supporting Figures and Tables

Table F.1: **Definitions of variables**. The table contains the definitions of all variables used throughout the paper, listed alphabetically.

Variable	Definition
Blackbook Data	
Vehicle Age	Age of the vehicle since vintage year
Wholesale Value – New	Average wholesale value for a make-model-year when new
Wholesale Value	Average wholesale value for a make-model-year
YoY Depreciation	Annual percentage change in the vehicle's wholesale value
Loan Data	
Amount Financed ($)	Total amount of loan at origination
APR (%)	Annualized APR of the loan at origination
Chapter 13 Bankruptcy (=1)	Indicator if the borrower record had a Ch. 13 bankruptcy
Chapter 7 Bankruptcy (=1)	Indicator if the borrower record had a Ch. 7 bankruptcy
Credit Score	Credit score of the borrower at origination
Dealer Profit ('000 $)	Dealer profit from the sale of the vehicle
Default (=1)	Indicator if borrower defaulted on loan
Down Payment ($)	Cash amount borrower paid at loan origination
Gross Default ($)	Remaining portion of the loan outstanding at default
Homeowner (=1)	Indicator if borrower owned their own home
Income	Borrower's reported monthly income
Income Recovery ($)	Post-default collections income net of fees
Income Recovery / Default (%)	Income Recovery /Gross Default
Loan Maturity (months)	Term of the loan (in months) at origination
Log (PTI)	Natural log of Payment to Income
Log Income	Natural log of borrower income
Low Income (=1)	Indicator if borrower is in lowest income quartile by year
LTV	Dollar amount of the loan at origination / Wholesale value
Payment to Income	Borrower's monthly payment / borrower's monthly income

Variable	Definition
Post Discontinuation (=1)	Indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued
Purchase Price ($)	Purchase price of the vehicle as reported to the lender
Purchased Before, Defaulted After (=1)	Indicator if borrower purchased vehicle prior to discontinuation and defaulted after discontinuation
Scaled Price (%)	Wholesale Value / Wholesale Value – When New
Time to Default (months)	Number of months between vehicle purchase and default
Vehicle Age (yrs.)	Vehicle age at sale
Vehicle Margin ($)	Dealer profit from sale of vehicle plus any additional contract less financing costs
Vehicle Mileage ('000)	Vehicle mileage at sale
Vehicle Recovery ($)	Auction proceeds after repossession net of fees
Vehicle Recovery / Default (%)	Vehicle Recovery / Gross Default
Wholesale Value – New	Wholesale value for the given make-model-year when new
Wholesale Value	Wholesale value at the time of origination
Other Data	
Equipment Securitization	Total securitized equipment loans in given year, from sifma.org
GDP Deflator	Annual GDP implicit price deflator (Index 2012=100), from Federal Reserve Bank of St. Louis
Total Securitization	Sum of securitized equipment, credit card, and student loans in given year, from sifma.org

Table F.3: **Discontinuation of Models.** This table reports the years of model discontinuations. All dates are from JD Power Associates for the discontinuation for a given model.

Make	Model	Year	Make	Model	Year
Acura	CL	2003	Cadillac	STS	2011
Acura	Integra	2001	Cadillac	XTS	2019
Acura	RL	2012	Chevrolet	Astro	2005
Acura	RSX	2006	Chevrolet	Avalanche	2013
Acura	TL	2014	Chevrolet	Aveo	2011
Acura	TSX	2014	Chevrolet	Cavalier	2005
BMW	325	2006	Chevrolet	Cobalt	2010
BMW	328	2016	Chevrolet	Cruze	2019
BMW	525	2007	Chevrolet	HHR	2011
BMW	535	2016	Chevrolet	Lumina	2001
BMW	550	2016	Chevrolet	Metro	2001
BMW	Z3	2002	Chevrolet	Monte Carlo	2007
Buick	Cascada	2019	Chevrolet	Prizm	2002
Buick	Century	2005	Chevrolet	SSR	2006
Buick	LeSabre	2005	Chevrolet	Tracker	2004
Buick	Lucerne	2011	Chevrolet	Uplander	2008
Buick	Park Avenue	2005	Chevrolet	Venture	2005
Buick	Rainier	2007	Chrysler	200	2017
Buick	Rendezvous	2007	Chrysler	300M	2004
Buick	Terraza	2007	Chrysler	Aspen	2009
Buick	Verano	2017	Chrysler	Concorde	2004
Cadillac	ATS	2019	Chrysler	Crossfire	2008
Cadillac	Catera	2001	Chrysler	PT Cruiser	2010
Cadillac	CTS	2019	Chrysler	Sebring	2010
Cadillac	DeVille	2005	Chrysler	Town & Country	2016
Cadillac	DTS	2011	Dodge	Avenger	2014
Cadillac	Seville	2004	Dodge	Caliber	2012
Cadillac	SRX	2016	Dodge	Dakota	2011

Dodge	Dart	2016	Hyundai	Azera	2017
Dodge	Intrepid	2004	Hyundai	Equus	2016
Dodge	Magnum	2008	Hyundai	Genesis	2016
Dodge	Neon	2005	Hyundai	Tiburon	2008
Dodge	Nitro	2011	Hyundai	Veracruz	2012
Dodge	Ram Van	2003	Infiniti	EX35	2012
Dodge	Stratus	2006	Infiniti	EX37	2013
Fiat	500	2019	Infiniti	FX35	2012
Ford	E150	2014	Infiniti	FX37	2013
Ford	Excursion	2005	Infiniti	G20	2002
Ford	Fiesta	2019	Infiniti	G25	2012
Ford	Five Hundred	2007	Infiniti	G35	2008
Ford	Flex	2019	Infiniti	G37	2013
Ford	Focus	2018	Infiniti	I30	2001
Ford	Freestar	2007	Infiniti	I35	2004
Ford	Freestyle	2007	Infiniti	M35	2010
Ford	Taurus	2019	Infiniti	M37	2013
Ford	Thunderbird	2005	Infiniti	M45	2010
Ford	Windstar	2003	Infiniti	Q40	2015
Geo	Metro	1997	Infiniti	Q70	2019
Geo	Prizm	1997	Infiniti	QX30	2019
Geo	Tracker	1997	Infiniti	QX56	2013
GMC	Envoy	2009	Infiniti	QX70	2017
GMC	Safari	2005	Isuzu	Ascender	2008
GMC	Sonoma	2004	Isuzu	Axiom	2004
Honda	Crosstour	2015	Isuzu	Rodeo	2004
Honda	Element	2011	Isuzu	Trooper	2002
Honda	Prelude	2001	Isuzu	VehiCROSS	2001
Honda	S2000	2009	Jaguar	XJ8	2009

Jeep	Commander	2010	Mazda	Protege	2003
Jeep	Liberty	2012	Mazda	Tribute	2011
Jeep	Patriot	2017	Mercury	Cougar	2002
Kia	Amanti	2009	Mercury	Grand Marquis	2011
Kia	Borrego	2009	Mercury	Mariner	2011
Kia	Rondo	2010	Mercury	Milan	2011
Kia	Sephia	2001	Mercury	Montego	2007
Kia	Spectra	2009	Mercury	Monterey	2007
Lexus	ES 300	2003	Mercury	Mountaineer	2010
Lexus	ES 330	2006	Mercury	Sable	2009
Lexus	GS 300	2019	Mercury	Villager	2002
Lexus	GX 470	2009	Mitsubishi	Eclipse	2012
Lexus	IS 250	2015	Mitsubishi	Endeavor	2011
Lexus	LS 430	2006	Mitsubishi	Galant	2012
Lexus	LS 460	2017	Mitsubishi	Lancer	2017
Lexus	RX 300	2003	Mitsubishi	Montero	2006
Lexus	RX 330	2006	Mitsubishi	Montero Sport	2004
Lincoln	LS	2006	Mitsubishi	Raider	2009
Lincoln	Mark LT	2008	Nissan	Cube	2014
Lincoln	MKC	2019	Nissan	Juke	2017
Lincoln	MKS	2016	Nissan	Xterra	2015
Lincoln	MKT	2019	Saab	9-7X	2009
Lincoln	MKX	2018	Saturn	Aura	2009
Lincoln	Town Car	2011	Saturn	Relay	2007
Lincoln	Zephyr	2006	Saturn	SC	2002
Mazda	626	2002	Saturn	Sky	2009
Mazda	CX-7	2012	Saturn	SL	2002
Mazda	Millenia	2002	Scion	FR-S	2016
Mazda	MPV	2006	Scion	iA	2016

Scion	iM	2016	Volkswagen	Beetle	2019
Scion	iQ	2015	Volkswagen	Cabrio	2002
Subaru	B9 Tribeca	2014	Volkswagen	CC	2017
Subaru	Baja	2006	Volkswagen	Eos	2016
Suzuki	Aerio	2007	Volkswagen	GTI	2014
Suzuki	Forenza	2008	Volkswagen	Rabbit	2009
Suzuki	Grand Vitara	2013	Volkswagen	Touareg	2017
Suzuki	Kizashi	2013	Volvo	C30	2013
Suzuki	Reno	2008	Volvo	C70	2013
Suzuki	SX4	2013	Volvo	S40	2011
Suzuki	Verona	2006	Volvo	S80	2016
Toyota	Camry Solara	2008	Volvo	V40	2004
Toyota	Celica	2005	Volvo	V50	2011
Toyota	Corolla iM	2018	Volvo	V70	2010
Toyota	FJ Cruiser	2014			
Toyota	Matrix	2013			
Toyota	MR2	2005			

Table F.4: **Discontinuation of Makes.** This table reports the discontinuation dates for US automotive brands since 1995. All dates are from Factiva and represent the press release date.

Make	**Parent**	**Year**
Geo	General Motors	1997
Eagle	Chrysler	1998
Plymouth	Daimler-Chrysler	2001
Oldsmobile	General Motors	2004
Saturn	General Motors	2010
Pontiac	General Motors	2010
Mercury	Ford	2011
Saab	Saab	2011

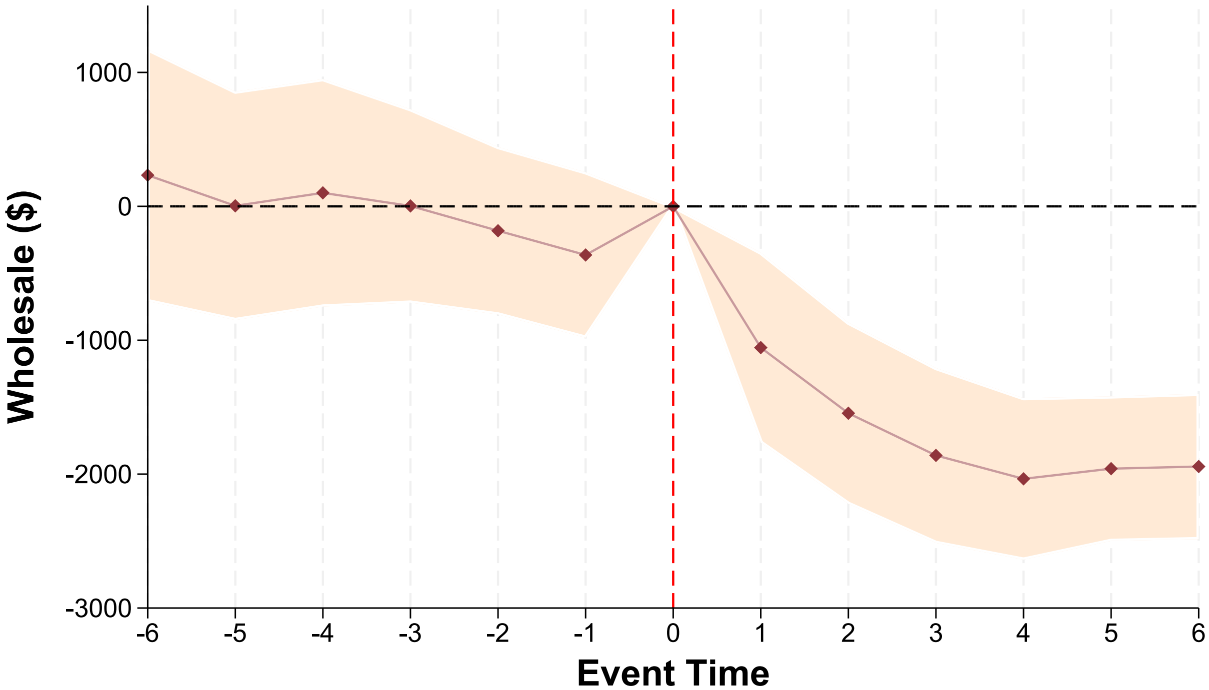

Figure F.1: **Change in Wholesale Value against Event Time.** This figure presents differences in the wholesale value across vehicles (models & makes) that were discontinued and those that were not. The plot displays the regression coefficients for timing indicators around the year the model was discontinued (discontinuation year=0). The dependent variable is the average annual wholesale value of the vehicle as reported by Black Book. Included fixed effects are Make/Model x Vintage Year and Contract Year x Parent Company.

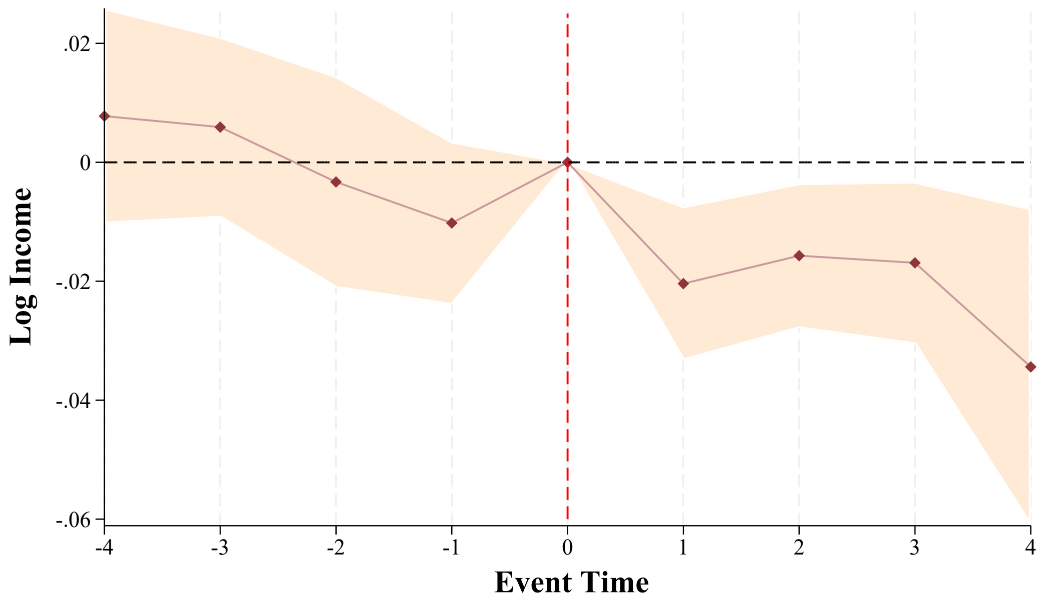

Figure F.2: **Change in Income against Event Time.** This figure presents differences in the borrower income across vehicles (models & makes) that were discontinued and those that were not. The plot displays the regression coefficients for timing indicators around the year the model was discontinued (discontinuation year=0). The dependent variable is the reported borrower's income at the time of origination. Included fixed effects are Make/Model x Vintage Year and Contract Year x Parent Company.

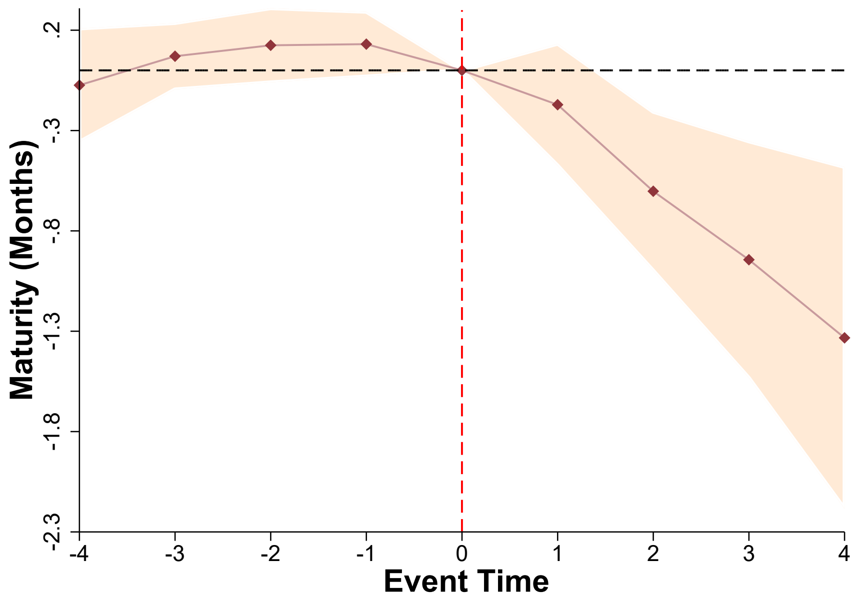

Figure F.3: **Change in Loan Maturity against Event Time.** This figure presents differences in the loan maturity across vehicles (models & makes) that were discontinued and those that were not. The plot displays the regression coefficients for timing indicators around the year the model was discontinued (discontinuation year=0). The dependent variable is the maturity of the loan (in months) as reported by the lender. Included fixed effects are Make/Model x Vintage Year and Contract Year x Parent Company.

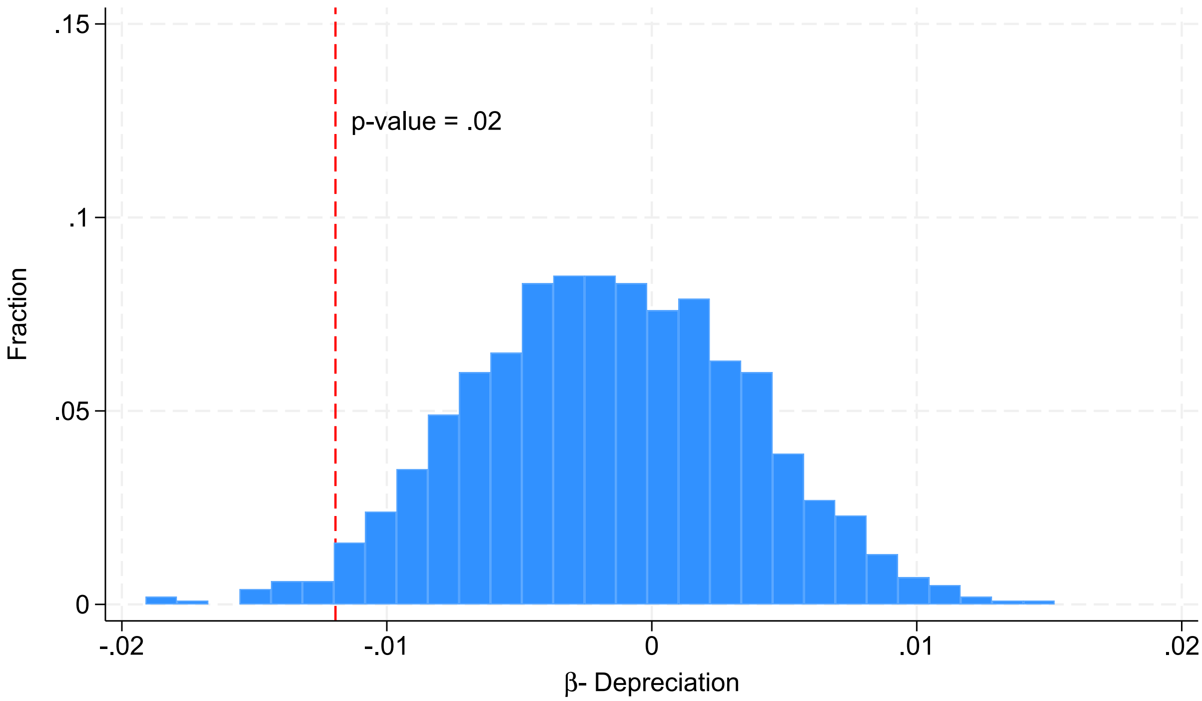

Figure F.4: **Permutation Test – Blackbook.** This figure presents the results from running a permutation test of the YoY depreciation results. Specifically, among vehicles that are never discontinued we randomly assign a discontinuation year to makes and models such that discontinuations approximately match the discontinuation years observed in our sample. We then run a regression of the YoY depreciation on the placebo Model Discontinuation indicator, analogous to column (1) of Table 2. We repeat this simulation 1,000 and plot the distribution of the placebo coefficients relative to the coefficient in column (1) of Table 2. The p-value represents the percent of observations in the distribution of placebo coefficients that exceed the observed coefficient.

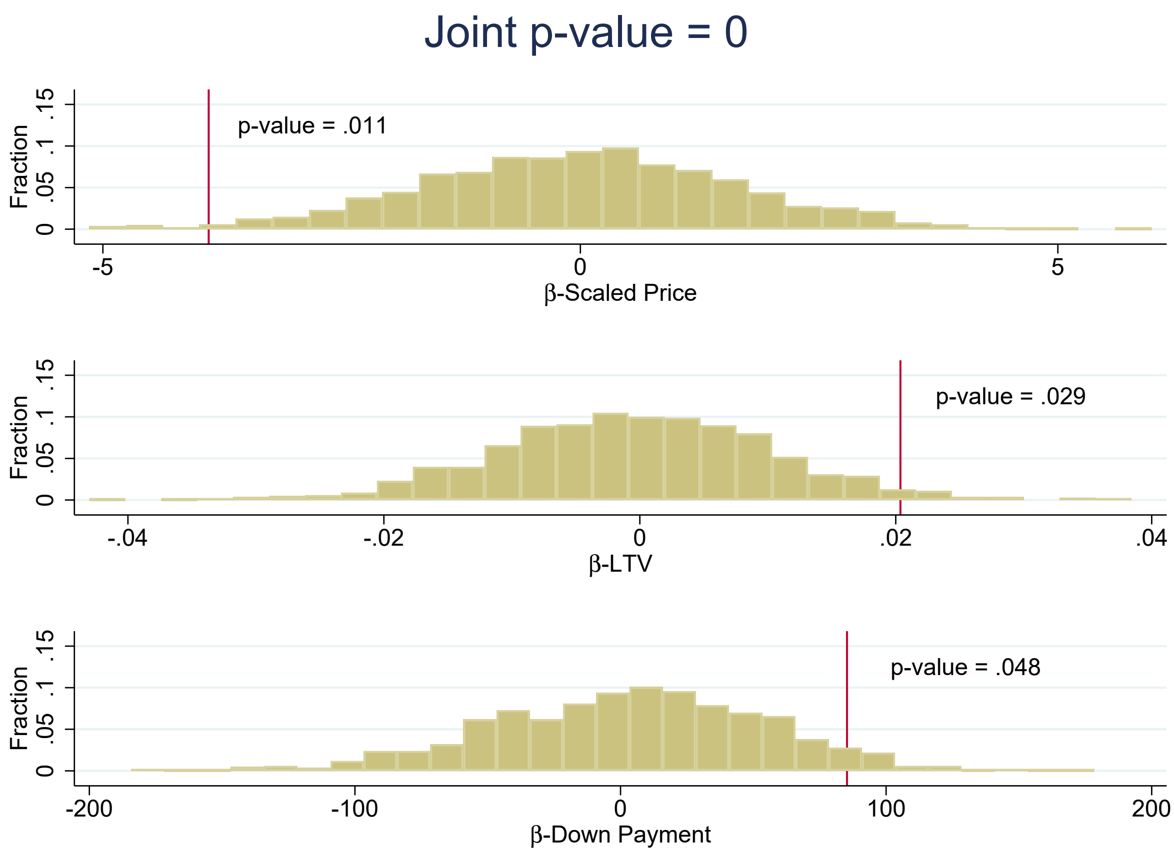

Figure F.5: **Permutation Test – Loan.** This figure presents the results from running a permutation test of the Scaled Price, Down Payment, and LTV results. Specifically, among vehicles that are never discontinued we randomly assign a discontinuation year to makes and models such that discontinuations approximately match the discontinuation years observed in our sample. We then run a regression of the Scaled Price, Down Payment, and LTV on the placebo Model Discontinuation indicator, analogous to column (4) of Table 3, and column (1) of Table 6 and Table 7, respectively. We repeat this simulation 1,000 and plot the distribution of the placebo coefficients relative to the coefficient in column (4) of Table 3, and column (1) of Table 6 and Table 7, respectively. The p-value represents the percent of observations in the distribution of placebo coefficients that exceed the observed coefficient. The joint p-value is the percent of observations for which the placebo coefficients across all three specifications jointly exceed the observed coefficients.

Table F.5: **Loan Maturity and Model Discontinuation.** This table reports estimates from panel regressions of the maturity of the loan at origination. The dependent variable *Loan Maturity* is the original maturity of the loan at origination (in months). *Post Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Loan Maturity (Months)	(1)	(2)	(3)
Post Discontinuation (=1)	-0.75***	-0.72***	-0.72***
	(-5.22)	(-4.10)	(-4.27)
Vehicle Model x Vintage FEs	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes
Parent x Contract Year FEs	Yes	Yes	Yes
Borrower Controls	No	Yes	Yes
Vehicle Controls	No	No	Yes
Observations	324820	273365	272725
Adjusted R^2	0.573	0.369	0.386

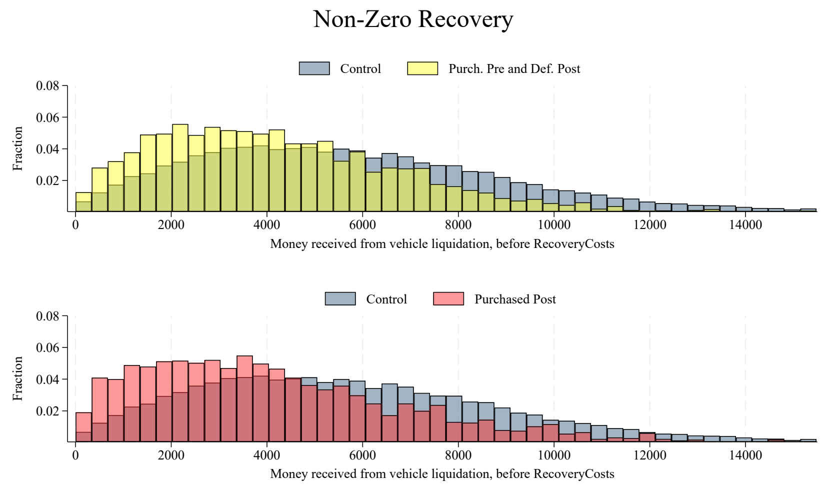

Figure F.6: **Vehicle Default Recovery Conditional on Purchase Timing.** This figure presents a histogram of the gross recovered vehicle value of defaulted loans conditional on the purchase timing and having positive vehicle recovery. The treated group in the top panel consists of loans purchased prior to discontinuation but defaulted after discontinuation and the treated group in the bottom panel consists of loans of vehicles purchased post-discontinuation. The control group in both panels consists of vehicles that were not ever discontinued and vehicles that were purchased no more than 2 years prior to vehicle discontinuation and defaulted prior to discontinuation.

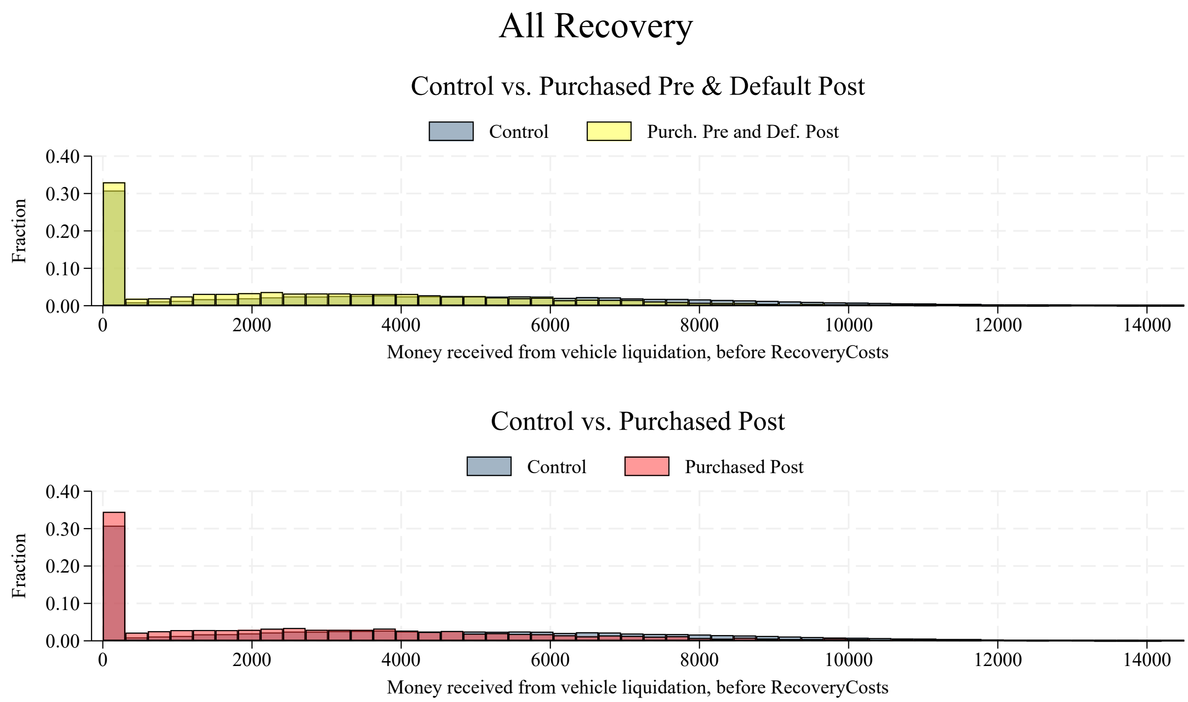

Figure F.7: **Gross Default Recovery (All Recoveries) Conditional on Purchase Timing.** This figure presents of the gross recovered vehicle value conditional on the timing of the purchase. The top panel compares the gross dollar vehicle recovery on loans of vehicles purchase discontinuation but defaulted after discontinuation, and the bottom panel compares the gross dollar vehicle recovery on loans of vehicles purchased post-discontinuation. The control group is both vehicles that were not ever discontinued and vehicles that were purchased within 2-years prior to vehicle discontinuation but defaulted before discontinuation.

Table F.6: **Sophistication and Model Discontinuation.** This table reports estimates from panel regressions of borrower characteristics at origination. In Columns (1) and (2) the dependent variable is if the borrower has evidence of higher education. In Columns (3)-(8), the dependent variable is if the borrower had a prior Chapter 13 bankruptcy. Columns (3)-(5) are across the whole sample. Columns (6)-(8) are conditional on the borrower having a prior Chapter 7 or Chapter 13 bankruptcy. Columns (9)-(10) is the vehicle margin taking into account profit from the sale of the vehicle and additional contracts less financing arrangement costs. *Post Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Higher Ed.(= 1)		Chapter 13 Bankruptcy (=1)						Vehicle Margin ($)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Post Discontinuation (=1)	-0.00	0.00	-0.00	0.00	0.00	-0.00	-0.00	-0.01	12.81	16.93
	(-0.36)	(0.15)	(-0.23)	(0.54)	(0.28)	(-0.49)	(-0.31)	(-1.23)	(0.27)	(0.46)
Log Income		0.06***		0.16***	0.15***		0.31***	0.27***		1407.59***
		(11.64)		(28.51)	(28.50)		(48.60)	(49.51)		(48.12)
Credit Score		0.00			0.00***			0.00***		5.00***
		(1.46)			(23.50)			(62.10)		(24.39)
Ch. 7 Bankruptcy (=1)		0.02***								220.54***
		(5.97)								(15.87)
Ch. 13 Bankruptcy (=1)		0.02***								-468.53***
		(4.01)								(-31.45)
Homeowner (=1)		-0.02***			0.04***			0.09***		76.10***
		(-3.81)			(4.76)			(14.12)		(4.22)
Log Mileage		-0.00		0.00***	0.00***		0.01***	0.01***		262.61***
		(-0.35)		(6.39)	(8.07)		(4.79)	(8.61)		(23.61)
Dealer Profit ('000 $)		-0.00*		-0.01***	-0.01***		-0.02***	-0.02***		
		(-1.82)		(-14.34)	(-16.75)		(-22.92)	(-26.81)		
Veh. Model x Vint. FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Trans. Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	92137	85744	324823	283928	272725	96188	94351	93336	324823	272725
Adjusted R^2	0.033	0.035	0.199	0.220	0.232	0.315	0.367	0.429	0.272	0.306

Table F.7: **Borrower Interest Rates, Defaults, and Model Discontinuation.** This table reports estimates from panel regressions of the borrower's interest rate on the loan and whether the borrower eventually defaults on the loan on vehicle discontinuation. In columns (1) to (2), the dependent variable is the reported interest rate, *APR*, on the loan to the borrower at the time of origination. In columns (3) to (4), the dependent variable is an indicator for if the borrower eventually defaults on the loan ($= 1$ if default). *Post-Discontinuation* is an indicator for all years after the transaction year for which the brand or model of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	APR (%)		Default ($= 1$)	
	(1)	(2)	(3)	(4)
Post Discontinuation (=1)	0.062*	0.059	-0.008	-0.009
	(1.73)	(1.68)	(-1.57)	(-1.59)
Borrower Controls	Yes	Yes	Yes	Yes
Vehicle Controls	No	Yes	No	Yes
Veh. Model x Vintage FEs	Yes	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes	Yes
Parent x Contract Yr. FEs	Yes	Yes	Yes	Yes
Observations	273365	272725	273365	272725
Adjusted R^2	0.399	0.409	0.110	0.111

Table F.8: **Log Vehicle Value and Purchase Price to Log Borrower Income.** This table reports estimates from panel regressions of the log of the vehicle's purchase price (columns 1 and 2) and the log of the vehicle's wholesale value (columns 3 and 4) on the borrower's log income. In columns (1) to (2), the dependent variable is the natural log of the wholesale value as reported to the lender. In columns (3) to (4), the dependent variable is the log of the purchase price of the vehicle. *Log Income* is the log of the borrower's income as reported to the lender. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The F-stats are for a test if the coefficient of log income is statistically significantly different from 1.

	Log(Wholesale)		Log(Price)	
	(1)	(2)	(3)	(4)
Log Income	0.279***	0.271***	0.254***	0.218***
	(17.99)	(17.13)	(18.24)	(14.33)
F-Stat (Log Income=1)	2159.09***	2129.68***	2870.75***	2630.38***
	(0.00)	(0.00)	(0.00)	(0.00)
Borrower Controls	Yes	Yes	Yes	Yes
Vehicle Controls	No	Yes	No	Yes
Veh. Vintage FEs	Yes	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes	Yes
Parent x Contract Yr. FEs	Yes	Yes	Yes	Yes
Observations	286049	284782	278154	277508
Adjusted R^2	0.390	0.454	0.416	0.457

Table F.9: **Correlations.** This table reports estimates of pairwise correlations of the reported variables in the sample. Standard errors are clustered on Vehicle Make.

	Down Payment ($)	Wholesale Value ($)	LTV	Term (Months)	Log Income ($)	PTI	Metal Recov. ($)
Wholesale Value ($)	0.172***						
LTV	-0.390***	-0.375***					
Loan Term (Months)	-0.121***	0.466***	0.127***				
Log Income	0.063***	0.454***	-0.012	0.115***			
PTI	-0.027***	0.054***	-0.042***	0.073***	-0.708***		
Metal Recovery ($)	0.045***	0.426***	-0.102***	0.227***	0.190***	0.217***	
Income Recovery ($)	0.015***	0.027***	-0.016***	-0.032***	0.034***	0.028***	-0.010

Table F.10: **Model versus Make Discontinuations.** This table reports estimates from panel regressions of the key variables from prior tables for model (Panel A) or make (Panel B) discontinuations. In Panel A, vehicles are excluded that had a make discontinuation in the following year or any year thereafter from the time of purchase. In Panel B, vehicles are excluded if the model was already discontinued or was discontinued in the 4-years following the purchase. *Post Model Discontinuation* is an indicator for all years after the transaction year for which the model of the vehicle was discontinued. *Post Make Discontinuation* is an indicator for all years after the transaction year for which the brand of the vehicle was discontinued. Robust standard errors are clustered by vehicle make. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Scaled Price	Wholesale	Low Income	Income	Down Payment	LTV	Maturity	PTI	Metal Recovery (%)	Income Rec. (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Model Discontinuations										
Post Model Discontinuation (=1)	-2.74***	-227.05**	1.96*	-0.01*	64.78**	0.01***	-0.74***	-0.23***	-2.55***	1.51
	(-5.00)	(-2.09)	(1.73)	(-1.85)	(2.04)	(5.82)	(-4.02)	(-6.54)	(-3.90)	(1.46)
Purchased Before, Defaulted After (=1)									-1.08	
									(-1.47)	
Observations	243907	268760	268760	279891	268516	268760	268760	268760	54691	66179
Adjusted R^2	0.777	0.816	0.493		0.227	0.709	0.382	0.661	0.510	0.122
Panel B: Make Discontinuations										
Post Make Discontinuation (=1)	-3.71***	-20.28	3.51***	-0.03***	83.94***	0.02*	-1.12***	-0.16	-3.66**	3.00*
	(-3.06)	(-0.09)	(4.85)	(-3.23)	(4.67)	(1.85)	(-7.23)	(-1.39)	(-2.43)	(1.88)
Purchased Before, Defaulted After (=1)									-3.76***	
									(-8.15)	
Observations	210624	230050	230050	239717	229858	230050	230050	230050	47987	55326
Adjusted R^2	0.774	0.813	0.486		0.230	0.708	0.372	0.660	0.520	0.119
Vehicle Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Borrower Controls	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Vehicle Model x Vintage FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Contract Yr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dealership FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income Decile FE	No	No	No	No	No	No	No	No	Yes	No
Vehicle Parent x Default Year FE	No	No	No	No	No	No	No	No	Yes	No
Vehicle Model x Default Yr FE	No	No	No	No	No	No	No	No	No	Yes
Recovery Type FE	No	No	No	No	Yes	No	No	No	Yes	Yes

Table F.11: **Amount Financed relative to Asset-Based Securitization.** This table reports estimates from panel regressions of the amount financed. In columns odd numbered columns, the dependent variable is the amount financed by the borrower. In even numbered columns, the dependent variable is the log of the amount financed. *Eq/Total* is the dollar value of securitization of equipment loans over the total of credit card, student, and equipment loan securitization. *Q2 Income*, *Q3 Income*, *Q4 Income* are indicators for the 2nd, 3rd, and 4th quartiles of income for the borrower in the vehicle purchase year. *Log Income* is the log of the monthly borrower income. *Post-Crisis* is an indicator =1 if the transaction took place after 2010. The sample period begins in 2003. Robust standard errors are clustered by transaction year. The t-statistics are shown in parentheses below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Post-2007		Full-Sample		Post-2007		Full Sample	
	Amt. Fin.	Log(Amt. Fin.)	Amt. Fin.	Log(Amt. Fin.)	Amt. Fin.	Log(Amt. Fin.)	Amt. Fin.	Log(Amt. Fin.)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Q2 Income	882.89***	0.05***	986.83***	0.06***				
	(8.38)	(5.76)	(11.23)	(8.05)				
Q3 Income	1149.31***	0.06***	1442.24***	0.08***				
	(7.08)	(5.18)	(12.67)	(9.37)				
Q4 Income	1377.68***	0.07***	1834.26***	0.10***				
	(7.25)	(5.02)	(14.65)	(9.06)				
Q2 Income x EQ/Total	1103.04**	0.11***	978.74	0.10**				
	(2.77)	(3.32)	(1.67)	(2.18)				
Q3 Income x EQ/Total	2440.84***	0.18***	2331.01**	0.17**				
	(3.70)	(3.92)	(2.38)	(2.71)				
Q4 Income x EQ/Total	2796.49***	0.19***	2882.08**	0.20**				
	(3.82)	(3.79)	(2.55)	(2.85)				
Post-Crisis x Q2 Income			-61.23	-0.01				
			(-0.48)	(-1.21)				
Post-Crisis x Q3 Income			-260.82	-0.02				
			(-1.13)	(-1.62)				
Post-Crisis x Q4 Income			-493.43	-0.04*				
			(-1.65)	(-2.01)				
Log Income					1342.06***	0.06***	2011.61***	0.11***
					(5.57)	(3.66)	(16.71)	(9.74)
Log Income x EQ / Total					3060.37***	0.22***	3526.45***	0.25***
					(3.64)	(3.93)	(3.25)	(3.85)
Post-Crisis x Log Income							-839.19**	-0.06***
							(-2.69)	(-3.07)
Vehicle Model x Vintage FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dealer FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parent x Contract Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	228638	228638	290420	290420	228638	228638	290420	290420
Adjusted R^2	0.69	0.69	0.71	0.71	0.69	0.69	0.71	0.71

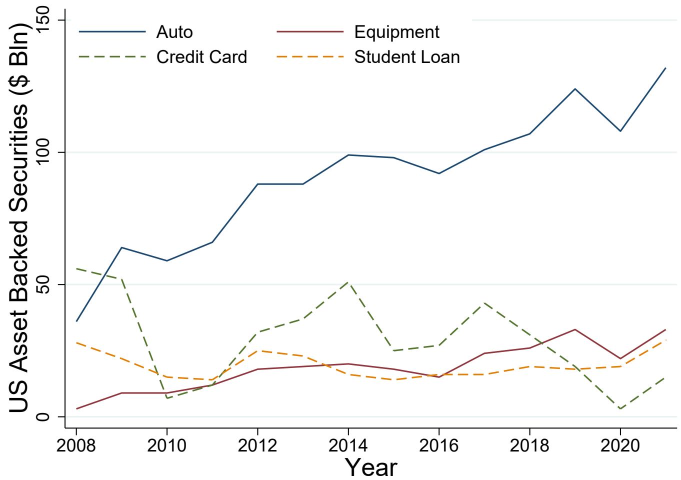

Figure F.8: **US Asset Backed Securitization** This figure presents the total annual issuance of US Asset Backed Securities in the United States for four categories (auto, equipment, student loans, and credit cards). All amounts are billions of U.S. Dollars. All data is from Bloomberg, Dealogic, Thomson Reuters; www.sifma.org, March 28 2022.

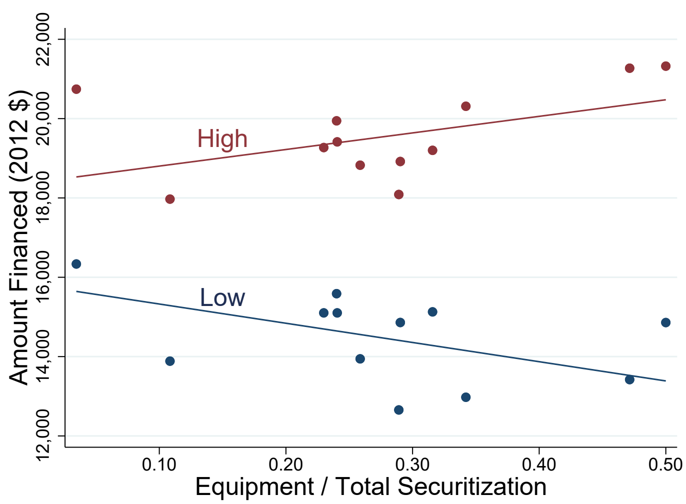

Figure F.9: **Amount Financed to Asset Based Securitization.** This figure presents the average amount financed across the equipment to total securitization ratio across the lowest and highest borrower income quartiles for years spanning 2008 to 2021. Amount financed is deflated to 2012 dollars using the GDP deflator from the St. Louis Federal Reserve. All securitization data is from Bloomberg, Dealogic, Thomson Reuters; www.sifma.org, March 28 2022.