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Pay-As-You-Go Insurance: Experimental Evidence on Consumer Demand and Behavior

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Pay-as-you-go contracts reduce minimum purchase requirements, which may increase market participation. This paper randomizes the introduction and price(s) of a novel pay-as-you-go contract to the California auto insurance market, where 17% of drivers are uninsured. The pay-as-you-go contract increases take-up by 10.8 p.p. (89%) and days with coverage by 4.6 days over the 3-month experiment (27%). Demand is relatively inelastic, and pay-as-you-go increases insurance coverage in part by relaxing liquidity requirements: most drivers' purchasing behavior is consistent with a cost of credit in excess of payday lending rates, and 19% of drivers have a purchase rejected for insufficient funds. (*JEL* D14, G22, G52, R41)

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Despite a universal insurance mandate, 17% of drivers in California operate their vehicles without the legally required coverage (Insurance Research Council 2021). Driving without auto insurance exposes drivers to large financial risks and increases insurance premiums for other drivers, imposing premium externalities of $27 billion per year in the United States (Sun and Yannelis 2016). Enrolling in auto insurance often requires large up-front payments and significant minimum purchase requirements, especially if drivers are purchasing coverage in the nonstandard auto insurance

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market.[1] Participation in many insurance markets is suboptimally low, and when premiums are charged up-front, liquidity requirements to enroll present a barrier to coverage (Cole et al. 2013; Casaburi and Willis 2018; Rampini and Viswanathan 2022).

Many markets, particularly those serving low-income consumers, offer smaller quantities at higher prices to increase market participation (Attanasio and Pastorino 2020). Pay-as-you-go contracts facilitate purchases of smaller quantities at flexible (typically higher) frequencies than traditional contracts with regular, longer-term billing cycles. These contract structures, which have proliferated across other domains serving low-income consumers including cell phone and utility contracts, relax minimum purchase requirements and allow households to retime insurance purchases to periods of higher liquidity.[2] Pay-as-you-go contracts may also increase coverage by allowing households to buy smaller durations of coverage that they can more easily afford. While pay-as-you-go contracts address commonly cited barriers to insurance market participation, they have never previously been introduced to insurance markets, so little is known about their effects on take-up of coverage, at what prices these contracts may be viable, or whether there is demand for smaller quantities at relatively higher prices.

This paper presents the results of a randomized control trial (RCT), which introduced a novel pay-as-you-go insurance contract to the California auto insurance market. The pay-as-you-go contract I study allows drivers to choose the size and timing of insurance coverage purchases by offering the option to buy a flexible number of days of coverage (3, 7, 14, or 30 days, with a 10-day grace period after exhausting their balance). Drivers can deactivate their insurance on days they are not driving to preserve their balance.

I randomize insurance contract offers along three dimensions. I offer applicants either a 3-month traditional contract or the pay-as-you-go contract to evaluate the effects of the pay-as-you-go contract on insurance take-up and persistence. Within the pay-as-you-go contract offer, I randomly shift the daily insurance premium conditional on the risk premium to estimate how demand varies by price. Finally, I offer half of the applicants assigned to the pay-as-you-go contract significant "bundle" discounts for purchasing a larger number of days of insurance (14 or 30) at a time to evaluate the role liquidity constraints play as a barrier to insurance take-up and to test willingness-to-pay for smaller quantities at relatively higher prices. I supplement the bundle-discount treatment arm with complementary evidence from credit reports, alternative credit data, utilization behavior, and data on transactions rejected for

[1] High-risk drivers must shop in the nonstandard auto insurance market, but low-risk drivers who are shopping for minimum liability insurance coverage also compose a large share of the nonstandard market (Walls 2015).

[2] Rampini and Viswanathan (2022) specifically note that their theory predicts that insurance technology innovations like pay-as-you-go break the connection between financing and insurance and have the potential to reduce high rates of uninsurance.

insufficient funds to shed light on the role of liquidity constraints in insurance purchasing decisions.

The pay-as-you-go contract increased insurance take-up by 10.8 percentage points (89%) and days with insurance available by 4.6 days (27%) over the 3-month experiment relative to the traditional contract offer. These intent-to-treat (ITT) estimates include coverage provided by carriers outside the experiment; effects are larger when only considering coverage through the experiment. Drivers take advantage of the feature of the contract that allows them not to pay for insurance on days they are not driving, "turning off" their insurance 32.5% of the days for which they have coverage available on average. After accounting for the ability to deactivate coverage, drivers offered the pay-as-you-go contract insure a similar number of days of driving to those offered the traditional contract. While the ITT effect of the pay-as-you-go contract on coverage erodes over time, there is suggestive evidence that the contract is particularly valuable for drivers who have historically struggled to maintain regular coverage.

Demand for the pay-as-you-go contract decreases in price but is strong relative to the traditional contract, even at the highest prices offered. Applicants offered the pay-as-you-go contracts were randomly offered a daily premium at one of three prices: base price (based on their risk, as priced by a backing insurance company, and translated to a daily premium by marking up the cost of a prorated day of insurance coverage by 67% to account for the option to deactivate coverage on days not driven), 120% of the base price, or 80% of the base price. Applicants in the lowest price group have larger effects on take-up through the experiment (16.1 percentage points vs. between 9.3 for the base price group and 11.4 percentage points for the high price group) and have roughly double the ITT effect on the number of days with access to coverage relative to the other two price groups (9.4 days vs. 4.9 days for the base price group and 6.2 days for the high price group). Applicants have an elasticity of demand (days purchased with respect to price) of −0.63 for all applicants and of −0.72 for those who enrolled. The relatively inelastic demand could indicate a preference for the flexibility and lower liquidity requirements features of the pay-as-you-go contract.

The market potential of the pay-as-you-go contract depends on the strength of demand for smaller quantities. The bundle discount treatment is designed such that forgoing the discount in favor of repeated purchases of smaller quantities implies a cost of borrowing similar to a payday loan. I find that demand for smaller quantities is high when prices are the same: 72% of days purchased are in bundles of 3 or 7 days when the price is the same across quantities. The bundle discount induces an increase in the share of large-quantity purchases by 12 percentage points, but many drivers continue to opt for smaller quantities even when relative prices are higher. Among those offered the discount, 51% of drivers forgo discounts for all of their purchases, and 77% of drivers forgo them at least once.

Drivers may prefer smaller quantities of coverage even at higher prices because they are liquidity constrained or because they are uncertain about their forecasted demand for driving relative to other consumption priorities. While the payment timing flexibility helps accommodate demand uncertainty, evidence suggests that liquidity constraints are binding and are significant in driving demand for smaller quantities. The drivers who apply for a pay-as-you-go insurance quote have limited access to formal credit: 77% have zero dollars of available credit on their credit report (81% are credit constrained when including the 15% of applicants who do not have a credit report), compared to 28% of a random sample of Californians. Nineteen percent of drivers who enroll in pay-as-you-go coverage have at least one purchase rejected for insufficient funds, which may be a more immediate sign of liquidity constraints. For 6% of enrolled drivers, an attempted insurance purchase rejected for insufficient funds is their last observable action before losing coverage.

This experiment created a rare opportunity to analyze the introduction of a novel insurance technology to the market and to randomize important insurance contract features. Furthermore, the experiment targeted uninsured drivers, an understudied and relevant group for policy. Beyond auto insurance, the results shed light on the efficacy of financial and insurance technologies—new and old—which seek to help this segment of consumers smooth their consumption (e.g., technologies enabling pay-as-you-go or buy-now-pay-later structures, brick-and-mortar rent-to-own retailers) and/or income (e.g., technologies enabling earned wage access, brick-and-mortar payday lending) over short periods of time. These technologies are growing in prevalence, with 56% of survey respondents indicating they used a buy-now-pay-later service in a March 2021 survey of 2,000 Americans, up from 38% in July 2020 (Caporal 2023), and three-quarters of workers reporting that it is important for their employer to offer earned wage access according to a survey conducted by ADP, Inc. (Elone 2022). Among uninsured drivers, the flexibility offered by the pay-as-you-go contract increases insurance take-up and coverage, which may point to a valuable role for technology in helping lower-income consumers manage their financial lives.

This paper contributes to several areas of research. First, I contribute to the modest literature studying optimal contracts and underinsurance in auto insurance markets. This literature dates back at least to Vickrey (1968), who observed the high-fixed-cost and no-marginal-cost properties of auto insurance contracts generate harmful externalities in the form of excess driving, congestion, and emissions and argued for a usage-based insurance contract. Edlin (1999) and Bordoff and Noel (2008a, 2008b) formalize these insights and estimate that a shift to per-mile premiums would generate large welfare benefits, with the largest benefits for low-income drivers who drive fewer miles on average. This paper studies a contract that partially addresses the "all-you-can-drive" concerns by allowing drivers to deactivate their insurance and save their balance on days they do not drive. Jin and Vasserman (2021) analyze a modern monitoring technology and find that both benefits and adoption costs are high. I focus on the high-churn minimum liability market where adoption of the on-board diagnostic devices required for monitoring may be less feasible.[3] Sun and Yannelis (2016) find a California program lowering premiums by lowering minimum coverage requirements reduces uninsured driving and calculate that the optimal fine (stochastic Pigouvian tax) for uninsured driving should be much higher, but acknowledge that uninsured drivers may be unable to pay. I contribute to this literature by estimating whether, how, and for whom a pay-as-you-go structure can reduce the rate of uninsured driving without reducing coverage limits. The prevalence of credit constraints among the uninsured drivers documented in this experiment also suggests that there they may indeed be limited gains from more severe enforcement, particularly if policy makers and regulators value the benefits of driving for economic mobility.[4]

Second, this paper contributes to our understanding of the role of liquidity constraints for insurance demand and lapsation. Liquidity constraints have been theorized or demonstrated to play a role in a number of related settings including microlending, subprime auto loans, consumer bankruptcy, flood insurance, health insurance, lapsation of life insurance policies, payday lending, and adoption of energy efficient technologies (Karlan and Zinman 2008; Adams, Einav, and Levin 2009; Gross, Notowidigdo, and Wang 2014; Liao and Mulder 2021; Ericson and Sydnor 2022; Gottlieb and Smetters 2021; Miller and Soo 2020; Berkouwer and Dean 2022). Casaburi and Willis (2018) find retiming premiums to harvest increases take-up of crop insurance in Kenya from 5% to 72%. Their crop insurance intervention, by committing to one-time premium payments at a future period of peak liquidity, presents an extreme case of eliminating liquidity constraints. This paper provides evidence that liquidity constraints are likely to be a barrier to auto insurance take-up and a factor contributing to policy lapsation for some consumers and tests the potential of smaller, periodic purchases to induce and sustain higher levels of coverage for recurring types of insurance. In a related theoretical paper, Rampini and Viswanathan (2022) model insurance as state-contingent savings (because insurance premiums are paid in advance), which implies that, with limited liability, households lacking liquidity are unlikely to participate in insurance markets at all. This paper presents experimental evidence that breaking the connection between financing and insurance can increase participation in insurance markets for low-resource households.

3 An earlier experiment offered by-the-minute insurance coverage. As part of that project, my research partners and I attempted to incentivize enrolled drivers to install on-board diagnostic devices to monitor their driving but there was minimal interest in taking up this offer.

4 Baum (2009) finds that lower barriers to driving increase employment and exit from welfare.

Third, and finally, this paper extends a small literature studying consumer behavior under pay-as-you-go contracts and a related literature on smaller, more frequent consumption patterns. In two papers studying prepaid electricity metering in South Africa, Jack and Smith (2015) document that poorer customers prefer to make smaller, more frequent electricity purchases, which are incompatible with traditional monthly billing cycles, and Jack and Smith (2020) find that switching poorer and in-debt customers to prepaid metering generates net revenue gains to the utility. Aker and Mbiti (2010) and Kalba (2008) document that the rapid adoption of mobile phones in Africa was enabled in part by a pay-as-you-go contract structure.[5] Baker, Johnson, and Kueng (2020), who find the returns to inventory management are high at low levels of wealth, and Attanasio and Pastorino (2020), who find the availability of smaller quantities—even at higher prices—increases market participation for food in rural Mexico, examine similar consumption decisions. To my knowledge, this is the first paper to study pay-as-you-go contracts of any kind in the United States and the first to study them in the context of insurance markets. In addition to estimating demand for these contracts in relation to standard contracts, I provide evidence on the elasticity of demand and willingness-to-pay for smaller quantities at higher prices using experimentally induced price variation.

1. Background: The Uninsured Driver Problem

Despite regulations that require all drivers to carry auto insurance,[6] thirteen percent of drivers in the United States operate their vehicles without the mandated insurance coverage; that number is even higher in our setting, California, where millions of people drive without insurance (17%) (Insurance Research Council 2021).[7] This paper focuses on uninsured drivers in California shopping for minimum liability insurance coverage. Uninsured drivers are exposed to large financial risks and impose externalities by increasing the financial risk other drivers face in the event of an accident. Sun and Yannelis (2016) find a one-percentage-point increase in the share of drivers in a county who are uninsured increases insurance premiums by 1% and calculate the annual cost of the uninsured driver externality to be $6 billion in California alone ($27 billion nationally).

Uninsured driving has historically been a high-profile policy problem, and California has several policies in place to combat the problem. California

[5] Similar contracts are popular in the developed world, but research on them is extremely limited. Chen (2012) describes an industry report that finds 23% of wireless customers had a prepaid contract in 2012 and that projected that number to grow to 29% by 2016.

[6] Two states are exceptions to this rule. Virginia allows drivers to pay a $500 fee with their registration instead of purchasing auto insurance coverage (Virginia Department of Motor Vehicles 2021). New Hampshire has no law mandating insurance (New Hampshire Department of Motor Vehicles 2021).

[7] Insurance Research Council (2021) estimates these numbers using the ratio of insurance claims made by individuals injured by uninsured versus insured drivers. See Table A1 in the Internet Appendix for the share uninsured by state.

requires minimum liability insurance of $15,000 of coverage for bodily injury to a single person ($30,000 for multiple people) and $5,000 of coverage for property damage ("15/30/5"). Insurance is legally mandated and required to register a vehicle. Punishments for uninsured driving include escalating fines (up to $720 of fines and fees for a first offense, up to $1,800 for a second offense) and vehicle impoundment at the discretion of the police (Fitzpatrick 2022). In the event of an accident where they are not at fault, "no-pay-no-play" laws prohibit uninsured drivers from collecting damages and compensation. While most of the policies addressing the problem are punitive, California also offers a Low Cost Auto Insurance program that lowers premiums by reducing the minimum insurance requirements from "15/30/5" to "10/20/3" for eligible "good" drivers with incomes below 250% of the Federal Poverty Level and vehicles valued at $20,000 or less with no outstanding loans. The program reduced uninsured driving by one to two percentage points off an average of 21% upon implementation in 1999 (Sun and Yannelis 2016) and eligibility was extended to drivers with fewer than 3 years of experience and vehicle values up to $25,000 in 2015 (California Department of Insurance 2021). While reducing minimum coverage requirements increases take-up on the extensive margin for standard monthly, all-you-can-drive contracts, this comes at the cost of increased liability in the event of an accident.

While little is known about why individuals drive without insurance, I will highlight several features of the auto insurance market as potential contributing factors. First, liability insurance does not cover any damages to oneself or one's own vehicle and drivers remain liable for costs exceeding these coverage limits. Households with limited assets may have limited liability in the event of an accident (either because the other driver and their insurance would not seek a judgment or because they have the option to file for bankruptcy), which could reduce their demand for insurance.

Second, insurers are restricted from pricing on some factors and choose not to price others, which could lead to actuarially unfair pricing along unpriced dimensions. Passed in 1988, Proposition 103 ("The Insurance Rate Reduction and Reform Act") limited the dimensions along which auto insurance premiums could be priced.[8] While annual mileage is one of three primary pricing factors (alongside driving record and experience), in practice the cost of verifying mileage may result in insurers underpricing mileage on the margin. Bordoff and Noel (2008b) estimate vehicle miles traveled would be 8% lower if insurance were priced per mile. Further, low-income drivers drive fewer miles on average and therefore subsidize the premiums of higher income drivers when mileage is underpriced (Bordoff and Noel 2008a, 2008b; Consumer Federation of America 2015), which could push some share of them to drive uninsured.

[8] See Internet Appendix A for additional details on auto insurance regulations and premium pricing.

Third, drivers shopping for minimum liability insurance coverage are also confined to shopping in the "nonstandard" auto insurance market. A distinctive feature of auto insurance markets is that insurers are free to deny coverage for classes of drivers they consider to be high-risk (Value Penguin 2021). Two groups of drivers are commonly relegated to shopping in the nonstandard market: high-risk drivers denied coverage in the standard market and drivers shopping for the minimum insurance coverage required by the state. Walls (2015) describes the nonstandard market as "a market for drivers who have certain risk factors that make it difficult or impossible for them to obtain insurance in a standard or preferred market. These insureds include new or young drivers, drivers with credit problems, drivers with multiple losses or moving violations, people who want only minimum limits coverage and those with an unusual driver's license status."

Pooling credit-constrained drivers shopping for minimum liability coverage with high-risk drivers with multiple losses or moving violations may exacerbate affordability challenges for low-income drivers. The nonstandard market also tends to be more volatile and transaction-heavy than the standard market; one executive reports nonstandard customers typically lapse on their policy within the first 3 months and re-enroll within 30 days (Walls 2015). These lapsations incur fees and nonpremium fees are a substantial share of nonstandard insurer revenue. Based on public filings, nonstandard carriers charge fees totaling approximately 13% of their net earned premiums.[9] These fees are disproportionately borne by drivers frequently cycling in and out of insurance and may present a barrier to maintaining coverage. In addition to the high share of premiums paid in fees in the nonstandard market, plans typically require a substantial up-front payment.[10] Collectively, the risk pool of drivers insured by nonstandard carriers (high-risk and/or low-resource drivers shopping for minimum coverage), administrative loads and customer acquisition costs posed by high customer churn, and high liquidity requirements to enroll in insurance are likely to push up the cost of insurance coverage for low-income or liquidity-constrained consumers seeking minimum liability coverage.

The pay-as-you-go contract studied in this experiment will more closely tie premiums paid to driving frequency, offer more flexible payment options to eliminate fees for missed payments and reactivation, and reduce the liquidity requirements to enroll in coverage, which may collectively address some of the existing barriers to insurance coverage.

[9] Author's calculation based on the 10-K filings for Infinity Property and Casualty Corporation, Mercury General Corporation, National General Holdings Corporation, First Acceptance Corporation, and Affirmative Insurance Holdings Incorporated. This is based on 2017 10-K filings for the first three, 2016 10-K filing for First Acceptance Corporation, and the 2014 10-K filing for Affirmative Insurance Holdings Incorporated.

[10] For example, Megna (2021) writes "[v]irtually every car insurance company requires that you pay at least one month ahead on a six-month policy... Drivers with a bad credit history or in need of an SR-22 filing are likely to be required to make a larger down payment or even to pay for the term in full."

2. Experimental Design and Data

2.1 Pay-as-you-go insurance and recruitment

I partnered with Hugo Insurance Services, a California-based insurance technology company offering no-fee and no-obligation minimum liability auto insurance contracts targeted at low-income uninsured drivers. In what follows, I evaluate the introduction of their novel pay-as-you-go auto insurance contract to the California auto insurance market. The pay-as-you-go contract allows drivers to buy minimum liability auto insurance coverage in quantities of 3, 7, 14, or 30 days and allows drivers to pay for insurance only on days in which they drive. Drivers can "pause" their insurance coverage for periods up to 10 days when they are not driving by texting `PAUSE`.[11] Drivers can reactivate their insurance at any time by texting `COVER`, which immediately initiates coverage for the subsequent 24-hour interval. Pausing coverage stops it from automatically renewing for another day at the end of the 24-hour interval. Drivers who have exhausted their balance of days can continue to insure their driving for a grace period of up to 10 days. Drivers who draw on their reserve balance of grace period days must repay them in addition to the 3, 7, 14, or 30 days when they top up their account.

The California Department of Insurance, given its vested interest in reducing uninsured driving, provided Hugo Insurance Services with permission to introduce this novel contract structure to the market and to vary features of the contract for the duration of the experiment. This provided a rare opportunity to understand how individuals shopping for insurance respond to contract structure, price, and bundle discounts. The experiment was preregistered with the AEA RCT Registry (Kluender 2019) and the pre-registration is available in Internet Appendix B.

Hugo Insurance Services acquired customers shopping for minimum liability auto insurance coverage through standard channels including Google Adwords and purchasing leads through other insurers.[12] Drivers were directed to the Hugo Insurance Services website (withhugo.com, see Internet Appendix Figure A1 for screenshots) and invited to apply for a quote. Drivers qualified for the experiment if they met the criteria of the underwriting backing insurer.[13] The experiment accepted applicants between March 8, 2019, and August 30, 2019, and the duration of the experiment for participants was 3 months from the time of insurance enrollment. During the application period, 1,537 participants were offered quotes for insurance coverage through the experiment.

11 After 10 days, Hugo will reactivate insurance coverage for drivers with a positive balance of days on their account. Drivers have the option to pause their insurance again following that 24-hour reactivation.

12 See, for example, the MediaAlpha (2015) white paper for how one auto insurance advertising platform operates.

13 Some applicants (456, or 23%) could not be underwritten by the backing insurer. The most common reasons the backing insurer rejected applicants were age (drivers younger than 18 were ineligible), driving record, vehicle make, and invalid license, respectively. Roughly a quarter of rejections were for technical failures (e.g., the third-party application programming interface [API] to pull motor vehicle reports was down).

2.2 Pricing daily pay-as-you-go premiums

Setting the daily premium for the pay-as-you-go contract required forecasting the risk exposure presented by a day when a driver who selects into pay-as-you-go coverage chooses to activate their insurance. I expect this risk to be higher than the average day underwritten by a traditional insurance contract because drivers can choose not to activate their coverage on days they are not driving, may risk driving uninsured on days where they only make short trips, and may intertemporally substitute more driving into fewer days. To set premiums, I first assume that the quoted traditional 3-month premium is actuarially appropriate for pay-as-you-go coverage applicants. This allows me to use this value as a base premium to be adjusted based on projected behavior under the pay-as-you-go contract. This decision abstracted away potential selection into the pay-as-you-go contract, which could be advantageous (if drivers are safer or drive fewer miles than their traditional premium reflects) or adverse (if drivers are riskier or drive more miles on the days they drive).

To estimate how much of the risk underwritten by the traditional contract would be borne on days the pay-as-you-go coverage was active, I used travel diary information from the 2017 National Household Transportation Survey (NHTS). Limiting the sample to California drivers, I assumed drivers would activate their insurance on days they drove more than five minutes and calculated the share of their reported annual mileage they drove on these days.[14] Comparing the mileage exposure on these days to the annual mileage prorated over all 365 days, I set the base mark-up at 67% over the prorated traditional premium. My research partner's willingness to randomize the price of the pay-as-you-go contract, which varied the size of this mark-up from 34% to 100%, reflects some of the uncertainty over the appropriate size of the mark-up.

Based on low loss-ratios realized by Hugo Insurance Services for the pay-as-you-go contract across 10 states in the 3 years since the experiment, the 67% mark-up may be higher than the steady-state equilibrium price. As of December 2022, the largest mark-up they use in any of the states in which they operate is approximately one-third of the mark-up used in the experiment. These low loss-ratios could be driven by advantageous selection into the contracts (safer, lower mileage drivers) or behavioral explanations (drivers do not meaningfully intertemporally substitute risk into the days coverage is active), but the magnitude of the reduction in the mark-up is difficult to justify with behavioral explanations alone. In aggregate, drivers activated their coverage on 59.6% of days in the experiment (the average share of days active was 67.5% across drivers), which would suggest a mark-up of 67% is appropriate based on activation frequency alone. The relatively high mark-up employed in the experiment will bias downward estimates of the effect of the contract on insurance take-up and coverage. The elasticity of demand estimates

14 See Internet Appendix A for additional details on this calculation, alternative methods, and the brief memo written to the California Department of Insurance to explain the premium mark-up.

for the pay-as-you-go contract should be interpreted relative to this benchmark price (plus or minus 20% based on the price treatment group).

2.3 Treatment arms

The first hypothesis the experiment tests is whether the pay-as-you-go contract offer increases insurance take-up and coverage relative to a traditional contract. Insurance applicants were randomly assigned to either the control group, which was offered a 3-month traditional all-you-can-drive minimum-liability-insurance contract with 3 months of premiums due at enrollment, or the pay-as-you-go contract. The traditional contract is the contract that would be offered to the applicant by the backing insurance company outside the experiment. The first dimension of the randomization is the type of contract: one-seventh of applicants are offered the traditional contract and the remaining six-sevenths are offered the pay-as-you-go contract. The second and third dimensions of randomization are within the pay-as-you-go contract. Figure A2 in the Internet Appendix visualizes each layer of the randomization.

To estimate sensitivity to price, the second dimension of randomization is the price of a day of insurance. I translate an applicant's traditional premium to a daily premium as described above and, conditional on the applicant's daily premium, induce additional random variation in price. Specifically, applicants offered the pay-as-you-go contract are randomly allocated to one of three pricing treatment groups: 20% up, no adjustment, and 20% down. By conditioning on the risk premium, I induce price variation orthogonal to risk type, which would otherwise confound estimates of demand. Figure 1 plots the distribution of the market-rate, 3-month premium for the control, low, base, and high price groups in panel A.[15] Figure 1, panel B, illustrates the pricing variation induced by the experiment.

The third and final dimension of the randomization tests demand for smaller quantities of insurance at relatively higher prices by offering discounts for 14- or 30-day purchases. By randomly varying the relative prices for smaller (3 or 7 days) and larger (14 or 30 days) quantities of insurance coverage, I can estimate how often drivers are willing to forgo the bundle discounts in favor of smaller quantities at higher prices. Half of applicants in each of the three pay-as-you-go price groups are offered a discount for buying a larger "bundle" of days of insurance at once to operationalize this. The bundle discount provides no discounts for 3- or 7-day purchases, but offers 14 days for the price of 12 and 30 days for the price of 24. Figure 1, panel C, plots the market-rate, 3-month premium distribution for the control and pay-as-you-go treatment groups split by whether they are offered the bundle discount. Panel D illustrates

15 A Kolmogorov-Smirnov test of distributional equality between the premium distributions of applicants offered the traditional versus pay-as-you-go contract is not significant (p-value = .18). I additionally test the null hypothesis of distributional equality for all two-way pairs of the four groups and between the bundle discount and no bundle discount groups. Only one (Control-High) is statistically significant. Results are robust to the inclusion of controls, including the base premium, and I describe these checks in more detail in Section 3.

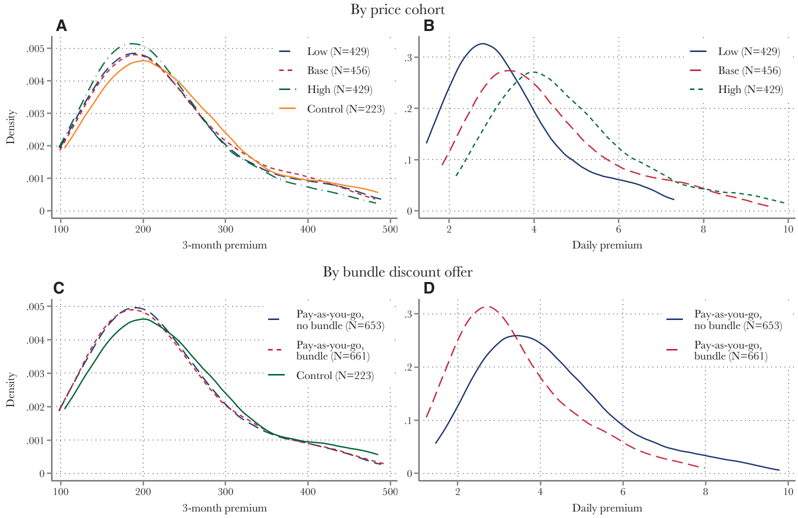

Figure 1
Premium distributions and experimental variation
Panels A and C plot the distributions of market-rate, 3-month premiums split by price (panel A) or bundle discount (panel C) treatment group assignment. Panels B and D plot the distributions of daily pay-as-you-go premiums split by price (panel B) and bundle discount (panel D) treatment group to illustrate the variation in premiums induced by the experiment. Panel D plots the bundle discounted premium distribution assuming a 30-day purchase (30 days for the price of 24, implying a 20% discount). The distributions are calculated via kernel density plots with bandwidths of 40 and .6 for the 3-month and daily premiums, respectively.

the variation induced by this arm of the experiment by plotting the daily premium distribution offered to the bundle and no-bundle treatment groups for 30-day purchases.

The cost of borrowing implied when an applicant forgoes the bundle discount to purchase smaller quantities of days of insurance is designed to approximate the cost of a payday loan, which is in the range of a 391 to 600 annual percentage rate (APR) (Hoevelmann 2019). Table A2 in the Internet Appendix illustrates the cost of borrowing implied by forgoing the bundle, which can be calculated by dividing the forgone savings from the bundle (the "interest") by the difference between price for the bundle purchases (14 or 30 days) and the smaller quantities (3 or 7 days) to determine the size of the loan. To calculate the duration of the loan, I divide the difference in the number of days purchased by the average utilization rate of 67.5% (share of days insurance is active among users with a positive balance of days).[16] The APR implied by forgoing the

16 Table A2 in the Internet Appendix shows the implied cost of borrowing for each pairwise choice based on the formula Implied APR$=\frac{\text{Forgone discount (“interest”)}}{\text{Borrowing required to access bundle (“principal”)}} * (\frac{365}{T})$. For example, the calculation treats the duration of the loan for a driver who forgoes the 30-day discount to purchase 3 days as 40 days (27 days divided by the utilization rate of 67.5%), the "interest" as 6 days, and the "principal" as 21 days for an implied APR of 261%.

bundle ranges from 261% for drivers who opt for 3 days relative to the 30-day bundle to 1,409% for drivers who opt for 7 days instead of 14-day bundle.

One-seventh of applicants were randomized into the control group and one-seventh into each of the six pay-as-you-go contract treatment groups, split by price adjustment and whether they were offered a bundle discount (low price-no bundle, low price-bundle, base price-no bundle, base price-bundle, high price-no bundle, high price-bundle). The randomization was prespecified and blocked for every 49 visitors to the website who began the application process.[17] Figure A2 in the Internet Appendix presents the number of applicants assigned to each layer of treatment. Table A3 in the Internet Appendix presents balance on observables by whether an applicant was offered a pay-as-you-go or a traditional contract. As expected, the F-statistic for joint significance of the differences in variables in groups is not statistically significant.

2.4 Data and summary statistics

Administrative data from Hugo Insurance Services is my primary data source. These data include insurance application information (age, years of experience, vehicle make, model, and year), a ledger of purchase actions (number of days purchased, amount, and current balance), and a ledger of coverage actions (coverage activations and deactivations) for each applicant. Using the vehicle make, model, and year, I supplement the application information with the private resale value of the vehicle based on the CARFAX vehicle valuation tool.[18] Additional data that Hugo Insurance Services uses to administer plans are derived from third-party databases, including motor vehicle reports (driving records) which generate the 3-month premium and insurance coverage from other carriers (whether drivers had previous regular insurance and whether they take up other coverage during the experiment). While I cannot access the third-party data sources, Hugo provides relevant derived information including the 3-month premium (which embeds information from the driving record), whether the driver has previous regular coverage, and the number of days of the experiment an applicant had coverage from another carrier. For users offered the pay-as-you-go contract, Hugo translates the 3-month premium to their daily premium and adjusts it as necessary based on their price treatment group.

I also receive transaction-level data for insurance purchases from Stripe, their payment processor, which I use to validate the administrative data

[17] The initial intent was to block every 49 *applicants* as specified in the pre-registration for the experiment; however, this was not feasible for my partner, as technical implementation required assigning the treatment group before pricing an applicant's quote. Therefore, a large number of randomization slots were "used up" with applicants who began but did not complete the quote process (receiving a quote was a requirement for inclusion in the study sample) or who did not meet the underwriting conditions of the backing insurer. Given the block randomization was interrupted by these technical challenges, I do not include strata fixed effects.

[18] I hired three contract workers on Mechanical Turk to use the vehicles' make, model, and year to look up the private, trade-in, and retail values of the vehicles using https://www.carfax.com/value/. After confirming all three completed the task, I take the median private resale value between the three recorded values.

on purchases and to observe failed transactions. Failed transactions include purchase attempts that were rejected due to insufficient funds, which provide one proxy for liquidity constraints.

To further supplement the administrative data from Hugo, I purchased credit report data from Experian and alternative credit reports tracking subprime borrowing from Clarity Services. These data include the standard bevy of credit-report measures including credit score, credit limits, inquiries, borrowing (including credit cards and auto loans), debt past-due, and debt in collections. Experian also provides an "Income Insight Score," an estimate of user income derived from a combination of proprietary and verified income data.[19] In the spirit of Miller and Soo (2020), I define users as "credit constrained" if they have outstanding balances equal to or exceeding their available credit or have no available credit (the 15% of applicants who do not have a credit report are coded as credit constrained).

Given all applicants apply for a pay-as-you-go insurance quote from Hugo, applicants may be less likely to take up a traditional contract offer even at the market rate (e.g., they may worry that a pay-as-you-go insurer may not provide the best traditional coverage). To address this concern, I obtain an indicator for whether applicants took up insurance through any other carrier (based on data they use for underwriting, which they report covers more than 90% of the market) that provides a more comprehensive measure of coverage.

I define four different measures of insurance coverage, separately for coverage from Hugo Insurance Services (i.e., coverage through the experiment) and from any carrier (including coverage from Hugo through the experiment): (1) initial take-up; (2) the number of days the driver had coverage available; (3) the number of days insurance was active; and, (4) whether the driver was insured at the end of the 3-month study period. To capture behavior over the full course of the pay-as-you-go contract, I consider the date of enrollment with Hugo Insurance Services as the start date for insurance outcomes within Hugo (purchases, activations, deactivations). Because users who do not take up insurance with Hugo do not have an enrollment date, I use the account creation date (the first time they arrived on the Hugo website) as the start date to align the experimental periods for outcomes that incorporate insurance coverage from other carriers. Take-up through Hugo Insurance Services is defined as any enrollment in a plan offered through the experiment. Take-up by any insurer is defined as within 7 days of their account creation date.

Table 1 presents summary statistics on the sample of applicants. The average 3-month premium is $232, which translates to an average daily premium of $4.27. Applicants are around 38 years old on average. Their vehicles are old (mean and median vehicle year of 2004) with low resale value (mean resale value of $1,877, median resale value of just $551). Table A4 in the

[19] https://www.experian.com/consumer-information/income-insight

Table 1
Applicant summary statistics

	Mean	SD	Median
A. Administrative data measures			
3-month premium	232	94.5	209
Daily premium	4.27	1.83	3.83
Vehicle resale value	1,877	3,293	551
Vehicle year	2004	6.65	2004
Age	37.8	10.4	36.6
N	1,537		
B. Credit report measures			
Income Insight Score	37,452	15,625	34,000
Vantage credit score	515	127	532
Total inquiries	5.5	6.82	3
Total revolving credit limit	665	3,402	0
Credit card limit	497	2,969	0
Credit card balance	404	1,587	0
Is credit constrained	80.8	39.4	100
Has auto loan	35.5	47.9	0
Auto loan amount	1,788	5,866	0
Medical collections	1,007	5,336	0
Nonmedical collections	1,432	2,944	284
Nonmissing credit report	1,309		
C. Alternative credit report measures			
Clarity total inquiries	5.17	19	0
Clarity credit limit	84.8	717	0
Clarity credit balance	44.5	435	0
Nonmissing alternative credit report	372		

The table presents the mean, standard deviation (SD), and median of each variable for the experiment sample of 1,537 drivers, split by data source. Measures of credit such as inquiries, limits, and balances are assumed to be zero if missing and summary statistics in panels B and C include all applicants.

Internet Appendix compares summary statistics for the sample of applicants with a random sample of one million credit reports across the United States and the subset of 122,886 credit reports for individuals located in California. Mean and median Income Insight Scores for the sample of applicants are around $35,000, significantly lower than the mean national Income Insight Score of roughly $85,000. Drivers applying for coverage appear to have limited access to credit, with a mean credit score that is firmly subprime. The overwhelming majority of applicants (80.8%) are credit constrained. The large number of inquiries (mean, 5.5; median, 3) suggests drivers are actively seeking additional sources of credit. Just 35.5% of the sample have an outstanding auto loan (with an average outstanding balance of $1,788), which is lower than the California mean of 51.6 and the national mean of 55.3.[20]

20 While the vast majority of subprime auto loans are reported to credit bureaus, auto loans from small finance companies and small buy-here-pay-here dealerships appear on credit reports less than a quarter of the time. These lenders comprise a little under 20% of the market but loans made for low-value vehicles and more subprime consumers are less likely to be reported (Clarkberg, Gardner, and Low 2021). The data are consistent with applicants being less likely to have an active auto loan but the share of applicants who own their vehicles outright may be overstated if their auto loans are underreported to credit bureaus.

3. Results

3.1 The effect of a pay-as-you-go contract offer on insurance coverage

The first hypothesis I test is whether the pay-as-you-go contract offer increases insurance coverage relative to a traditional contract offer. I regress measures of insurance coverage, y_i, defined above, on an indicator for whether the applicant was offered an pay-as-you-go contract, $\mathbb{1}\{PAYG_i\}$:

$$y_i = \alpha + \beta \mathbb{1}\{PAYG_i\} + \epsilon_i. \quad (1)$$

Figure 2 plots estimates for take-up and days with coverage separately for coverage through the experiment and coverage from any carrier, along with 95% confidence intervals for the coefficient β estimated in Equation (1). Offering users the pay-as-you-go contract has a large effect on initial take-up of insurance coverage: users offered the pay-as-you-go contract are 12.2 percentage points (227%) more likely to take-up insurance coverage from Hugo. ITT effects on take-up remain high when incorporating coverage through Hugo or any other carrier: 22.9% of applicants offered the pay-as-you-go plan took up insurance within 7 days of their account creation, an 89% increase over the traditional contract offer. Patterns remain statistically and economically significant, though more muted, when analyzing the number of days with coverage. Applicants offered the pay-as-you-go plan have 4.6 more days with coverage available (27%) in the 3 months after the account creation date.

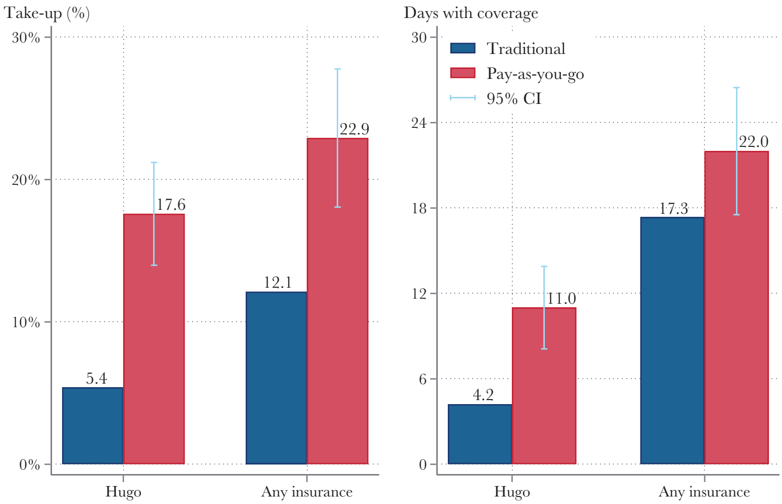

Figure 2
Effect of the pay-as-you-go contract offer on insurance coverage
The figure presents the mean values of take-up and days with coverage through the experiment and from any carrier, separately for those offered the traditional and pay-as-you-go insurance contract. Error bars represent the 95% confidence interval of the treatment effect as estimated in Equation 1.

Table 2
Effect of pay-as-you-go contract offer on insurance coverage

	Take-up (1)	Days with coverage (2)	Days insured (3)	Insured end of study (4)
		A. Insurance through experiment		
Pay-as-you-go	12.20	6.79	2.35	4.19
	(1.84)	(1.48)	(1.37)	(1.59)
	[0.000]	[0.000]	[0.085]	[0.008]
Constant	5.38	4.20	4.20	4.48
	(1.51)	(1.27)	(1.27)	(1.39)
	[0.000]	[0.001]	[0.001]	[0.001]
N	1,537	1,537	1,537	1,537
Mean	15.8	10.0	6.21	8.07
		B. Any insurance		
Pay-as-you-go	10.80	4.64	0.60	2.49
	(2.47)	(2.28)	(2.23)	(2.90)
	[0.000]	[0.042]	[0.788]	[0.391]
Constant	12.11	17.34	17.34	19.73
	(2.19)	(2.08)	(2.08)	(2.67)
	[0.000]	[0.000]	[0.000]	[0.000]
N	1,537	1,537	1,537	1,537
Mean	21.3	21.3	17.9	21.9

The table presents estimates from Equation 1 of the effect of being offered a pay-as-you-go insurance contract on take-up (defined as accepting the quote at any time for coverage through the experiment and within seven days of receiving their Hugo quote for any insurance), days with coverage (days where users are covered or have nonzero coverage balance), days insured, and whether they were insured at the end of the 3-month study period. The coefficients are listed with robust standard errors in parentheses and p-values in brackets. The number of observations, N, and the mean of the dependent variable are also presented.

Table 2 adds days insured and whether drivers were insured at the end of the study as outcomes and displays the regression coefficients with robust standard errors in parentheses and p-values in brackets. Relative to days with coverage, insured days will include only days in which insurance was active and puts the pay-as-you-go contract at a particular disadvantage to the traditional contract, which provides insurance every day regardless of whether the user drives. Nevertheless, it is informative in providing the actual days the driver is covered and the insurer is exposed to risk. Conditional on enrolling in coverage, pay-as-you-go drivers insure 37.3 days on average versus 78.0 days for drivers who enroll in the traditional contract.[21] Drivers offered the pay-as-you-go contract insure 0.6 additional days and this difference is not statistically significant.

In Table A5 in the Internet Appendix, I test whether the ITT effects are robust to controlling for the full set of covariates in Table 1 and selecting covariates via post-double-Lasso (Belloni, Chernozhukov, and Hansen 2014). The procedure does not find any consistent predictors of take-up other than the pay-as-you-go treatment assignment and the ITT estimates are stable across specifications.

21 The 78 days covered for those enrolled in the traditional contract reflects two drivers who canceled their traditional contract shortly after enrolling. Drivers enrolled in pay-as-you-coverage had 62.5 days with coverage available on average, insurance was active on 59.6% of those days in aggregate. Across drivers, the average utilization rate (share of days with coverage available that coverage is active) is higher at 67.5%.

3.2 Elasticity of demand with respect to the price of a day of insurance

The market potential for the pay-as-you-go contract hinges on drivers' willingness-to-pay for this alternative contract structure. In this section, I use randomly induced variation to estimate the price sensitivity of demand for the pay-as-you-go contract.

In general, estimating demand for insurance is challenging: higher risk applicants face higher prices. Further, variation uncorrelated with applicant risk is rare and often relies on local discontinuities where it does exist (e.g., Finkelstein, Hendren, and Shepard (2019)). This experiment offers a rare opportunity to estimate demand using randomly varied prices *conditional on baseline risk premium* which, as displayed in Figure 1, exhibits substantial variation across applicants. The 3-month premium is translated to a daily premium as described in Section 2.2, then prices are increased by 20% for the high premium group, unchanged for the base group, and reduced by 20% for the low premium group. For this section and the next, I focus on outcomes within the pay-as-you-go contract and the premiums for the 3- and 7-day bundles, controlling for whether an applicant is offered the bundle discount, because that is the level at which the price variation operates. I continue to present results for take-up but substitute days insured instead of days with coverage because that better reflects the effect of price on the decision to "spend" a day of coverage. To begin, I residualize the base premium and estimate the impact of price on these outcomes:

$$y_i = \beta_0 + \underbrace{\beta_1 p_{induced_i}}_{\text{Isolates random price variation}} + \underbrace{\beta_2 p_{base_i}}_{\text{Controls for risk premium}} + \beta_3 Bundle_i + \epsilon_i. \quad (2)$$

Both take-up and days insured decrease in price. Figure 3 presents binscatters of take-up and days of paid coverage against the induced variation in price (after residualizing the base premium). β_1 dictates the slope of the lines and is presented in the upper right-hand corner of each of the panels. A one-dollar increase in the premium decreases take-up by 3.23 percentage points (19% off the pay-as-you-go mean take-up rate of 17.6) and days insured by 1.91 (29% off the pay-as-you-go mean days insured of 6.5).

To facilitate easy comparisons to other populations and settings, I also estimate the elasticity of demand for days of auto insurance coverage using the induced random variation in price. I analyze the same two outcome variables above with y_i representing the take-up rate of insurance and days insured (both defined using only coverage through Hugo). I take an inverse hyperbolic sine transformation of days insured to accommodate those who do not take up insurance. Chen and Roth (2022) caution that estimating elasticities using log-like transformations of variables with zeroes will combine intensive and extensive margin effects, which renders them arbitrarily scale-dependent. One way to address this concern is to separately estimate the extensive margin (take-up) and intensive margin (days insured conditional on take-up) price sensitivities. I include estimates in Table 3 for take-up and days insured,

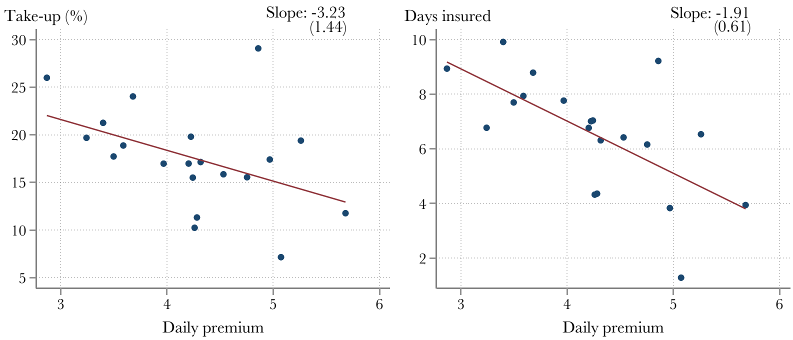

Figure 3
Demand for insurance by induced price variation
The figure presents binscatters of take-up rate and days insured against the daily premium (for the 3- and 7-day bundles) for the 1,325 drivers offered the pay-as-you-go contract. The binscatters and slopes control for whether the user was offered a bundle discount as well as the base daily premium before the price variation induced by the experiment. The slope of the associated regression is presented in the top-right corner with the standard error in parentheses.

separately for all applicants and conditional on take-up. Table A6 in the Internet Appendix also presents $log(y_i)$ and $log(y_i+1)$ as alternative transformations with remarkably similar estimates across transformations and conditioning the sample on enrollment. Nevertheless, given the limitations of each of these transformations, one should interpret these estimates as elasticities with caution. I estimate

$$y_i = \beta_0 + \beta_1 log(p_{induced_i}) + \beta_2 log(p_{base_i}) + \beta_3 Bundle_i + \epsilon_i. \quad (3)$$

Table 3 presents the elasticity of demand estimates. A 10% increase in the quoted daily premium for the pay-as-you-go contract decreases take-up of the contract by 1.27 percentage points. The price sensitivity of demand for the uninsured drivers in my sample is more pronounced when looking at how the number of days insured respond to an increase in price: the elasticity of demand is −0.63 for all applicants and rises to −0.72 for drivers who enroll in the pay-as-you-go contract. Separate ITT regressions by price group, presented in Figure A3 and Table A7 in the Internet Appendix, show the strongest effects on coverage for the low price group with smaller effects on take-up and days with coverage for the base and high price treatment groups. Elasticity estimates are slightly more inelastic than other estimates of demand for auto insurance. Barone and Bella (2004), for example, find an average elasticity of demand for auto insurance across market segments of −1.1. This relatively inelastic demand could reflect the inaccessibility of alternative insurance contracts, particularly if they are poorly suited to the needs of these uninsured drivers due to large minimum purchase amounts and high up-front liquidity requirements. I explore the relative demand for smaller quantities and lower liquidity requirements in the next subsection.

Table 3
Demand for insurance with respect to induced price variation

	Take-up	Take-up, > 3	asinh(Days insured)	
	(1)	(2)	(3)	(4)
Log(Daily premium)	−12.66	−13.65	−0.63	−0.72
	(6.61)	(5.32)	(0.27)	(0.34)
	[0.056]	[0.010]	[0.020]	[0.032]
Log(Base daily premium)	4.99	3.20	0.24	0.17
	(7.18)	(5.71)	(0.29)	(0.35)
	[0.487]	[0.575]	[0.408]	[0.637]
Bundle discount offered	−1.23	−0.84	−0.05	−0.03
	(2.10)	(1.68)	(0.09)	(0.11)
	[0.557]	[0.618]	[0.559]	[0.814]
Constant	28.58	25.20	1.26	4.75
	(4.12)	(3.40)	(0.17)	(0.18)
	[0.000]	[0.000]	[0.000]	[0.000]
N	1,314	1,314	1,314	231
Sample	All	All	All	Enrolled

The table reports estimates of Equation 3. The dependent variable in column 1 is whether the driver took up coverage through the experiment, while column 2 is whether the driver took up coverage through the experiment and purchased more than 3 days of insurance. Columns 3 and 4 estimate the inverse hyperbolic sine transformation of total days insured. The sample in columns 1 through 3 is restricted to drivers offered the pay-as-you-go contract, while the sample for column 4 is conditional on enrollment in the pay-as-you-go contract. The daily premium is the premium offered for the 3- and 7-day bundles. The coefficients are reported along with robust standard errors in parentheses and *p*-values in brackets.

3.3 Demand for smaller quantities and evidence of liquidity constraints

The pay-as-you-go contract provides consumers the option to smooth their consumption relative to typical payment cycles by purchasing smaller quantities over time. To explore the demand for this contract feature, I analyze the revealed preference for 3 or 7 days relative to 14 or 30 days. I do this first for those offered the pay-as-you-go contract without the bundle discount who face the same price for small and large quantities. Next, I test whether preferences for smaller quantities persist even when applicants are offered a "bundle discount" for purchasing more days of insurance at a time. Drivers who forgo the bundle discounts reveal that they prefer to buy smaller quantities of insurance even when prices are higher, with the size of the bundle discounts designed such that forgoing them implies a lower bound of the cost of borrowing that is similar to a payday loan (see Table A2 in the Internet Appendix).

There is high demand for smaller quantities of days when they are offered at the same price: 71.7% of days purchased are in bundles of 3 or 7 days at a time on average among those who are not offered the bundle discount. Demand remains high even as the relative prices of smaller quantities are higher. Figure 4 plots the distribution of purchases in quantities of days by whether the driver was offered the bundle discount. Accompanying regression estimates of the ITT effect of the bundle discount offer are presented in Table A8 in the Internet Appendix. Bundles comprise 28.3% of days purchased on average

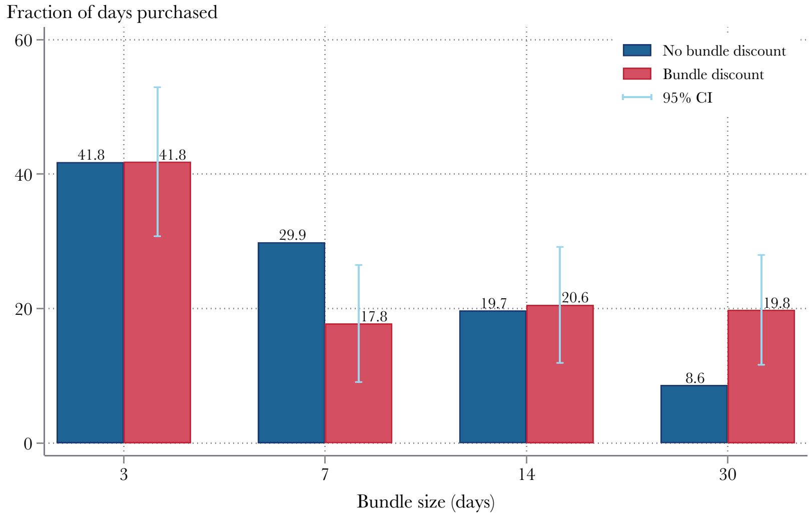

Figure 4
Quantities of days purchased by bundle discount treatment
The figure plots the mean driver-level share of days purchased by the bundle size of the purchase, split by whether the driver was offered the bundle discount. Error bars represent the 95% confidence interval of the treatment effect of being offered the bundle discount on bundle size fraction.

for those offered the pay-as-you-go contract without the bundle discount and the discount increases the share of days purchased via the bundle by 12.0 percentage points. Nearly all of those induced by the discount to purchase the bundle would have counterfactually purchased 7 (rather than 3) days of coverage at a time: the share of days purchased in 3-day quantities is 41.8% for *both* the no-discount and discount groups, while the share of 7-day quantities purchased falls from 29.9% to 17.8%.

Drivers induced by the discount to purchase larger quantities of days are almost entirely drawn from those who would have counterfactually purchased 7 (instead of 3) days. This is consistent with those selecting 3 days having stronger demand for smaller quantities. Drivers who "comply" with the bundle discount treatment are more likely to access the largest discounts at 30 days than the 14-day bundle. Demand for the minimum, 3-day purchases are remarkably stable and continue to comprise half of purchases even in the presence of the bundle discount.

Drivers may prefer smaller quantities of coverage because they are lower frequency drivers and do not expect to need many days of coverage, have a high degree of demand uncertainty, or because they face binding liquidity constraints. Figure A4 in the Internet Appendix plots daily user activity in the pay-as-you-go plan and regular activation/deactivation behavior is pervasive. Nevertheless, in the absence of liquidity constraints, one would still expect to see nearly all drivers opting for the bundle discounts. Few drivers drive so infrequently that the 3 or 7 days would cover their insurance needs over 3 months and any excess days that are not used are refundable at the driver's request.

To the extent the demand behavior in response to the bundle discount treatment is driven by liquidity constraints, it can inform the degree to which liquidity constraints may limit participation in auto insurance markets more broadly. Drivers who cannot afford an additional 5 (7 to 12 days), 9 (3 to 12), 17 (7 to 24), or 21 (3 to 24) days of coverage in order to access significant discounts are unlikely to be able to afford traditional insurance plans requiring semiannual, quarterly, or monthly premium payments. Seventy-seven percent of drivers with discounts available forgo the discount in at least one purchase, and 51% forgo them for all purchases. These can provide reasonable upper bounds on the share of uninsured drivers applying for coverage in my sample who are liquidity constrained, but could overstate the degree of liquidity constraints if drivers have a high degree of demand uncertainty or demand for driving itself is low. Forgoing the bundle discount is also consistent with a model where drivers decide to pursue additional consumption today at the expense of committing to additional insurance coverage in the future. If drivers are hyperbolic discounters, the consumption commitment aspect of traditional contracts could increase coverage despite barriers they present to market participation. I find no evidence that this contract rigidity is beneficial in my sample; drivers offered the traditional contract are slightly less likely to be insured at the end of the 3-month experiment.

In addition to inferences from demand behavior, there is complementary evidence that speaks to a central role for binding liquidity constraints. First, it is useful to refer back to the credit report characteristics in Table 1. The mean and median credit scores of 515 and 532 are classified as "poor." Eighty-one percent of applicants to Hugo have zero dollars of available credit on their reports and the high mean number of inquiries is suggestive of unmet demand for credit. These are strong indications that the uninsured drivers applying for coverage through Hugo are liquidity constrained.

Second, I can examine patterns of purchases by day of the week to see whether a disproportionate share of payments occur on Fridays when drivers are more likely to receive their paychecks. Figure A5 in the Internet Appendix presents the share of insurance purchases made by day of the week. While this analysis is only suggestive, drivers are 43% more likely to make a purchase on a Friday, which could suggest limited liquidity before payday.

Third, and finally, I can leverage the Stripe data to observe attempted insurance purchases that failed due to insufficient funds as "smoking gun" evidence of liquidity constraints. Nineteen percent of drivers who enroll in a pay-as-you-go insurance plan have at least one attempted purchase fail for insufficient funds. Eleven percent have an attempted debit transaction fail, and 10% have an attempted purchase using a prepaid card fail. Insufficient funds bounces from a debit account present a clear indicator that they have near-zero dollars available in their bank account. Insufficient funds bounces from prepaid cards may be less of a "smoking gun" for liquidity constraints than failed debit transactions, but may indicate that these drivers are unbanked.

In either case, it is informative to track behavior after the failed transaction. Thirty-eight percent of an insufficient funds event are followed by another insufficient funds event; 47% are followed by a successful payment; and 14% result in attrition from coverage (they are the user's last action). Users with an insufficient funds notice as their last action make up 12% of those daily users who attrit. Successful payments following an insufficient funds failure occur on average 3 days after the failed transaction, suggesting that these are binding constraints that take time to alleviate (in contrast to, for example, trying another card immediately afterward). Six percent of all drivers who enroll in pay-as-you-go coverage attrit following an insufficient funds failure.

3.4 Heterogeneous effects of the pay-as-you-go contract

The evidence presented so far shows that the pay-as-you-go contract increases market participation, but understanding which types of drivers are most responsive to the pay-as-you-go contract can enhance our understanding of both the mechanisms driving the results and for whom these contracts may be most beneficial. A key potential benefit of the contract is insuring marginal drivers who may not be well-served by traditional auto insurance contracts. Here I test whether drivers who do not have a history of regular policy coverage respond differently to the contract offers than drivers who have regular insurance history.

To explore heterogeneity along this dimension, I interact the ITT regression with an indicator for whether the applicant has no regular policy history at the time of application (an indicator Hugo defines as the absence of any record of completed insurance coverage of normal policy durations [e.g., multiples of 3 months]):

$$y_i = \alpha_0 + \beta_0 \mathbb{1}\{PAYG_i\} + \alpha_1 \mathbb{1}\{History_i\} + \beta_1 \mathbb{1}\{PAYG_i\} * \mathbb{1}\{History_i\} + \epsilon_i. \quad (4)$$

Table 4 presents regression results for insurance take-up and coverage outcomes through any carrier. 70.2% of drivers applying for coverage through the experiment have no regular coverage policy history at the time of application. The results support the notion that these drivers have limited demand for traditional contracts: they are 7.2 percentage points (69%) less likely to take up the traditional contract than drivers with prior coverage history. The interaction effects suggest the pay-as-you-go contract effectively closes those baseline differences and differentially increases the take-up and coverage outcomes for drivers without prior coverage history, increasing take-up by an additional 8.2 percentage points and days with coverage by an additional 10.95 days. The interacted ITT regression is under-powered but p-values between .05 and .08 for these outcomes provides suggestive evidence that the pay-as-you-go contract may hold some promise for increasing insurance coverage among those who have historically struggled the most to stay insured.

Table 4
Effect of pay-as-you-go contract offer by prior coverage history

	Take-up (1)	Days with coverage (2)	Days insured (3)	Insured end of study (4)
Pay-as-you-go=1	6.43	3.15	−2.17	−2.59
	(4.20)	(5.42)	(3.33)	(4.71)
	[0.125]	[0.562]	[0.514]	[0.581]
No regular policy history=1	−7.24	−12.56	−6.08	−11.19
	(4.00)	(5.44)	(3.42)	(4.93)
	[0.070]	[0.021]	[0.076]	[0.023]
Pay-as-you-go=1 × No regular policy history=1	8.24	10.95	6.47	10.35
	(4.60)	(6.02)	(3.58)	(5.33)
	[0.074]	[0.069]	[0.071]	[0.052]
Constant	10.45	20.90	8.45	25.17
	(3.74)	(4.97)	(3.21)	(4.39)
	[0.005]	[0.000]	[0.009]	[0.000]
N	1,537			
No regular policy history	70.2			

The table presents the intent-to-treat effect of being offered a pay-as-you-go insurance contract interacted with whether the driver has no regular policy history (defined as having either no past auto insurance history or exclusively auto insurance contracts that lapsed due to nonpayment or early cancellation) per Equation 4. The coefficients are listed with robust standard errors below in parentheses and *p*-values in brackets.

Given the results on the price sensitivity of demand and binding liquidity constraints, natural additional dimensions of heterogeneity to test are income and credit constraints. Table A9 in the Internet Appendix presents results interacted with below-median income (defined using the Experian Income Insight Score) and whether the driver is credit constrained (defined as zero dollars of available credit on their credit report or a missing credit report). I find limited evidence of differential treatment effects along these dimensions, but this may reflect limited variation in the interaction variables (e.g., 80.8% of drivers are credit constrained) or attenuation bias from measurement error in the income measure.

4. Discussion

In this section, I contextualize the key results of the paper and briefly discuss their implications for pay-as-you-go insurance, the uninsured driver problem, and similar financial products.

The pay-as-you-go insurance contract operationalizes keys insights of recent theoretical work (Ericson and Sydnor 2022; Rampini and Viswanathan 2022), breaking the connection between financing and insurance by reducing lower up-front liquidity requirements to enroll in coverage, allowing drivers to retime their insurance premium payments to periods of higher liquidity, and enabling purchases of smaller quantities. The pay-as-you-go contract increases take-up and days with insurance coverage over the duration of the experiment.

For the pay-as-you-go insurance contract to ameliorate the uninsured driver problem, these increases in take-up will need to persist over time. Figure 5 plots

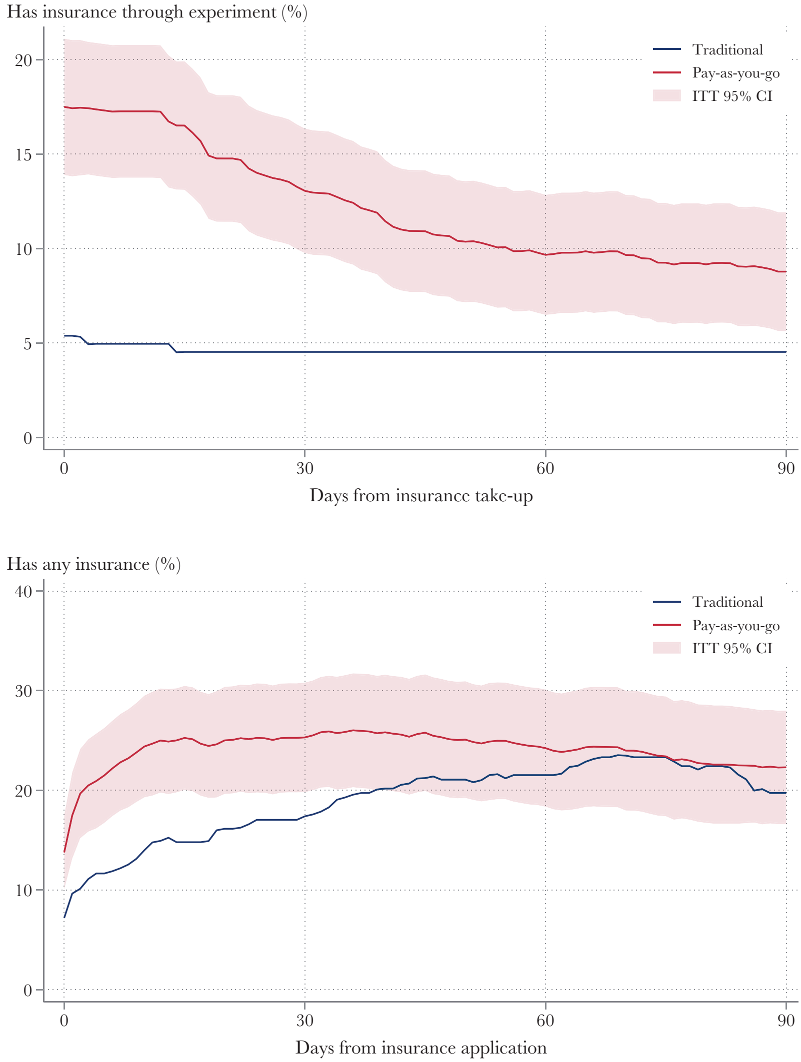

Figure 5
Intent-to-treat effect of pay-as-you-go contract over time
The figures plot the ITT effect of the pay-as-you-go contract offer by day separately for coverage through the experiment and through any insurer. The blue and red lines plot the share with insurance coverage for drivers offered the traditional contract and pay-as-you-go contract, respectively. The shaded region of the figures display the 95% confidence interval of the ITT as estimated by a fixed effects regression of insurance coverage on the interaction between the running day variable and whether the driver was offered the pay-as-you-go contract, absorbing the running day variable and clustering the standard error at the driver level.

the ITT effects over the course of the study and shows convergence between the traditional and pay-as-you-go treatment groups, with the coverage effects of the pay-as-you-go contract no longer statistically significant after 3 months when accounting for coverage through any carrier.

There are several potential explanations for attrition from coverage. To the degree retiming insurance purchases from today to the future exposes drivers to income or expense shocks in the interim, this may limit the coverage benefits even as drivers may be better off by shifting consumption to meet more pressing needs.[22] Auto insurance may not be at the top of households' consumption hierarchy, particularly if they have limited assets to protect in the event of an accident. Drivers may need proof of insurance in order to register their vehicle and promptly cancel coverage once it is registered.[23] Jack and Smith (2015, 2020) offer a complementary setting, pay-as-you-go contracts for utilities in South Africa, where liquidity constrained households also preferred to make frequent, small payments and decrease their electricity consumption, but become more profitable customers for the utility. In the Rampini and Viswanathan (2022) conceptualization of insurance as state-contingent savings, attrition from coverage may be a way of drawing down "savings" to afford other needs and indicate that auto insurance is a lower consumption priority than, for example, utility bills.

In addition to these explanations, there are several reasons the experimental ITT estimates are likely to understate the steady-state potential of the pay-as-you-go to increase coverage. First, the RCT evaluated an early version of the product as it was introduced to the auto insurance market and frictions in this early version of the product likely increased the transaction costs of maintaining coverage for drivers. For example, coverage was managed primarily through SMS in order to reach even the lowest-income drivers who may not have smartphones.[24] The company has since improved its product design and developed a customer interface designed for smartphones in addition to the SMS option. Second, the contract bundled the pay-as-you-go financing features with the option to deactivate coverage, with concomitant mark-ups that made the contract less competitive for frequent drivers. While both features have desirable properties as described in Section 1, they may differentially appeal to different customer segments and drive larger increases in insurance take-up when unbundled. As of December 2022, Hugo Insurance Services offers two different plans: one matching the features offered in the experiment and a separate plan that limits the "pause" feature to reduce the costs of the pay-as-you-go plan for frequent drivers. Finally, as discussed in

22 This potential explanation is similar in spirit to Dobbie and Song (2020), who find that short-run liquidity relief for credit card borrowers (i.e., smaller payments due over a longer period of time) does not improve financial or labor market outcomes.

23 This is a problem for both traditional and pay-as-you-go contracts, but pay-as-you-go contracts may reduce the up-front money needed to enroll relative to traditional contracts which require payment for the longer coverage term that is refunded upon cancellation. Two-thirds of pay-as-you-go drivers in the experiment renewed their coverage with a follow-on purchase and Figure A6 in the Internet Appendix shows the effects of the pay-as-you-go contract on take-up are still statistically significant when excluding drivers who make only a single purchase or cancel their traditional coverage.

24 A Pew Research Center survey found 85% of Americans owned a smartphone as of 2021, including 76% of those making less than $30,000 per year (Pew Research Center 2021).

Section 2.2, pricing in the experiment was high (mark-ups on a prorated day of traditional coverage was 67% for the base price group, roughly triple the maximum mark-ups charged by Hugo Insurance Services as of December 2022) and only offered minimum liability insurance coverage, which would not accommodate drivers interested in "graduating" to comprehensive coverage. An internal company survey found that more than half of drivers cited lower prices or a need for full coverage as their reason for attrition.[25] As the technology matures, expands its contract offerings, and lowers prices, pay-as-you-go contracts may drive larger and more persistent increases in coverage than those estimated in this experiment.

High rates of uninsured driving have proven to be a difficult problem to solve. The tools used by policy makers to enforce insurance coverage may have limited scope to improve the problem: lowering minimum coverage limits in order to lower premiums (as California does with their Low Cost Auto Insurance program) further exposes drivers to financial risks in the event of a severe accident and steeper penalties for uninsured driving may be counterproductive if drivers are as liquidity constrained as those studied in this experiment. In other insurance markets in which willingness-to-pay is lower than the cost of providing coverage (Finkelstein, Hendren, and Shepard 2019), the government subsidizes coverage for low-income individuals, a policy that has proven to be more effective than mandates at increasing coverage (Frean, Gruber, and Sommers 2017).[26] Smith and Wright (1992) argue that auto insurance markets feature multiple equilibria: an efficient full-insurance equilibrium and inefficient high-price equilibrium with many uninsured drivers can simultaneously exist, suggesting there may be large benefits of increasing insurance enrollment if it helps shift to the full-insurance equilibrium. From the insurer's perspective, high costs of customer acquisition and high rates of attrition make providing minimum coverage an expensive business with significant administrative loads that necessitate high fees and up-front liquidity requirements to defray costs. Insurance technology has the potential to automate these processes and the contract offered in this experiment provides one example of how insurers may handle attrition and re-enrollment in the future.

For pay-as-you-go contracts to reduce high rates of uninsured driving, it is important to note that drivers must first shop and qualify for coverage. The experimental estimates presented in this paper are conditional on drivers

[25] Hugo Insurance Services surveyed 36 drivers who churned before 3 months and categorized mutually exclusively reasons for attrition. Twenty-two percent found cheaper coverage elsewhere. These were often "heavy drivers" who had no interest in deactivating their coverage. Nineteen percent got rid of their car; 33% needed full coverage (the pay-as-you-go contract was only offered as a minimum liability contract); 6% only needed insurance for a brief period; 11% had underwriting issues with the backing insurer forcing their cancellation; 3% moved to a different state; and the remaining 6% cancelled for unknown reasons.

[26] The optimal level of subsidies is beyond the scope of the paper and would depend on the value of insurance coverage to the insured, the externality on the insured, and any driving externalities (could be positive or negative depending on whether economic benefits of driving offset any increased emissions and congestion).

applying for a quote and may not represent all uninsured drivers. It is difficult to know what share of uninsured drivers are in the market for coverage and can be sustainably underwritten for a contract, two prerequisites for increasing insurance take-up and coverage. As pay-as-you-go contracts proliferate, understanding their potential to increase overall rates of coverage is a valuable area for future research.

Beyond auto insurance, consumer behavior under the pay-as-you-go contract has implications for similar financial technology products like buy-now-pay-later and earned wage access. Reducing up-front payment requirements (a feature of pay-as-you-go and buy-now-pay-later) increases market participation. As evidenced by the larger effects observed by those who have no history of insurance coverage, they may increase participation most among consumers who have not previously participated. The erosion of the increases in coverage over the course of the experiment may suggest that—in the absence of subsidies or policies addressing the financial precarity of uninsured drivers—contract structure alone may not be sufficient to address affordability challenges. More broadly, technologies that enable consumers to smooth consumption can alleviate short-run constraints and increase consumption (in this application, increasing insurance coverage from suboptimally low levels), but may be harmful if they facilitate more discretionary purchases and users are present-biased.[27] Nevertheless, the insurance technology studied here exhibits exciting potential to reduce administrative loads, reduce transaction costs and fees, and better tailor financial contract structures to help drivers, who would otherwise be uninsured, afford coverage.

5. Conclusion

I study the introduction of a novel pay-as-you-go insurance contract to the California auto insurance market. Drivers randomly offered the contract increase their insurance take-up by 10.8 percentage points (89%) and days insured by 4.6 days (27%) relative to a traditional contract, with smaller effects by the end of the 3-month experiment. Demand is relatively price inelastic. Applicants for the pay-as-you-go contract are severely credit constrained based on their credit reports, and more than half of drivers exhibit demand behavior consistent with a shadow cost of borrowing at least as high as a payday loan. There is strong demand for quantities of coverage smaller than those available in the market (before the introduction of the pay-as-you-go contract) and this demand persists for most drivers even when relative prices are higher. There is suggestive evidence that the benefits of the pay-as-you-go contract increases

[27] Di Maggio, Katz, and Williams (2022) argue consumer behavior under buy-now-pay-later products are consistent with a “liquidity flypaper effect” in which the liquidity “sticks where it hits.” The results in this paper suggest that encouraging financial product innovation in markets with underconsumption relative to optimal levels could be beneficial.

take-up and days insured more for drivers who have historically struggled to stay insured, indicating that the smaller minimum payments enabled by pay-as-you-go contracts increase market participation among those who are least well-served by the traditional contracts available.

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