Access to Credit Reduces the Value of Insurance*

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Abstract

We study how access to credit markets affects the value of insurance. Loans allow consumers to smooth financial shocks over time, reducing the incremental benefits provided by insurance. We derive tractable formulas for the value of insurance that can be taken to data and show how that value varies with loan features. We then apply our framework to health insurance. Access to a five-year loan decreases the values of community- and experience-rated health insurance for the average two-person household by \$232–\$366 (58–61%). Even for the sickest decile, loan access reduces the value of community-rated insurance by \$1,099 (17%). Our results suggest that greater credit availability can serve as a substitute for health insurance.

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1 Introduction

A central purpose of insurance is to help consumers smooth consumption over time in the presence of financial shocks. However, insurance is not the only tool available for stabilizing consumption. Consumers can also self-insure through saving or borrowing, allowing them to smooth consumption across periods. Yet empirical frameworks often abstract from these alternative channels, potentially overstating the value of insurance by comparing it to a counterfactual in which no other consumption-smoothing technologies exist.[1]

This paper studies the value of insurance in a setting where consumers facing a financial shock can smooth consumption either by purchasing insurance or by borrowing. Our contribution is twofold. First, we develop a model where consumers choose whether to purchase insurance; if they decline insurance, they can finance the shock with loans. We derive analytic and approximation formulas for the value of insurance in the presence of credit markets. Second, while our framework applies broadly to settings such as unemployment, disability, auto, and property insurance, we focus on health insurance as an application. Specifically, we use health expenditures data from the Medical Expenditure Panel Survey (MEPS) to measure the drivers of insurance value under full coverage.

Our analysis yields several policy-relevant insights, illustrated through the health insurance application but applicable more broadly. First, we show that insurance and loans act as substitutes: access to credit reduces the incremental value of health insurance. In a baseline case with actuarially-fair insurance, the availability of a 5-year loan reduces the value of experience-rated insurance by \$232 (58%) and community-rated insurance by \$366 (61%), relative to a setting without loan markets. Even in cases where insurance is expected to be most valuable—such as for the sickest decile—access to a 5-year loan reduces the value of community-rated insurance by \$1,099 (17%). We obtain similar results after introducing markups on both insurance and loan contracts.

Increasing credit access—through longer repayment periods or lower interest rates—further reduces the value of insurance. For example, providing access to a 2-year loan reduces the value of experience-rated insurance by \$159 (40%), access to a 5-year loan reduces the value by \$232 (58%), and access to a 10-year loan reduces the value by \$254 (64%). Likewise, a reduction in the interest rate markup on loans reduces the value of insurance: reducing the interest rate on a 5-year loan from 8.40% to 2.78% reduces the value of experience-rated insurance by \$67 (22%).

[1] A large literature combines insurance theory with medical spending data to estimate the risk-reduction value of health insurance (Feldstein and Gruber, 1995; Finkelstein and McKnight, 2008; Engelhardt and Gruber, 2011; Barcellos and Jacobson, 2015; Limwattananon et al., 2015). Related willingness-to-pay approaches have been used to value disability insurance (e.g., Deshpande and Lockwood, 2022).

We also find that access to loans reduces the value of insurance more for low-income households than for high-income households. Because financial spending shocks are more costly for people with low income, additional consumption-smoothing technologies are especially valuable to them. Access to an actuarially fair, 5-year loan reduces the value of insurance by \$851 (67%) for households earning \$20,000–\$30,000, compared with just \$28 (48%) for those earning \$250,000–\$300,000. Accounting for markups yields similar distributional patterns.

Finally, our approximation formula, which requires only aggregate data on the mean and variance of medical expenditures, closely tracks our exact formula across different loan lengths, suggesting it can be a practical tool for empirical applications.

Our main model examines the value of insurance in a single-period setting. This environment abstracts from additional benefits of insurance that may arise when spending shocks are persistent (i.e., serially correlated across time). To address this, we extend the analysis with a life-cycle model in which individuals remain uninsured for ten periods and face shocks with persistence parameters estimated from MEPS data. We find that allowing for serial correlation raises the absolute value of insurance but does not overturn the central conclusion: access to credit markets still sharply reduces insurance's incremental value. In particular, the value of full, experience-rated insurance without loans is \$619, compared to just \$160 with loans—a 74 percent decline. In other words, serial correlation amplifies the gains from insurance, but loan availability still substantially reduces its value.

Our analysis has three important caveats. First, we focus exclusively on the consumption-smoothing role of insurance and credit, abstracting from other potential benefits such as improved bargaining power against providers. Second, we do not explicitly model complications such as moral hazard or adverse selection; these are instead captured indirectly through an insurance markup. Third, we focus on the stylized value of full insurance, without incorporating other design features such as deductibles. This simplification is consistent with much of the existing literature, which uses tractable formulas to study simplified insurance environments.

The remainder of this paper is organized as follows. Section 2 reviews related literature on the value of insurance. Section 3 develops a model in which consumers choose between insurance and loans as alternative mechanisms for smoothing financial shocks. Section 4 applies the model's formulas to data from MEPS. Section 5 uses numerical simulations to explore the implications of serially correlated spending shocks for the value of health insurance. Section 6 concludes.

2 Literature review

This paper contributes to three strands of literature on insurance. The first strand measures the consumption-smoothing value of insurance. A canonical paper is Finkelstein, Hendren and Luttmer (2019), who value Medicaid using data from the Oregon Health Insurance Experiment. They propose two approaches. The first equates out-of-pocket (OOP) payments with lost consumption, which can overestimate the value of insurance because it assumes consumers lack access to credit markets. The second approach compares observed consumption with and without insurance, which accounts for saving and borrowing. However, this approach can understate the value of insurance if researchers lack data on later periods, since prior health shocks may reduce consumption among the uninsured as they continue to repay prior loans.

We contribute to this first strand by developing a new method for valuing the consumption-smoothing benefits of insurance. Our approach reallocates OOP payments over time through borrowing, allowing repayment periods to extend beyond the horizon of observed consumption. As a result, concurrent consumption decreases by less than the OOP shock, while later consumption may fall by more than is directly observed by the researcher. This approach delivers estimates of insurance value that lie between those implied by the two approaches in Finkelstein, Hendren and Luttmer (2019).

A second strand of the literature values insurance in settings where consumers have access to credit.[2] Unlike the studies cited in the introduction, which assume no saving or borrowing, this strand explicitly incorporates credit access. Applications span a variety of insurance markets, including weather (de Nicola, 2015), auto and property (Hansen, Jacobsen and Lau, 2016), and healthcare.[3] Our work is most closely related to Handel, Hendel and Whinston (2015), who calculate the welfare value of one-year health insurance contracts under community- versus experience-rating. We, by contrast, estimate how the value of experience- and community-rated health insurance changes when consumers gain access to credit markets. While their analysis briefly considers credit access, it does not examine how the value of insurance under either pricing scheme differs with and without credit markets,

[2]This strand connects to a broader literature showing that risk aversion in wealth decreases with opportunities to spread risk (Gollier, 2002). Complementary work examines the value or optimal design of insurance when individuals have access to savings rather than borrowing (Gollier, 2003), and studies the demand for insurance when liquidity constraints are so tight that individuals cannot even pay for premiums (Ericson and Sydnor, 2018). In contrast, our focus is on the value of insurance when individuals can borrow, specifically through loans.

[3]A related line of work studies the optimal level of social insurance programs, such as unemployment benefits, when beneficiaries do and do not have access to credit (Braxton, Herkenhoff and M. Phillips, 2024). Our focus differs: rather than characterizing optimal policy when insurance is tax-financed, we measure how the private value of insurance changes with credit access.

nor how loan features such as interest rates, markups, and repayment periods shape insurance value. We address these questions directly by estimating how access to credit markets alters the value of experience- and community-rated health insurance.

A third strand of insurance literature examines the interplay of health insurance and debt. One set of papers studies how insurance affects indebtedness (e.g. Mazumder and Miller, 2016; Barcellos and Jacobson, 2015; Hu et al., 2018; Caswell and Goddeeris, 2019; Goldsmith-Pinkham, Pinkovskiy and Wallace, 2021; Batty, Gibbs and Ippolito, 2022). These studies, however, rarely quantify the value of access to loans, which is our central contribution. One exception is Brevoort, Grodzicki and Hackmann (2020), who estimate the value of health insurance through its effect on consumers' credit scores and subsequent access to credit. Our framework is more direct: we model debt as repaid directly over time, rather than indirectly mediated through future credit constraints.

Another line of work within this strand argues that protection against excess debt (e.g., access to bankruptcy) can substitute for health insurance (Gross and Notowidigdo, 2011; Mahoney, 2015). Bankruptcy, however, typically provides relief only from extreme financial events, which are relatively rare even among the uninsured (Dobkin et al., 2018; Malani, 2021). By contrast, our study focuses on how routine access to loans affects the value of health insurance. In this context, lower interest rates or longer repayment terms benefits consumers across a wide range of states, not just during catastrophic events, and therefore reduce the incremental value of insurance more broadly.

3 Theory

This section develops a model where consumers facing a financial shock choose either to purchase insurance or to finance the shock with loans. This model does not restrict the source of risk and therefore applies broadly to all forms of insurance contracts. We assume that people can borrow only to cover expenditures that would otherwise be uninsured (e.g., covered medical costs in the case of health insurance), and cannot otherwise use saving and borrowing to smooth consumption across time. Because we hobble credit markets in this manner, our model provides an upper bound on the value of insurance.

Previous studies have considered a single-period setting without credit markets (e.g., Engelhardt and Gruber, 2011; Finkelstein and McKnight, 2008; Deshpande and Lockwood, 2022). Because we allow for borrowing, our model necessarily includes multiple periods. We focus attention on the decision to insure or borrow in a single period, while assuming that the consumer is insured in all other periods. Consequently, our empirical estimates can be interpreted as the annual value of insurance, similar to other studies.[4]

With a multi-period model, the standard "certainty equivalent" approach to valuing insurance—asking how much consumption a consumer would forgo to smooth consumption across states—becomes problematic, because the answer depends on which period's consumption is reduced. Instead, we measure the value of insurance as the difference in utility from consumption with and without insurance coverage, expressed in dollars by normalizing by the marginal utility of consumption.[5] A useful byproduct of our approach is that it yields a closed-form solution for the value of insurance, which is not possible with the certainty equivalent method.

We begin with a simplified model where individuals face a single financial risk each period. We then extend the model to incorporate multiple shocks, savings, and loan fees.

3.1 One-shock model

A consumer lives for T periods and earns income y in each period. Consumption, c, is equal to income net of financial shocks and any credit market transactions. We assume the period utility function, $u(c)$, is strictly increasing, concave, and continuously differentiable, and denote the consumer rate of time preference as β. In each period, the consumer faces a financial risk that, with probability π, reduces her income available for consumption by p. While the magnitude of the shock p is fixed, the probability π may vary across consumers, and we assume shocks are serially uncorrelated. Thus, the only parameters that vary cross consumers are T, y, and π.

The consumer can smooth her consumption through insurance or through borrowing. We assume the consumer purchases insurance in periods $2, \ldots, T$, and focus our attention on the consumer's purchase decision in period 1. If she declines to purchase insurance, she can borrow to cover the financial shock should it occur.

If the consumer purchases insurance, she pays a premium at the beginning of the period equal to the actuarially-fair cost multiplied by a markup, m^I. The actuarially-fair premium depends on how insurance is priced. Under community rating, the fair premium is $\pi^C p$, where π^C is the average risk in the insurance pool. Under experience rating, the fair premium is πp, where π is the consumer's own risk. To avoid the possibility of market unraveling, we assume that insurance is priced under one scheme only (community or experience rating), and that premiums remain constant across periods (Rothschild and Stiglitz, 1976).

[4]This interpretation assumes that costs of health shocks are serially uncorrelated. Section 5 uses numerical simulations to explore the implications of persistent spending shocks for the value of health insurance.

[5]To compare our results to certainty equivalent estimates, one could add the insurance premium to our dollarized estimates, yielding an approximate willingness-to-pay.

We assume that only one insurance contract is available and that it provides full coverage, i.e., no co-pays, deductibles, or co-insurance. We also assume there is no adverse selection. The markup on the insurance premium, m^I, captures additional costs such as administrative fees and moral hazard. We assume that m^I is sufficiently small that, absent loan markets, consumers would prefer to buy insurance. This assumption ensures that our analysis focuses on how credit access affects the value of insurance, rather than on whether insurance is purchased in the first place.[6]

If insurance is community-rated and the individual purchases insurance in period 1, her lifetime utility is:

$$V^I(\pi^C) = \frac{1-\beta^T}{1-\beta}u(y - m^I\pi^C p)$$

In each period, the individual pays a premium that reduces her consumption by $m^I\pi^C p$.

If instead the consumer relies on borrowing, she must repay p over n periods at an effective interest rate, r^e. This effective rate reflects both the underlying interest rate r, which corresponds to the rate of time preference $\beta = 1/(1+r)$, and an interest rate markup r^m:

$$r^e = r + r^m$$

We require $n \leq T$, so that loans are fully repaid within the consumer's lifetime, with no possibility of debt relief or bankruptcy. The repayment amount is αp per period for n periods, where:

$$\alpha(r^e) = \frac{1 - \frac{1}{1+r^e}}{1 - \left(\frac{1}{1+r^e}\right)^n}$$

The repayment share α is increasing in the effective interest rate and decreasing in the loan length n, with repayment beginning in the same period the loan is originated.

An alternative to modeling borrowing costs with an interest rate markup, $r^m \geq 0$, is to use a markup on the loan principal, $m^L \geq 1$. Under this approach, the per-period payment on a loan of size p is $m^L\alpha(r)p$. The two markups are related to each other by the formula:

$$m^L(r^e) = \frac{1 - \frac{1}{1+r+r^m}}{1 - \left(\frac{1}{1+r+r^m}\right)^n} \frac{1 - \left(\frac{1}{1+r}\right)^n}{1 - \frac{1}{1+r}}$$

The loan markup, m^L, has the advantage of being directly comparable to the insurance

[6]This assumption requires $m^I < 1/\pi^C$ under community rating or $m^I < 1/\pi$ under experience rating.

markup, m^I, but it is less realistic for empirical applications, since loans in practice are priced using interest rates. For this reason, our application will focus on interest rate markups instead of loan markups.

Just as a markup on insurance premiums may cause a person to purchase less than full insurance, a markup on interest rates may discourage full consumption smoothing through borrowing. In the simplified model presented here, we assume $r^m = 0$ (equivalently, $m^L = 1$) so that individuals fully smooth consumption when borrowing. This assumption also implies $\beta = 1/(1+r^e)$ and $\frac{1-\beta^n}{1-\beta} = \frac{1}{\alpha(r)}$, which simplifies the expressions below. For notational ease, we suppress the dependence of α on r until Section 3.4, where we consider a more general model with interest rate markups.

If the consumer declines community-rated insurance in period 1, her expected lifetime utility is:

$$\begin{aligned} V^L(\pi^C) = (1-\pi)&\left(u(y) + \frac{\beta - \beta^T}{1-\beta} u(y - m^I\pi^C p)\right) \\ &+ \pi \left(\frac{1}{\alpha} u\left(y - m^I\pi^C p - \alpha(1 - m^I\pi^C)p\right) + \frac{\beta^n - \beta^T}{1-\beta} u(y - m^I\pi^C p)\right) \end{aligned}$$

With probability $(1-\pi)$, no shock occurs. The individual consumes y in period 1 and pays premiums of $m^I\pi^C p$ in periods 2 through T. With probability π, a shock occurs in period 1. In that case, she directly pays an amount equal to $m^I\pi^C p$ and borrows the remaining $(1-m^I\pi^C)p$ to smooth the shock over n periods.[7] Thus, in periods 1 through n, the individual pays both an amount equal to the premium, $m^I\pi^C p$, and the loan repayment, $\alpha p(1-m^I\pi^C)$. From period $n+1$ onward, the individual pays only her insurance premium.

The incremental utility of community-rated insurance relative to loans is:

$$\begin{aligned} V^{\Delta,L}(\pi^C) &= V^I(\pi^C) - V^L(\pi^C) \\ &= (1-\pi)\left(u(y - m^I\pi^C p) - u(y)\right) \\ &\quad + \frac{\pi}{\alpha}\left(u(y - m^I\pi^C p) - u(y - m^I\pi^C p - \alpha(1 - m^I\pi^C)p)\right) \end{aligned} \tag{1}$$

If the individual purchases insurance and no shock occurs, she loses the premium $m^I\pi^C p$ in period 1. If there is a shock, however, insurance is valuable because it prevents the consumer from having to repay $\alpha\left(1 - m^I\pi^C\right)p$ each period for n periods. In the special case where $n = 1$ (which implies $\alpha = 1$), this expression simplifies to the conventional value of insurance, where loans are unavailable.

[7] The individual pays $m^I\pi^C p$ to maintain smooth consumption across periods, since this payment equals the premium paid in (future) insured periods.

3.1.1 Discussion

Our basic model yields several insights into the value of insurance. First, if insurance is actuarially fair ($m^I = 1$) and experience rated ($\pi^C = \pi$), then the incremental value of insurance is strictly positive.[8] In this benchmark, actuarially fair, experience-rated insurance always dominates borrowing. However, its incremental value is smaller when consumers have access to loans than when they do not.[9] Of course, real-world insurance is rarely actuarially fair and often not experience rated. We turn to that more realistic case in our empirical analysis.

Second, increasing access to credit reduces the incremental value of insurance. For example, extending the repayment horizon n lowers the value of insurance, as shown formally in the Appendix. Intuitively, consumers would never choose a longer repayment period unless it benefits them, so the option value of larger n is weakly positive, making borrowing more attractive and insurance relatively less valuable. Likewise, lowering the interest rate markup r^m makes credit markets more accommodating, which also reduces the incremental value of insurance. While this result cannot be demonstrated under the assumption $r^m = 0$ imposed here, we show it explicitly in Section 3.4, which allows for loan markups.

Third, the effect of loan markets on the value of insurance is smaller for higher-income people. It is well established that the conventional value of insurance—ignoring loan markets—declines with income: financial shocks reduce marginal utility less for high-income people than for low-income people. Consequently, when consumers gain access to loan markets, the resulting reduction in the value of insurance is smaller for higher-income people, because their initial valuation was already low.[10]

The formulas we have derived apply to the case of full insurance. In practice, however, most insurance contracts include coinsurance, deductibles, and other forms of cost-sharing that limit financial protection. In Appendix A.5, we extend the one-shock model to incorporate a coinsurance rate and derive corresponding formulas for the incremental value of insurance. This extension provides a more realistic assessment of insurance value in settings where households continue to bear part of their medical expenditures out of pocket.

[8] See Appendix A.1 for the proof. Appendix A.2 provides additional comparative statics, examining how the value of insurance responds to changes in risk, the magnitude of the price shock, credit market access, and the insurance markup. Appendix A.3 incorporates income shocks.

[9] Intuitively, insurance is more valuable when consumers cannot borrow, since their alternatives for smoothing shocks are more limited. In the Appendix, we show formally that $\partial V^{\Delta,L}/\partial\alpha > 0$.

[10] Because higher-income people have lower marginal utility of consumption, converting incremental utility to dollars inflates the value of insurance for them relative to lower-income people. Our empirical analysis shows that this countervailing effect does not dominate, however.

3.2 Multiple shocks

To make our model more realistic, we extend it to allow for multiple financial shocks. All consumers face the same set of possible shocks, but the probabilities of those shocks can differ across individuals. For a given consumer, let shock i occur with probability π_i and produce cost p_i. Let $\mathrm{E}^C[p]$ denote the community-rated fair premium, which depends on the expected costs of all individuals in the risk pool. Extending Equation (1) to this setting yields:

$$\begin{aligned} V^{\Delta,L}(\mathrm{E}^C[p]) = &\sum_{i:\, p_i \le m^I \mathrm{E}^C[p]} \pi_i \left(u(y - m^I \mathrm{E}^C[p]) - u(y - p_i) \right) \\ &+ \frac{1}{\alpha} \sum_{i:\, p_i > m^I \mathrm{E}^C[p]} \pi_i \left(u\left(y - m^I \mathrm{E}^C[p]\right) - u\left(y - \alpha p_i - (1-\alpha) m^I \mathrm{E}^C[p]\right)\right) \end{aligned} \tag{2}$$

The individual must choose whether to insure all period 1 shocks or none of them. If she forgoes insurance, she uses loans to smooth only the portion of the realized shock that exceeds the premium paid in later periods.

The first term in (2) corresponds to shocks no larger than the premium ($p_i \le m^I \mathrm{E}^C[p]$).[11] In these cases, an uninsured individual just pays out of current income, so the incremental value of insurance is negative because the premium exceeds the realized cost. The second term captures shocks larger than the premium ($p_i > m^I \mathrm{E}^C[p]$). In these cases, insurance is valuable: without coverage, the individual would pay $m^I \mathrm{E}^C[p]$ up front and borrow the remaining amount, $p_i - m^I \mathrm{E}^C[p]$, to smooth consumption.

3.3 Savings and a Taylor approximation

Using Equation (2) to quantify the value of insurance requires individual-level data on financial shocks, which may not be available. A useful alternative is to approximate the dollar value of insurance using only the population mean and variance of shocks. This approximation can be done by taking a second-order Taylor expansion of Equation (2). Implementing this approximation directly, however, would require conditioning the mean and variance on whether a shock is above or below the community-rated premium. Doing so requires either knowing the full distribution of shocks—defeating the purpose of the approximation—or assuming a restrictive functional form. To simplify, we assume instead that individuals can borrow and save for n periods.

[11] Recall that by assumption the individual purchases insurance in later periods. Thus, she will not borrow against future consumption unless the first-period shock exceeds the cost of future premiums. This issue was not relevant in Section 3.1, because our assumption $m^I < 1/\pi^C$ guaranteed that the shock was larger than the premium.

When saving is allowed, behavior changes in the case of a shock of $p_i < m^I E^C[p]$ in period 1. In that event, the individual reallocates the difference $m^I \mathrm{E}^C[p] - p_i$ (which is not spent on insurance or medical expenditures) evenly across n periods. The resulting value of insurance is:

$$V^{\Delta,LS}(\mathrm{E}^C[p]) = \frac{1}{\alpha} \sum_i \pi_i \left(u\left(y - m^I \mathrm{E}^C[p]\right) - u\left(y - m^I \mathrm{E}^C[p] - \alpha\left(p_i - m^I \mathrm{E}^C[p]\right)\right)\right) \tag{3}$$

Because the banking system now allows both borrowing and saving, the incremental value of insurance falls, i.e., $V^{\Delta,LS} < V^{\Delta,L}$.

Taking a second-order Taylor approximation around $\tilde{y} = y - m^I \mathrm{E}^C[p]$ then yields:

$$V^{\Delta,LS}(\mathrm{E}^C[p]) \approx \frac{1}{\alpha} \sum_i \pi_i \left(u'(\tilde{y}) \left[\alpha\left(p_i - m^I \mathrm{E}^C[p]\right)\right] - \frac{u''(\tilde{y})}{2} \left[\alpha\left(m^I \mathrm{E}^C[p] - p_i\right)\right]^2 \right)$$

This weighted sum reflected the expected value of insurance for an individual. Taking the expectation across all individuals in the risk pool, regrouping terms, and dividing through by $u'(\tilde{y})$, we obtain:

$$\frac{V^{\Delta,LS}(\mathrm{E}^C[p])}{u'(\tilde{y})} \approx -(m^I - 1)\mathrm{E}^C[p] + \frac{1}{2}\frac{\gamma}{\tilde{y}}\alpha \left(\mathrm{Var}^C[p] + \left(m^I - 1\right)^2 \left(\mathrm{E}^C[p]\right)^2 \right) \tag{4}$$

where γ is the coefficient of relative risk aversion and $\mathrm{Var}^C[p]$ is the variance of the shocks. Intuitively, the dollar value of insurance declines with the expected cost (because the markup m^I scales premiums) and rises with both the variance of shocks and the degree of risk aversion.

This approximation requires much less information than Equation (2). Specifically, it depends only on: (i) α, which is determined by the interest rate and the loan period; (ii) the insurance markup m^I; (iii) the community-level mean and variance of medical spending shocks; (iv) the coefficient of relative risk aversion γ; and (v) net-of-premium income $\tilde{y}$.

3.4 Loan markups

Finally, we extend the model to allow for loan markups, $r^m > 0$ (equivalently, $m^L > 1$). With a markup, borrowers repay at an effective interest rate above their rate of time preference, $r^e > r$, which increases the repayment rate: $\alpha(r^e) > \alpha(r)$. Introducing a loan markup complicates the analysis because consumers will no longer perfectly smooth consumption across periods. Rather than borrowing the entire portion of the shock that exceeds $m^I \mathrm{E}^C[p]$, as in Equation (2), consumers will optimally borrow less.

Let $L^*(p_i)$ denote the optimal loan amount when the shock is p_i and $r^e > r$. Generalizing Equation (2) yields:

$$\begin{aligned} V^{\Delta,L}(\mathrm{E}^C[p]) = & \sum_{i:p_i \leq p_{min}} \pi_i (u\left(y - m^I \mathrm{E}^C[p]\right) - u(y - p_i)) \\ & + \sum_{i:p_i > p_{min}} \pi_i \left[\frac{1}{\alpha(r)} u(y - m^I \mathrm{E}^C[p]) \right. \\ & \left. - \left(u\big(y - p_i + (1-\alpha(r^e))L^*(p_i)\big) + \left(\frac{1}{\alpha(r)} - 1\right) u(y - m^I \mathrm{E}^C[p] - \alpha(r^e) L^*(p_i)) \right) \right] \end{aligned} \tag{5}$$

where $L^*(p_i) \geq 0$ satisfies the following first-order condition:

$$(1-\alpha(r^e))u'(y - p_i + (1-\alpha(r^e))L^*(p_i)) = \alpha(r^e)\frac{\beta - \beta^n}{1-\beta} u'(y - m^I \mathrm{E}^C[p] - \alpha(r^e)L^*(p_i)) \tag{6}$$

and p_{min} is the smallest shock for which borrowing occurs, defined implicitly by $L^*(p_{min}) = 0$. Details, including a closed-form derivation under CRRA utility, are provided in Appendix A.4.

This extension delivers a clear implication: loan markups increase the value of insurance. Because the value of insurance is increasing in the loan repayment rate, $\alpha(r^e)$, which in turn rises with loan markup, higher borrowing costs make loan-based smoothing less attractive and raise the incremental benefit of insurance.

4 Quantitative Analysis of Health Insurance Value

4.1 Data

We obtain individual-level data on medical spending from the 1996–2014 MEPS. We end the sample period in 2014, the first year in which the ACA's major provisions took effect. Because household members co-insure each other's risk, we perform our main analysis at the household level. To focus on the private insurance market, we exclude households with members over age 65 (eligible for Medicare) and households with income below 138% of the federal poverty line (eligible for Medicaid in many states). We also drop households where the oldest member is under age 22. Our final sample includes 334,230 adults in 135,570 households.

To estimate the distribution of medical expenditures faced by each household, we first predict medical expenditures at the individual level using a flexible function of geography, age, sex, and pre-existing medical conditions (see Appendix B). We then aggregate these predictions to the household level and classify households into deciles of predicted medical expenditures, conditional on family size. Finally, we use the distribution of actual medical expenditures within each decile to approximate the distribution of potential shocks faced ex ante by each household in that decile (Abaluck and Gruber, 2011). Consequently, households in lower deciles face less spending risk than those in higher deciles, reflecting the notion that people have some private information about their expected medical spending.

We cap healthcare spending shocks at the household's federal poverty level. Since our sample only includes households with income above 138% of the federal poverty level, this cap helps ensure positive consumption.[12] This assumption is consistent with the fresh start principle in bankruptcy law, which protects future income from past debts (Jackson, 1984).

We consider both experience- and community-rated policies. While US healthcare insurance is largely community-rated, in some pockets it is meaningfully experience-rated. For example, self-funded group plans—which can include as few as two people in some states—are subject to experience-rated premiums for their stop-loss policies. Even under the ACA, insurers can price discriminate to some extent based on age, family size, and health behaviors such as smoking.

We set experience-rated premiums equal to average spending, conditional on household size and predicting spending decile. Similar to the ACA, we set community-rated premiums equal to average spending, conditional on household size, age group, and Census region. Age groups are defined as under 35, 35–44, 45–54, and 55–64. Premiums for households of size 2 are shown in Figure A.1. Community-rated premiums rise with age but span a smaller range than experience-rated premiums, reflecting cross-subsidization: individuals with high expected spending pay the same premium as those with low expected spending within an age-region cell.

Table A.1 shows summary statistics for our sample. The average age is 32, and 49% are female. Median income is $24,937 (2014 dollars) for individuals and $66,671 for households. On average, individuals have 1.32 self-reported chronic conditions, as measured using Clinical Classification Software (see Appendix B for details). The median household has 2 members (including children), and 18 percent of households include at least one member without health insurance. Average annual household medical spending is $5,729, of which $1,561 is paid out of pocket.

Our analysis focuses on the incremental value of a health insurance policy that fully insures medical spending. In practice, however, even insured households often face nontrivial

[12] We also apply this cap when calculating expected costs for insurance premiums. Limiting the right-tail in this way reduces the value of insurance. An alternative would be to impose a consumption floor, but this would make the distribution of health shocks and community-rated premiums explicitly income-dependent.

out-of-pocket (OOP) costs due to deductibles, copayments, and uncovered services. Panel (a) of Figure A.2 shows that, among two-person households, the average OOP spending share is 32.1% for insured households, compared to 52.9% for uninsured households.[13] Although insured households face a substantially lower OOP burden on average, the difference should not be interpreted causally, since insurance status is endogenous. For instance, Panel (b) of Figure A.2 reveals that uninsured individuals have lower total medical spending on average, consistent with better health or greater selectivity in seeking care.

Empirical evidence from the literature supports the view that health insurance significantly reduces, but does not eliminate, out-of-pocket spending. Finkelstein et al. (2012), using data from the Oregon Health Insurance Experiment, estimate that gaining Medicaid coverage lowers OOP expenditures by approximately 40 percent. Similarly, Finkelstein and McKnight (2008) find that the introduction of Medicare led to a 40 percent reduction in OOP spending for individuals in the top quartile of the OOP distribution. These findings underscore the substantial financial protection offered by insurance, even when some cost-sharing remains.[14] While our empirical analysis assumes full insurance in order to cleanly quantify the role of credit markets, the resulting estimates of incremental value should be interpreted as approximations, since real-world policies involve some degree of cost-sharing.

4.2 Model parameterization

We estimate the incremental value of health insurance using Equation (5), which allows for multiple health shocks and loan markups. We assume constant relative risk aversion (CRRA) preferences:

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma} \tag{7}$$

While there is no consensus regarding the precise value of γ, the coefficient of relative risk aversion, its value is conventionally set below 2 (Chetty, 2009). To be conservative, our main specification sets $\gamma = 2$, which raises the value of insurance relative to lower values of γ. Appendix A.4 derives the optimal loan choice, L^*, under CRRA utility. We set the consumer rate of time preference, β, equal to 0.95, corresponding to an annual interest rate $r = 5.26\%$.

Our preferred specification assumes a 5% markup on insurance premiums ($m^I = 1.05$). The Affordable Care Act requires minimum medical-loss ratios (MLRs, equal to $1/m^I$) of

[13] Uninsured households do not necessarily face OOP shares of 100%. Many providers offer free or discounted care to uninsured individuals, and in some cases, bills are simply not paid.

[14] These reductions in OOP spending occur despite corresponding increases in total utilization and overall health expenditures. Similar patterns are documented for Medicare prescription drug coverage (Engelhardt and Gruber, 2011; Huh and Reif, 2017) and for non-US programs (e.g., Shigeoka, 2014; Sood et al., 2014).

85% for large insurers and 80% for small ones. As of 2022, actual MLRs for large group, small group and individual markets averaged 88%, 86%, and 83% (Ortaliza, Amin and Cox, 2023), respectively, implying markups of about $m^I \approx 1.15$. Offsetting this, tax law allows households to deduct insurance premiums, providing an implicit subsidy approximately equal to the average tax rate, which was 13.6% in 2000 (York, 2023). Accounting for both the MLR regulations and the tax subsidy implies an effective markup of $m^I \approx 1$. Because the distribution of tax rates is right-skewed (averaging only 3.1% for below-median-income taxpayers), we adopt an intermediate markup of $m^I = 1.05$. We compare this markup to a baseline of $m^I = 1$ in our main figures, and to $m^I = 1.1$ and 1.15 in the appendix (Table A.3).

Our baseline assumption is no interest rate markup on loans ($r^m = 0$). Although loans generally have administrative costs, those costs may be limited in healthcare markets: under the Emergency Medical Treatment and Labor Act (EMTALA), hospitals must treat uninsured patients before charging them, and those charges often do not accrue interest. Moreover, uninsured patients often negotiate discounts that reduce effective prices below insurer rates, and they retain the option of discharging debt through bankruptcy (Mahoney, 2015). To assess sensitivity, we also consider markups ranging from r^m from –2.78% to 8.40%.

Our preferred specification sets the loan payback horizon to 5 years, although we also show alternative specifications with shorter or longer payback lengths. We choose 5 years because it is near the midpoint of the typical range of 2–7 years for consumer loans (Safier, 2023).

Finally, we report all estimates in units of dollars by dividing $V^{\Delta,L}(n)$ and $V^{\Delta,L}(n = 1)$ by the marginal utility of income, $u'\left(y - m^I \mathrm{E}^j[p]\right)$, where $j \in \{E, C\}$ indicates experience- or community-rated pricing.

4.3 Results

The availability of loans substantially reduces the incremental value of insurance. Figure 1(a) reports the average dollar value of experience-rated insurance for two-person households, by decile of predicted spending risk. The blue line reports our benchmark: the conventional value of actuarially-fair ($m^I = 1$) insurance when credit markets are absent. This value increases with decile of predicted spending, averaging \$399 across households.[15] The dashed red line shows that credit access lowers this value considerably: access to an actuarially-fair

[15] By way of comparison, Engelhardt and Gruber (2011) estimate that the average financial risk-reduction value of Medicare Part D insurance is \$455 (2007 dollars) for individuals aged 60–70. While Part D only covers prescription drugs, its enrollees are older than the population we study.

($r^m = 0\%$), five-year loan reduces the average value of insurance by \$232, to \$167—a 58% decline. This reduction is large, in absolute and relative terms, across all deciles of spending risk.

Introducing markups further reduces the value of experience-rated insurance. The green line in Figure 1(a) shows the conventional value of insurance when it is priced with a 5% markup ($m^I = 1.05$) and loan markets are absent. Relative to actuarially fair pricing, the markup lowers the value of insurance from \$214 to \$131 (a 39% drop) in the lowest-risk decile. This value gap rises with spending risk because insurance markups scale with expenditures. For the highest-risk decile, the value of insurance turns negative, implying that consumers would forgo insurance absent subsidies. When credit markets are introduced (dashed orange line), the value of insurance falls further, even with loan markups ($r^m = 2.78\%$). This decrease is substantial enough that insurance becomes unattractive across all deciles.

Figure 1(b) shows analogous results for community-rated insurance. The reduction in insurance value from loans is roughly the same in absolute terms as for experience-rated insurance. However, this effect is relatively small compared with the extensive cross-subsidization across risk types. On average, credit access reduces the value of actuarially fair community-rated insurance by \$366, from \$598 to \$232—a 61% decline.

The decline in insurance value is especially pronounced for low-income households. Figure 2(a) plots the value of experience-rated insurance by income bin, from \$20,000 to \$300,000. In the absence of loans, insurance value declines with income, consistent with the standard prediction that higher-income households derive less value from the consumption-smoothing benefits offered by insurance. Introducing loans reduces the value of insurance by \$851 (67%) for the lowest-income group (\$20,000–\$30,000), but only by \$28 (48%) for the highest-income group (\$250,000–\$300,000). Introducing markups causes the conventional value of insurance to turn negative for households with income above \$70,000, and once loan markets are introduced, even households earning \$50,000 derive no positive benefit from insurance. Panel (b) shows qualitatively similar results for community-rated insurance.

Next, we investigate how loan length and interest rates affect insurance value. Figure 3(a) considers actuarially-fair loans with repayment terms ranging from 2–10 years. Even a two-year loan reduces the average value of insurance by \$159 (40%). Longer repayment horizons, which allow for greater consumption smoothing, further reduce the value of insurance but at a diminishing rate: a 5-year loan reduces the value by \$232 (58%), while a 10-year loan reduces it by \$254 (64%).

Figure 3(c) shows that loans substantially reduce insurance value even when borrowing is costly. Each line corresponds to a different annual interest rate with for a 5-year loan. Lower borrowing costs reduce the value of experience-rated insurance, but even at an interest rate as high as 8.40%, access to credit still reduces the average value of experience-rated insurance by \$97 (24%).

Panels (b) and (d) of Figure 3 show the corresponding results for community-rated insurance. Depending on loan terms, loan markets reduce the value of insurance by up to \$123 (7%) for the lowest decile and by as much as \$1,386 (21%) for the highest decile.

Table 1 summarizes average reductions across different combinations of insurance markups (m^I), interest rate markups (r^m), and loan lengths (n). For example, the fifth row reports that the availability of a five-year, actuarially-fair loan reduces the average value of actuarially-fair, experience-rated insurance by 58.2%. The corresponding effect for community-rated insurance is slightly larger, at 61.2%. In some cases, the average reduction exceeds 100%, implying that many consumers would optimally decline to purchase insurance.

Finally, we gauge the accuracy of our Taylor approximation by comparing it to exact estimates from Equation (3) calculated using the full data. We focus on the approximation's ability to capture how credit access changes the value of health insurance changes, i.e., the difference between $n = 1$ and $n > 1$. Figure A.3 compares the approximated and exact changes for loan lengths of 2, 5, and 10 years. The approximation understates the effect by 10–18%, depending on loan length, but nevertheless provides a close and policy-relevant approximation.

5 Serially Correlated Shocks

Up to this point, we have evaluated the value of insurance in a single-period setting. This framework is reasonable when risks are short-lived, but many financial risks exhibit serial correlation: a shock today raises the likelihood of shocks in subsequent periods. To capture this feature, we extend the analysis to a multi-period life-cycle model with limited financial markets. In this setting, households can borrow only to cover contemporaneous medical spending shocks, which themselves follow a serially correlated process calibrated to MEPS data. This framework allows us to examine how the persistence of shocks interacts with loan availability in shaping the value of insurance.

5.1 Life-cycle model with serially correlated shocks

Consider an individual who lives for T periods. Each period she earns income y and incurs a medical spending shock $p(t)$. For the first $\tau < T$ periods she is uninsured; afterwards she obtains full insurance. While uninsured, she can borrow at the effective interest rate r^e up to the size of the realized shock, $L(t) \leq p(t)$, in order to maintain non-negative wealth. Loans must be repaid equally over two periods ($n = 2$), implying that the share:

$$\alpha = (1 + r^e)/(2 + r^e)$$

is repaid in both t and $t+1$.[16] To keep the presentation concise, we focus on experience-rated insurance.

The consumer's problem is:

$$\max_{c(t)} \mathbb{E}\left[\sum_{t=1}^{T} \beta^t u\big(c(t)\big) \,\middle|\, W_1, P_0, L_0\right]$$

subject to:

$$\begin{aligned}
W(1) &= W_1, \\
p(0) &= P_0, \\
L(0) &= L_0, \\
\log p(t) &= \mu + \phi \log p(t-1) + \varepsilon(t), \quad \varepsilon(t) \sim \mathcal{N}(0, \sigma^2), \qquad (8)\\
L(t) &= \begin{cases} \max\Big\{0,\ \min\big\{-\big(R(t) - c(t) - p(t)\big)/(1-\alpha),\ p(t)\big\}\Big\}, & \text{if } t \le \tau \\ 0, & \text{if } t > \tau \end{cases} \\
W(t+1) &= \begin{cases} \big(R(t) - c(t) - p(t) + (1-\alpha)L(t)\big)(1+r), & \text{if } t \le \tau \\ \big(R(t) - c(t) - m^I \mathrm{E}[p]\big)\,(1+r), & \text{if } t > \tau \end{cases} \\
W(t) &\ge 0, \\
c(t) &> 0
\end{aligned}$$

where $R(t) \equiv W(t) + y - \alpha L(t-1)$ are the resources available at time t after repaying past loans. The three state variables are wealth, $W(t)$, medical expenditures, $p(t)$, and outstanding loans, $L(t-1)$. Serial correlation in log expenditures follows the AR(1) process in Equation (8). The loan $L(t)$ is the minimum required to avoid negative wealth in $t+1$, subject to the borrowing constraint $L(t) \le p(t)$. The loan is paid back over the two periods t and $t+1$. If the consumer is insured from the outset ($\tau = 0$), loans are never taken; instead, she pays a premium each period in exchange for full coverage.

To solve the model, we discretize the AR(1) process using Tauchen's method, generating a Markov chain with $N_p = 10$ price states and transition matrix Π. We then rewrite the

[16] Allowing $n > 2$ would require an additional state variable, greatly increasing computational complexity. Since two-period loans suffice to capture the effects of serial correlation, we adopt this simplification.

optimization problem as a recursive Bellman equation:

$$V_t(p_j, W, L) = \max_c \left[u(c) + \beta \sum_{k=1}^{N_p} \Pi_{jk} V_{t+1}(p_k, W', L') \right] \tag{9}$$

where W' and L' depend on the consumer's optimal consumption decision as described above. We provide details in Appendix A.6.

Let $V_1^x(p, W, L)$ denote expected lifetime utility at $t = 1$, under environment $x \in \{I, L\}$ (insurance from the outset or τ uninsured periods with access to loans). Averaging over stationary probabilities π_j of $p(0)$ yields:

$$V_1^x(W_1, L_0) = \sum_{j=1}^{N_p} \pi_j V_1^x(p_j, W_1, L_0), \quad x \in \{I, L\},$$

The incremental value of insurance is then equal to the per-year monetized utility gain:

$$V^{\Delta,L} = \frac{V_1^I (W_1, L_0) - V_1^L (W_1, L_0)}{\tau\, u'(y - m^I \mathrm{E}[p])} \tag{10}$$

To compute the value of insurance in the absence of loan markets, we repeat the analysis with the restriction $L(t) = 0$ for all t in the uninsured regime.

5.1.1 Calibration and results

We calibrate the process governing serially correlated medical spending separately by spending decile. The persistence parameter ϕ is estimated by fitting Equation (8) to MEPS panel data for two-person households and then smoothed using a quadratic fit (Figure A.4). To isolate the role of serial correlation, we also run counterfactuals with $\phi = 0$, holding $\mathrm{E}[p(t)]$ and $\mathrm{Var}[p(t)]$ constant (see Appendix A.6.4 and Table A.4 for details).

As in our main specification, preferences follow CRRA utility with $\gamma = 2$ and $\beta = 0.95$. We assume an insurance markup $m^I = 1.05$, a loan interest rate markup of 11.4% (equivalent to a 5% loan markup when $n = 2$), and horizon $T = 20$ periods with $\tau = 10$ uninsured years. These values are intended to capture an uninsured consumer's experience beginning ten years prior to gaining eligibility for public coverage such as Medicare. Income y is estimated separately by decile. Initial wealth W_1 is chosen so that the average incremental value of insurance, $V^{\Delta,L}$, matches the one-period benchmark when $\phi = 0$.[17] Table A.5 summarizes

[17]Exact decile-specific values may differ from the benchmark because the life-cycle model incorporates multiple uninsured periods, represents each decile with a single household, and involves numerical approximation error.

the model parameters.

Figure 4 presents the main results. The solid blue line depicts the baseline estimates without serial correlation ($\phi = 0$) and no loan markets. In this benchmark, the value of insurance is highest for low-spending deciles and declines with spending, reflecting the growing burden of insurance markups as average expenditures rise. The solid red line shows that introducing loans reduces the value of insurance substantially, as households can borrow to smooth temporary shocks in the absence of coverage. These patterns closely mirror those from the corresponding one-period model, shown in Figure A.5.

One notable difference from the one-period benchmark is that the value of insurance is substantially larger in the life-cycle model. The reason is that households face repeated uninsured shocks over many periods and, without access to credit, must accumulate precautionary savings to avoid insolvency. Insurance eliminates both the need for precautionary savings and the exposure to cumulative risk, producing larger welfare gains than in the one-period setting, where the consumer faces only a single uninsured draw.

The dashed lines in Figure 4 incorporate serial correlation in spending shocks. In the absence of loan markets, serial correlation increases the average incremental value of insurance from \$450 to \$619, reflecting the greater benefit of covering shocks that recur across multiple periods. A similar pattern arises when loan markets are present, where serial correlation raises the average value from \$13 to \$160. Thus, serial correlation amplifies the value of insurance regardless of credit access. Yet even under serial correlation, loan availability continues to dramatically reduce the value of insurance: the value falls from \$619 to \$160, a 74 percent decline.[18] In short, while serial correlation strengthens the case for insurance, it does not alter the central conclusion that loan availability substantially reduces its value.

6 Conclusion

The value of insurance depends critically on how consumers would otherwise finance spending shocks. We show that greater access to credit substantially reduces the incremental consumption-smoothing value of insurance. We find that this effect is quantitatively significant when applied to data on medical spending: in a baseline case with no insurance loads or loan administrative costs, introducing a two-year loan contract reduces the incremental value of health insurance by about 40% (Table 1).

A key contribution of our analysis is to provide both exact and approximate formulas for valuing insurance. Our approximation requires only a few parameters: the loan terms, the insurance mark-up m^I (capturing administrative costs and moral hazard), income, the

[18] For comparison, the corresponding one-period model yields a decline of 85% (Figure A.5).

mean and variance of spending shocks, and the coefficient of relative risk aversion. We show that this approximation performs well across a range of loan lengths.

An important limitation of our study is that we abstract from frictions in both insurance and credit markets. In insurance markets, adverse selection and moral hazard could reduce the value of coverage as a consumption-smoothing technology. In credit markets, asymmetric information and risk-based pricing may limit access to borrowing when individuals fall ill. Such imperfections would make credit less reliable as a substitute, and hence increase the relative value of insurance. Exploring these alternative settings is an important direction for future research.

Our analysis has several implications for policy. First and foremost, some of the welfare gains typically attributed to insurance could be obtained through improved credit access. Depending on the setting, a lower-cost policy response to spending risk may be to provide public or subsidized loans rather than insurance. Second, our analysis highlights how the value of insurance varies with financial conditions: expansions of public coverage are less valuable when credit markets are well-developed or when interest rates are low, implying that optimal subsidy levels should rise with interest rates. Third, policies in healthcare and credit markets can act as substitutes, sometimes unintentionally. EMTALA, for example, requires hospitals to treat patients before billing, effectively providing implicit loans for emergency care. This credit supply reduces demand for insurance and may help explain why take-up can be low even for actuarially fair contracts (Finkelstein, Hendren and Shepard, 2019). Likewise, bankruptcy protection functions as a form of credit insurance: it smooths consumption but also reduces the value of health insurance (Mahoney, 2015).

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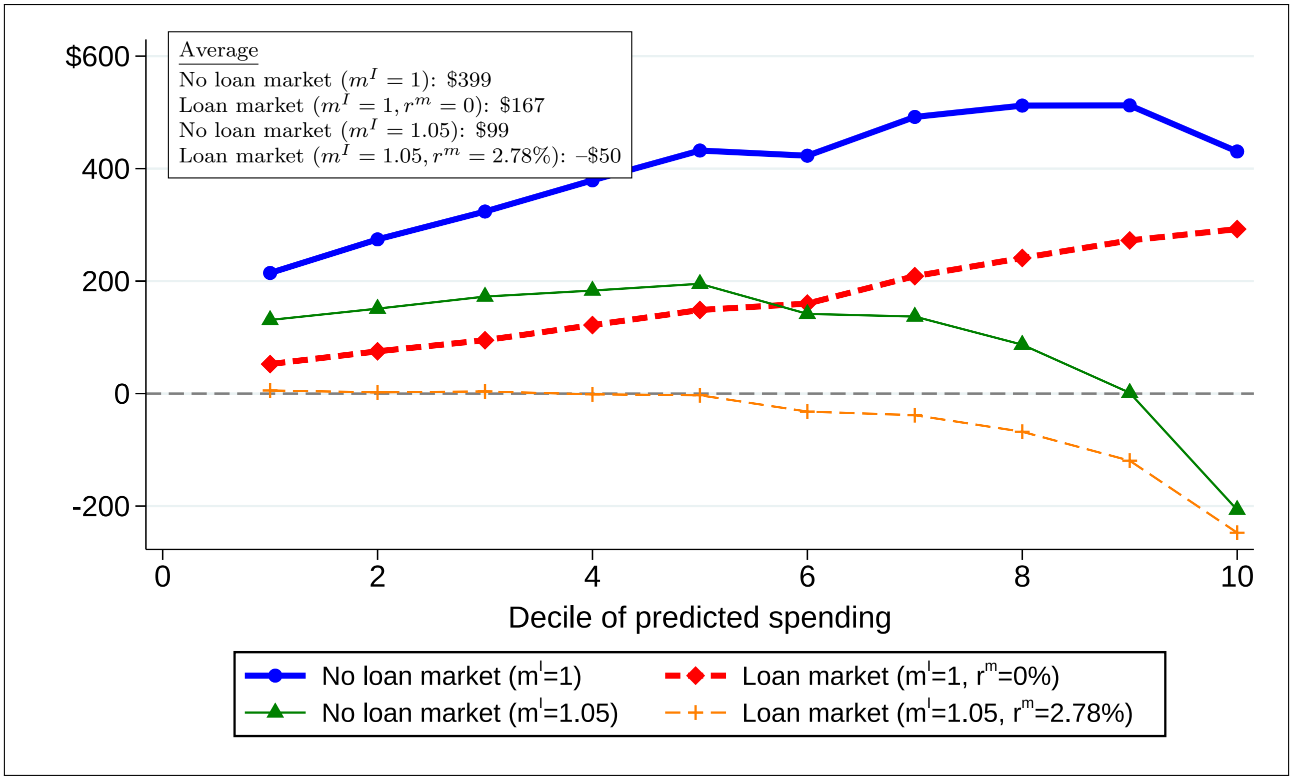
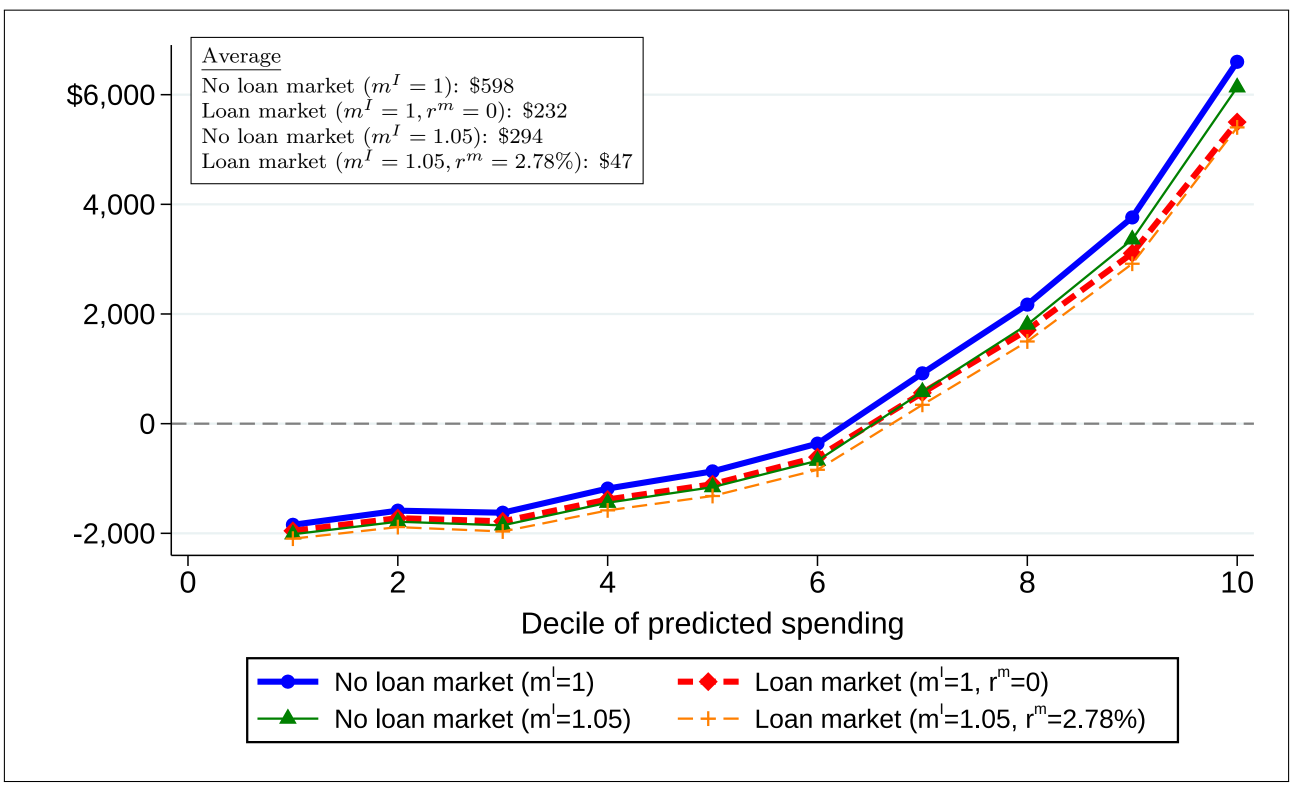
Figure 1: The value of health insurance, with and without a loan market

(a) Experience-rated insurance



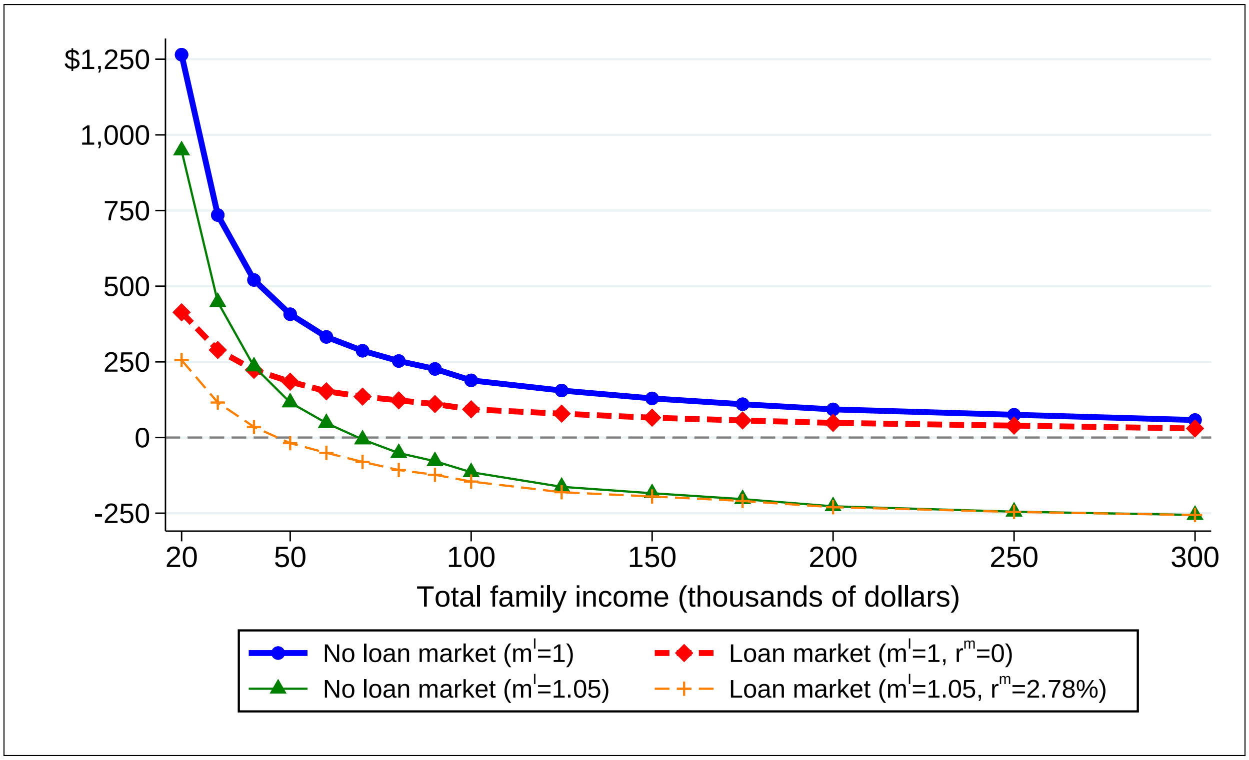
(b) Community-rated insurance



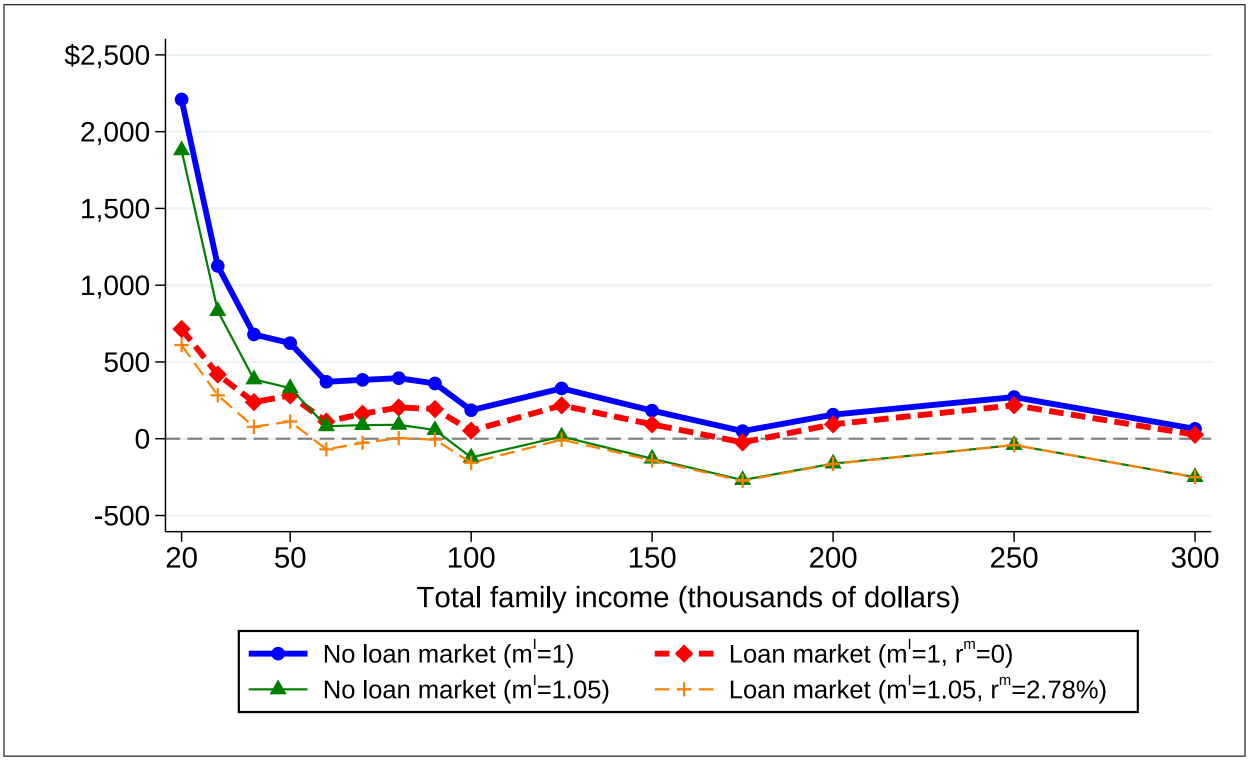
Notes: This figure plots the value of health insurance as calculated by Equation (5) for two-person households. "No loan market ($m^I = 1$)" allows only actuarially-fair insurance. "Loan market ($m^I = 1, r^m = 0\%$)" adds an actuarially-fair 5-year loan option. "Loan market ($m^I = 1.05, r^m = 2.78\%$)" adds a 5% markup on insurance premiums and a 2.78% annual interest rate markup on loans (5% loan markup). Experience-rated premiums reflect average spending by predicted spending decile. Community-rated premiums reflect population averages for two-person households, conditional on geographic region and age group.

Figure 2: The value of health insurance with and without a loan market, by income

(a) Experience-rated insurance, by income

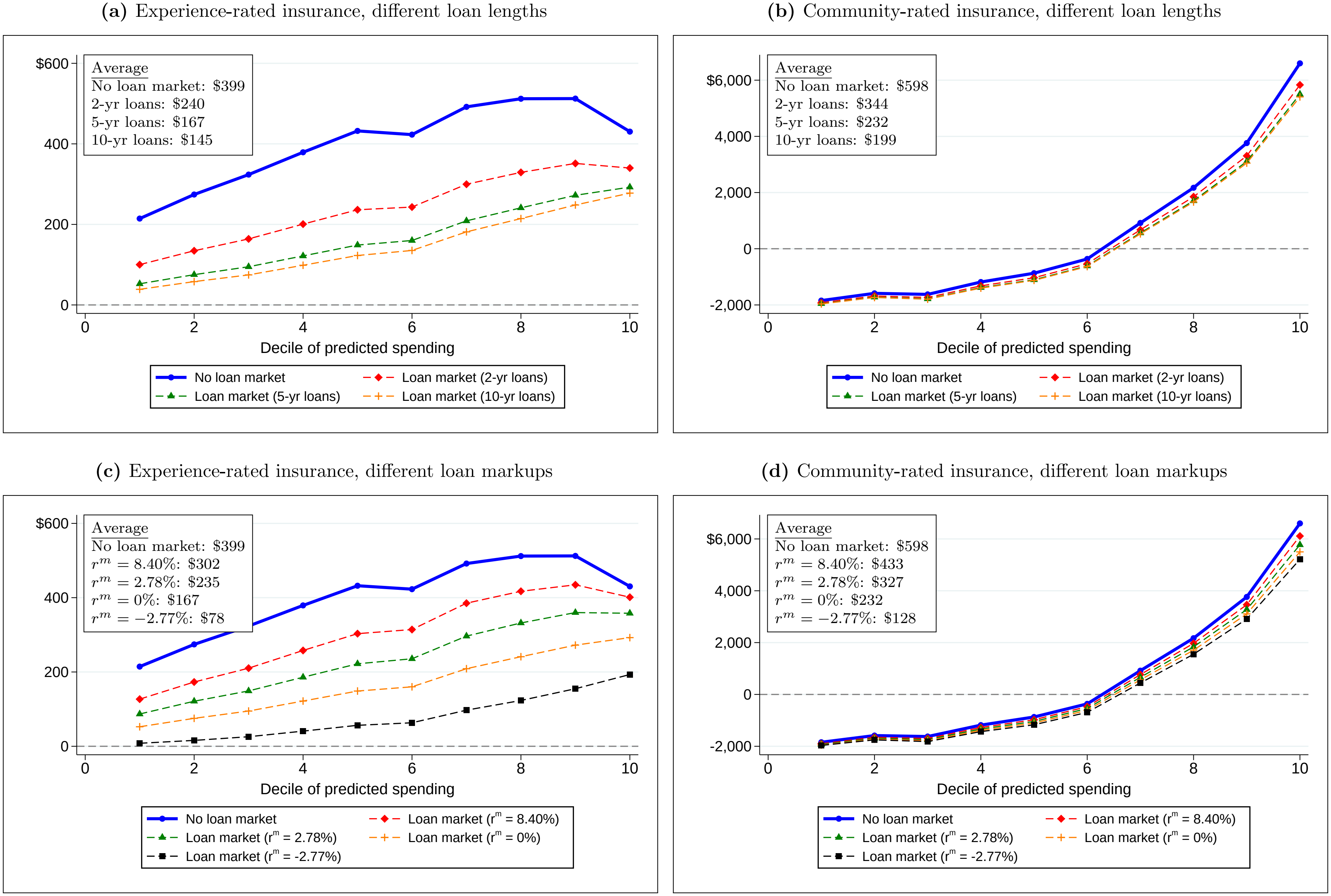


(b) Community-rated insurance, by income



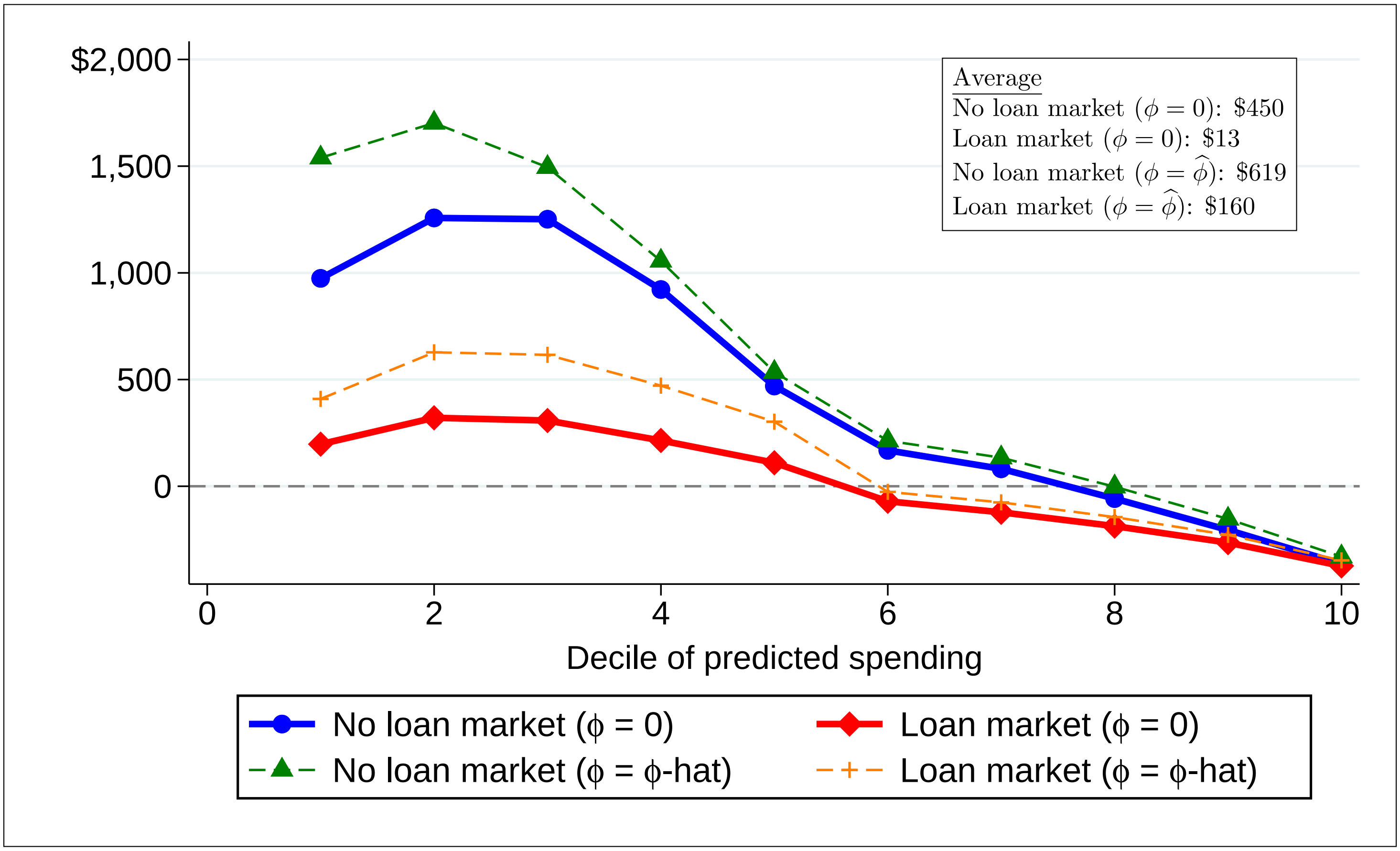
Notes: This figure plots the value of health insurance as calculated by Equation (5) for two-person households. "No loan market ($m^I = 1$)" allows only actuarially-fair insurance. "Loan market ($m^I = 1, r^m = 0\%$)" adds an actuarially-fair 5-year loan option. "Loan market ($m^I = 1.05, r^m = 2.78\%$)" adds a 5% markup on insurance premiums and a 2.78% annual interest rate markup on loans (5% loan markup). Experience-rated premiums reflect average spending by predicted spending decile. Community-rated premiums reflect population averages for two-person households, conditional on geographic region and age group.

Figure 3: The value of actuarially-fair insurance when loan markets are present, for different loan lengths and loan markups



Notes: This figure plots the value of actuarially-fair ($m^I = 1$) health insurance as calculated by Equation (5) for two-person households. In panels (a) and (b), insurance and loan markets are both actuarially fair ($m^I = 1, r^m = 0\%$), but we vary the length of the loan payback period. In panels (c) and (d), insurance markets are actuarially fair but the interest rate markup on the loan ranges from –2.78% (5% loan subsidy) to 8.40% (15% loan markup). Experience-rated premiums reflect average spending by predicted spending decile. Community-rated premiums reflect population averages for two-person households, conditional on geographic region and age group.

Figure 4: The annual value of health insurance, with and without serial correlation in spending shocks



Notes: This figure plots the average annual value of experience-rated health insurance, calculated using Equation (10) for two-person households. When $\phi = 0$, spending shocks are i.i.d. across periods. When $\phi = \widehat{\phi}$, shocks follow the AR(1) process in Equation (8). Experience-rated premiums reflect average spending by predicted spending decile. Numerical estimates are reported in Table A.4, and the estimates of $\widehat{\phi}$ are shown in Figure A.4. The one-period model corresponding to $\phi = 0$ is shown in Figure A.5.

Table 1: The effect of accounting for loan markets on the value of health insurance

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				Experience rated insurance			Community rated insurance		
Insurance markup (ratio)	Loan markup (ratio)	Loan interest rate markup (%)	Loan length (yrs)	Baseline value (dollars)	Reduction (dollars)	Reduction (%)	Baseline value (dollars)	Reduction (dollars)	Reduction (%)
1	0.95	–10.26	2	399.4	-256.1	64.1	597.7	-369.3	61.8
1	0.95	–2.77	5	399.4	-321.5	80.5	597.7	-469.3	78.5
1	0.95	–1.30	10	399.4	-341.1	85.4	597.7	-499.0	83.5
1	1	0	2	399.4	-159.4	39.9	597.7	-253.5	42.4
1	1	0	5	399.4	-232.6	58.2	597.7	-365.6	61.2
1	1	0	10	399.4	-254.4	63.7	597.7	-398.7	66.7
1	1.05	11.40	2	399.4	-93.3	23.4	597.7	-157.1	26.3
1	1.05	2.78	5	399.4	-164.6	41.2	597.7	-270.8	45.3
1	1.05	1.28	10	399.4	-186.7	46.7	597.7	-305.2	51.1
1	1.15	38.49	2	399.4	-41.3	10.3	597.7	-72.0	12.1
1	1.15	8.40	5	399.4	-97.0	24.3	597.7	-164.2	27.5
1	1.15	3.81	10	399.4	-115.8	29.0	597.7	-194.7	32.6
1.05	0.95	–10.26	2	99.3	-233.7	235.2	294.5	-342.4	116.3
1.05	0.95	–2.77	5	99.3	-293.0	295.0	294.5	-435.2	147.8
1.05	0.95	–1.30	10	99.3	-310.8	312.9	294.5	-462.8	157.2
1.05	1	0	2	99.3	-144.7	145.7	294.5	-234.3	79.6
1.05	1	0	5	99.3	-211.2	212.6	294.5	-338.3	114.9
1.05	1	0	10	99.3	-231.0	232.5	294.5	-369.0	125.3
1.05	1.05	11.40	2	99.3	-84.5	85.0	294.5	-142.7	48.5
1.05	1.05	2.78	5	99.3	-149.1	150.1	294.5	-247.7	84.1
1.05	1.05	1.28	10	99.3	-169.1	170.2	294.5	-279.6	95.0
1.05	1.15	38.49	2	99.3	-37.4	37.7	294.5	-63.2	21.5
1.05	1.15	8.40	5	99.3	-87.8	88.4	294.5	-147.5	50.1
1.05	1.15	3.81	10	99.3	-104.8	105.5	294.5	-175.3	59.5

Notes: This table reports the average value (2014 dollars) of health insurance, $V^{\Delta,L}$, for two-person households. Columns (1) and (2) report the parameter values for insurance and loan markups, m^I and m^L. Column (3) reports the loan annual interest rate markup, r^m, which is a function of the loan markup, m^L, and the consumer rate of time preference, β. Actuarially fair insurance corresponds to $m^I = 1$ and actuarially fair loans correspond to $r^m = 0\%$ (equivalently, $m^L = 1$). Column (4) reports the loan length, n, in years. Community-rated premiums reflect population averages for two-person households, conditional on geographic region and age group. Percentage changes are not reported when the baseline value of insurance is negative.

Online Appendix

"Access to Credit Reduces the Value of Health Insurance"

Sonia Jaffe, Anup Malani, Julian Reif

A Model

A.1 Value of fair insurance

If insurance is actuarially fair ($m^I = 1$) and experience rated ($\pi^C = \pi$), then Equation (1) reduces to:

$$V^{\Delta,L} = (1-\pi)\left(u(y-\pi p) - u(y)\right) + \frac{\pi}{\alpha}\left(u\left(y-\pi p\right) - u\left(y-\pi p-\alpha p(1-\pi)\right)\right) \tag{11}$$

This expression is positive by Jensen's inequality. To see this, multiply both sides by α and rearrange to obtain:

$$\alpha V^{\Delta,L} = \left(\alpha\left(1-\pi\right)+\pi\right)u\left(y-\pi p\right) - \left(\alpha\left(1-\pi\right)u\left(y\right) + \pi u\left(y-p\left[\alpha\left(1-\pi\right)+\pi\right]\right)\right)$$

Note that $u(y-\pi p)$ is the weighted average of y and $y-p[\alpha(1-\pi)+\pi]$, with weights $\alpha\left(1-\pi\right)/\left(\alpha\left(1-\pi\right)+\pi\right)$ and $\pi/\left(\alpha\left(1-\pi\right)+\pi\right)$. Strict concavity of $u(\cdot)$, together with $p>0$ and $0<\pi<1$, then implies that $V^{\Delta,L}$ is positive.

A.2 Comparative statics

As shown in Equation (1), when there is a single potential shock, insurance available in later periods, no loan markup, and limited credit markets (so borrowing is possible only following a shock), the value of insurance is:

$$V^{\Delta,L}(\pi^C) = (1-\pi)\ \left(u\left(y-m^I\pi^C p\right) - u\left(y\right)\right) - \frac{\pi}{\alpha}\left(u\left(y-m^I\pi^C p-\alpha p\left(1-m^I\pi^C\right)\right) - u\left(y-m^I\pi^C p\right)\right)$$

A.2.1 Risk

The effect of π under community rating is straightforward:

$$\frac{\partial V^{\Delta,L}(\pi^C)}{\partial \pi} = u\left(y\right) - u\left(y-m^I\pi^C p\right) + \frac{1}{\alpha}\left(u\left(y-m^I\pi^C p\right) - u\left(y-m^I\pi^C p-\alpha p\left(1-m^I\pi^C\right)\right)\right) > 0$$

Under experience rating, the effect is more complex. If we isolate the impact of risk in the first period (splitting π into π_1 for the first period and π_t for subsequent periods), the incremental value of insurance becomes:

$$\begin{aligned} V^{\Delta,L} = {} & (1-\pi_1)\left(u\left(y-m^I\pi_1 p\right) - u\left(y\right)\right) \\ & + \pi_1\Big[\left(u(y-m^I\pi_1 p) - u\left(y-m^I\pi_t p-\alpha p(1-m^I\pi_t)\right)\right) \\ & + \left(\frac{1}{\alpha}-1\right)\left(u(y-m^I\pi_t p) - u(y-m^I\pi_t p-\alpha p(1-m^I\pi_t))\right)\Big] \end{aligned}$$

The probability of the shock and period 1's premium are determined by π_1, while future premiums and out-of-pocket payments depend on π_t. The effect of π_1 is:

$$\begin{aligned} \frac{\partial V^{\Delta,L}}{\partial \pi_1} = {} & \Big[u(y) - u(y-m^I\pi_t p-\alpha p(1-m^I\pi_t)) \\ & + \left(\frac{1}{\alpha}-1\right)\left(u\left(y-m^I\pi_t p\right) - u\left(y-m^I\pi_t p-\alpha p\left(1-m^I\pi_t\right)\right)\right)\Big] - pm^I u'(y-m^I\pi_1 p) \end{aligned}$$

The second derivative is:

$$\frac{\partial^2 V^{\Delta,L}}{\partial \pi_1^2} = (pm^I)^2 u''\left(y - m^I \pi_1 p\right) < 0$$

Also note that $V^{\Delta,L}(\pi_1 = 0) = 0$. Therefore, if V equals zero for some $\pi_1 > 0$, it follows that $\partial V^{\Delta,L}/\partial \pi_1 < 0$ at that π_1. Hence, if someone is indifferent between insurance and loans, then, on the margin, raising π_1 makes them prefer loans.

Because risks are correlated across periods, comparing individuals requires considering simultaneous changes in both π_1 and π_t:

$$\begin{aligned}\frac{\partial V^{\Delta,L}}{\partial \pi} =& \frac{\partial V^{\Delta,L}}{\partial \pi_1} - pm^I\pi\left(\left(\frac{1}{\alpha}-1\right)u'\left(y - m^I\pi p\right) - \frac{1}{\alpha}u'\left(y - m^I\pi p - \alpha p\left(1 - m^I\pi\right)\right)(1-\alpha)\right)\\ =& \frac{\partial V^{\Delta,L}}{\partial \pi_1} - pm^I\pi\left(\frac{1}{\alpha}-1\right)\left(u'\left(y - m^I\pi p\right) - u'\left(y - m^I\pi p - \alpha p\left(1 - m^I\pi\right)\right)\right)\end{aligned}$$

Intuitively, higher expected future premiums raise the marginal utility of income in later periods, increasing the effective cost of borrowing early. However, this can be partially offset if the individual chooses to borrow less (hence the second term is multiplied by $1-\alpha$). Consequently, greater future risk tends to shift preferences slightly toward borrowing rather than insuring.

Risk is also reflected in the price of medical care, which may vary across periods. To see this, separate the first-period price, p_1, from the future-period price, p_t:

$$\begin{aligned}V^{\Delta,L}(\pi^C) = (1-\pi)\ &\left(u\left(y - m^I\pi^C p_1\right) - u\left(y\right)\right)\\ &+ \pi\Bigg[\left(u\left(y - m^I\pi^C p_1\right) - u\left(y - m^I\pi^C p_t - \alpha\left(p_1 - m^I\pi^C p_t\right)\right)\right)\\ &+ \left(\frac{1}{\alpha}-1\right)\left(u\left(y - m^I\pi^C p_t\right) - u\left(y - m^I\pi^C p_t - \alpha\left(p_1 - m^I\pi^C p_t\right)\right)\right)\Bigg]\end{aligned}$$

$$\frac{\partial V^{\Delta,L}(\pi^C)}{\partial p_1} = -\pi^C m^I u'\left(y - m^I\pi^C p_1\right) + \frac{\pi}{\alpha}\alpha u'\left(y - m^I\pi^C p_t - \alpha\left(p_1 - m^I\pi^C p_t\right)\right)$$

The marginal utility of income is higher under loans, so when loans are relatively more costly($\pi > \pi^C m^I$), an increase in prices clearly raises the value of insurance $\left(\frac{\partial V^{\Delta,L}(\pi^C)}{\partial p_1} > 0\right)$. If insurance is costlier, the effect becomes ambiguous: higher prices increase the cost of the insurance load, but this is partly offset because, without insurance, those same expenses would occur when income is most scarce—during loan repayment, when the marginal utility of income is highest.

Moreover, a higher current price suggests higher future prices as well:

$$\begin{aligned}\frac{\partial V^{\Delta,L}(\pi^C)}{\partial p} =& \frac{\partial V^{\Delta,L}(\pi^C)}{\partial p_1} - \pi\pi^C m^I\left(u'\left(y - m^I\pi^C p_t\right)\left(\frac{1}{\alpha}-1\right) - \frac{1}{\alpha}(1-\alpha)u'\left(y - m^I\pi^C p_t - \alpha\left(p_1 - m^I\pi^C p_t\right)\right)\right)\\ =& \frac{\partial V^{\Delta,L}(\pi^C)}{\partial p_1} - \pi\pi^C m^I\left(\frac{1}{\alpha}-1\right)\left(u'\left(y - m^I\pi^C p_t\right) - u'\left(y - m^I\pi^C p_t - \alpha\left(p_1 - m^I\pi^C p_t\right)\right)\right)\end{aligned}$$

Higher expected future prices lead to larger premium payments in later periods, which increase the marginal utility of income at those times. This makes borrowing in the first period effectively more expensive, thereby raising the relative value of insurance. Although individuals may respond by borrowing slightly less, this adjustment does not fully offset the effect.

A.2.2 Credit market access

Changing n affects α, which in turn raises $V^{\Delta,L}(\pi^C)$. Again using the shorthand $\tilde{y} = y - m^I \pi^C p$, we obtain:

$$\frac{\partial V^{\Delta,L}(\pi^C)}{\partial \alpha} = \frac{\pi}{\alpha^2}\left(-u\left(\tilde{y}\right) + u\left(\tilde{y} - \alpha p\left(1 - m^I \pi^C\right)\right) + \alpha p\left(1 - m^I \pi^C\right) u'\left(\tilde{y} - \alpha p\left(1 - m^I \pi^C\right)\right)\right) > 0$$

This derivative is positive because u is concave.

A.2.3 Insurance markup

Increasing the insurance load affects both current premium payments and future premiums:

$$\begin{aligned}\frac{\partial V^{\Delta,L}(\pi^C)}{\partial m^I} &= -\pi^C p\ \left(\left(1 - \pi + \frac{\pi}{\alpha}\right) u'\left(\tilde{y}\right) - \frac{\pi}{\alpha} u'\left(\tilde{y} - \alpha p\left(1 - m^I \pi^C\right)\right)(1-\alpha)\right)\\ &= -\pi^C p\ \left(u'\left(\tilde{y}\right) + \pi\left(\frac{1}{\alpha} - 1\right)\left(u'\left(\tilde{y}\right) - u'\left(\tilde{y} - \alpha p\left(1 - m^I \pi^C\right)\right)\right)\right)\end{aligned}$$

An increase in the current-period markup m^I directly lowers $V^{\Delta,L}$ by $\pi^C p\,(1-\pi)\,u'\left(\tilde{y}\right)$, reflecting the higher cost of premiums today. However, a higher future m^I also reduces the value of borrowing, since future premiums raise the marginal utility of income during repayment. This increases $V^{\Delta,L}$ (i.e., makes insurance relatively more attractive) by $\pi^C p \frac{\pi}{\alpha}\left(u'\left(\tilde{y} - \alpha p\left(1 - m^I \pi^C\right)\right)(1-\alpha) - u'\left(\tilde{y}\right)\right)$.

A.3 Income shocks

If health expenditure shocks are accompanied by negative income shocks (denoted ϵ_y), this reduces the relative attractiveness of loans, since income is lowest precisely when repayment obligations are highest. When the shock occurs in period 1 only, the value of insurance is:

$$\begin{aligned}V^{\Delta,L} &= (1-\pi)\left(u\left(y - m^I \pi^C p_1\right) - u\left(y\right)\right)\\ &+ \pi\Bigg[\left(u\left(y - m^I \pi^C p_1 - \epsilon_y\right) - u\left(y - m^I \pi^C p_t - \alpha\left(p_1 + \epsilon_y - m^I \pi^C p_t\right)\right)\right)\\ &+ \left(\frac{1}{\alpha} - 1\right)\left(u(y - m^I \pi^C p_t) - u\left(y - m^I \pi^C p_t - \alpha\left(p_1 + \epsilon_y - m^I \pi^C p_t\right)\right)\right)\Bigg]\end{aligned}$$

Income shocks make insurance more valuable:

$$\begin{aligned}\frac{\partial V^{\Delta,L}}{\partial \epsilon_y} &= \pi\Bigg(-u'\left(y - m^I \pi^C p_1 - \epsilon_y\right) + \alpha u'\left(y - m^I \pi^C p_t - \alpha\left(p_1 + \epsilon_y - m^I \pi^C p_t\right)\right)\\ &+ \alpha\left(\frac{1}{\alpha} - 1\right) u'\left(y - m^I \pi^C p_t - \alpha\left(p_1 + \epsilon_y - m^I \pi^C p_t\right)\right)\Bigg)\end{aligned}$$

$$\frac{\partial V^{\Delta,L}}{\partial \epsilon_y} = \pi\Big(-u'\left(y - m^I \pi^C p_1 - \epsilon_y\right) + u'\left(y - m^I \pi^C p_t - \alpha\left(p_1 + \epsilon_y - m^I \pi^C p_t\right)\right)\Big) > 0$$

If the income shock instead occurs in later periods (for simplicity, over the same n periods as the loan term, though the intuition is more general), the value of insurance is:

$$\begin{aligned} V^{\Delta,L} &= (1-\pi)\ \left(u\left(y - m^I \pi^C p_1\right) - u\left(y\right)\right) \\ &+ \frac{\pi}{\alpha}\left(\left(u\left(y - m^I\pi^C p_1 - \epsilon_y\right) - u\left(y - m^I\pi^C p_t - \epsilon_y - \alpha\left(p_1 - m^I\pi^C p_t\right)\right)\right)\right) \end{aligned}$$

The corresponding derivative with respect to ϵ_y is:

$$\frac{\partial V^{\Delta,L}}{\partial \epsilon_y} = \pi\left(-u'\left(y - m^I\pi^C p_1 - \epsilon_y\right) + u'\left(y - m^I\pi^C p_t - \epsilon_y - \alpha\left(p_1 - m^I\pi^C p_t\right)\right)\right) > 0$$

Thus, income shocks—whether contemporaneous or delayed—raise the incremental value of insurance relative to loans.

A.4 Optimal borrowing amount

Consider the multiple shock model with loans but no savings. If we allow for a loan markup so that $m^L > 1$, it will generally not be optimal for the individual to fully smooth consumption across periods. Instead, the individual chooses a loan amount L that solves:

$$\max_L u(y - p + L - \alpha(r^e)L) + \sum_{t=1}^{n-1}\beta^t u\left(y - m^I E[p] - \alpha(r^e)L\right).$$

This yields the first-order condition

$$(1-\alpha(r^e))u'(y - p + L - \alpha(r^e)L) = \alpha(r^e)\frac{\beta - \beta^n}{1-\beta}u'\left(y - m^I E[p] - \alpha(r^e)L\right). \tag{12}$$

Note that $\frac{\beta-\beta^n}{1-\beta} = \frac{1}{\alpha(r)} - 1$.

We can obtain a closed-form solution under constant relative risk aversion (CRRA) preferences, $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$. Substituting into (12) yields:

$$\begin{aligned} \frac{(1-\alpha(r^e))}{(y-p+L-\alpha(r^e)L)^\gamma} &= \frac{\alpha(r^e)(1/\alpha(r)-1)}{(y - m^I E[p] - \alpha(r^e)L)^\gamma} \\ \frac{(1-\alpha(r^e))}{\alpha(r^e)(1/\alpha(r)-1)} &= \frac{(y-p+L-\alpha(r^e)L)^\gamma}{(y - m^I E[p] - \alpha(r^e)L)^\gamma} \\ \left(\frac{(1-\alpha(r^e))}{\alpha(r^e)(1/\alpha(r)-1)}\right)^{1/\gamma} &= \frac{(y-p+L(1-\alpha(r^e)))}{(y - m^I E[p] - \alpha(r^e)L)} \end{aligned}$$

Defining $z = \left(\frac{(1-\alpha(r^e))}{\alpha(r^e)(1/\alpha(r)-1)}\right)^{1/\gamma}$, the first-order condition becomes:

$$L\left(1 - \alpha(r^e) + \alpha(r^e)z\right) = p - m^I E[p]z - y(1-z)$$

If $r^m = 0$, then $\alpha(r^e) = \alpha(r)$, implying $z = 1$. In that case, $L = p - m^I E[p]$, i.e., the consumer borrows exactly enough to fully smooth consumption across periods.

To illustrate the sensitivity of L to changes in $\alpha(r^e)$, consider a CRRA utility function with $\gamma = 2$, $n = 5$, $\beta = .95$, and $r^m = .05$.[1] We obtain $\alpha(r) \approx .221$ and $\alpha(r^e) \approx .241$ so $z \approx .946$. Substituting, we find $L = \frac{1}{.987}\left(p - .946\ m^I E[p] - .054y\right)$.

[1] If we want to think of the markup as multiplicative instead of increasing the interest rate, note that $m^L = \frac{\alpha(r^e)}{\alpha(r)}$, which in this case is about 1.09.

A.5 Coinsurance

Let the coinsurance rate be denoted by $\delta \in [0,1]$, representing the fraction of medical expenses paid out of pocket by the insured individual. The corresponding premium is:

$$\tilde{p} \equiv m^I \pi^C (1-\delta) p$$

where p is the full cost of medical care, π^C is the average probability of illness in the community-rated pool, and m^I reflects the insurance markup. Assuming shocks are uncorrelated across periods, expected lifetime utility with community-rated insurance is:

$$V^I(\pi^C, \delta) = \frac{1-\beta^T}{1-\beta}\left[(1-\pi)u\left(y-\tilde{p}\right) + \pi u\left(y-\delta p-\tilde{p}\right)\right]$$

Expected lifetime utility when the individual declines to purchase community-rated insurance in period 1 is:

$$\begin{aligned} V^L(\pi^C, \delta) = (1-\pi)\Big[u(y) + \frac{\beta-\beta^T}{1-\beta}\big[(1-\pi)\,u(y-\tilde{p}) + \pi\,u(y-\delta p-\tilde{p})\big]\Big] \\ + \pi\left[u\big(y-\alpha p-(1-\alpha)\tilde{p}\big) + \left(\frac{1}{\alpha}-1\right)\big((1-\pi)u\big(y-\alpha p-(1-\alpha)\tilde{p}\big) + \pi u\big(y-\alpha p-(1-\alpha)\tilde{p}-\delta p\big)\big)\right] \\ + \pi\left[\frac{\beta^n-\beta^T}{1-\beta}\big[(1-\pi)\,u(y-\tilde{p}) + \pi\,u(y-\delta p-\tilde{p})\big]\right] \end{aligned}$$

The incremental utility of purchasing insurance relative to relying on loans is therefore:

$$\begin{aligned} V^{\Delta,L}(\pi^C, \delta) =&(1-\pi)\big[u(y-\tilde{p}) - u(y)\big] + \pi\left[u(y-\delta p-\tilde{p}) - u(y-\tilde{p}-\alpha(p-\tilde{p}))\right] \\ &+ \pi\left(\frac{1}{\alpha}-1\right)\Big[(1-\pi)\left(u(y-\tilde{p}) - u\big(y-\alpha p-(1-\alpha)\tilde{p}\big)\right) + \pi\left(u(y-\tilde{p}-\delta p) - u\big(y-\alpha p-(1-\alpha)\tilde{p}-\delta p\big)\right)\Big] \end{aligned}$$

For sufficiently low m^I and when $\pi^C \approx \pi$, we expect co-insurance to decrease the value of insurance. However, its effect on the incremental value of insurance over loans is ambiguous: coinsurance both reduces protection against shocks and affects the marginal utility in repayment periods, while also changing the loan size through its effect on the price of insurance.

A.6 Life-cycle model

A.6.1 Discretizing the AR(1) shock

We discretize the AR(1) process (8) using Tauchen's method with N_p states. Let $z(t) = \ln p(t)$, where:

$$\begin{aligned} \mu_z &= \frac{\mu}{1-\phi} \\ \sigma_z^2 &= \frac{\sigma^2}{1-\phi^2} \end{aligned}$$

We set a symmetric grid over the log-price process spanning $m = 4$ standard deviations around the stationary mean:

$$\begin{aligned} z_{\min} &= \mu_z - m\sigma_z \\ z_{\max} &= \mu_z + m\sigma_z \end{aligned}$$

We then evenly space the log-price grid points:

$$z_j = z_{\min} + \frac{(j-1)(z_{\max}-z_{\min})}{N_p-1}, \quad j = 1, \ldots, N_p$$

and exponentiate to recover the actual price levels:

$$p_j = \exp(z_j)$$

Let Π denote the Markov transition probability matrix, where element Π_{jk} represents the probability of transitioning from state z_j at time t to state z_k at time $t+1$. We calculate these probabilities using the normal distribution. Define the midpoints between grid values as:

$$a_k = \frac{z_{k-1} + z_k}{2}, \quad k = 2, 3, \ldots, N_p$$

The transition matrix Π has the following entries:

$$\begin{aligned}
\Pi_{j,1} &= \Phi\big((a_2 - \mu - \phi z_j)/\sigma\big), \\
\Pi_{j,k} &= \Phi\big((a_{k+1} - \mu - \phi z_j)/\sigma\big) - \Phi\big((a_k - \mu - \phi z_j)/\sigma\big), \quad k = 2, \ldots, N_p - 1, \\
\Pi_{j,N_p} &= 1 - \Phi\big((a_{N_p} - \mu - \phi z_j)/\sigma\big)
\end{aligned}$$

A.6.2 Constructing the loan grid

A loan in period t is paid back over the two periods t and $t+1$, with a per-period repayment share of α. Thus, the amount of the loan carried forward from period t to $t+1$ is equal to:

$$\widetilde{L}(t) = (1 - \alpha)L(t)$$

Let N_L be the number of loan states. Because the loan can never exeed the realized price shock, we build the loan grid $\{\widetilde{L}_i\}_{i=1}^{N_L}$ from the transformed price nodes:

$$\widetilde{L}_j^{\max} = (1 - \alpha)\, p_j, \quad j = 1, \ldots, N_p$$

We then set $\widetilde{L}_1 = 0$ and:

$$\widetilde{L}_i = \text{the } (i-1)/(N_L - 1)\text{-quantile of } \{\widetilde{L}_j^{\max} : j = 1, \ldots, N_p\}, \quad i = 2, \ldots, N_L$$

A.6.3 Backward induction with loan and wealth grids

We solve the Bellman equation recursively by starting at the final period T:

$$V_T(p_j, W_n, \widetilde{L}_m) = u(W_n + y), \quad \text{for all } j = 1, \ldots, N_p,\ m = 1, \ldots, N_L$$

and then recursively solving backwards for $t = T-1, T-2, \ldots, 1$:

$$V_t(p_j, W_n, \widetilde{L}_m) = \max_c \left\{ u(c) + \beta \sum_{k=1}^{N_p} \Pi_{jk}\, V_{t+1}\big(p_k, W', \widetilde{L}'\big) \right\},$$

We linearly interpolate over the $(W, \widetilde{L})$ grid when W' or $\widetilde{L}'$ fall between grid points. If $t > \tau$, the future loan state is always $\widetilde{L}' = 0$.

When the consumer is uninsured, next-period wealth W' may be negative. To discourage this, we replace the continuation value with a quadratic penalty whenever $W' < 0$.[2] Define the worst possible lifetime utility as:

$$V_{\text{worst}} \equiv \frac{1 - \beta^T}{1 - \beta} u(c_{\min})$$

[2]Without such a penalty, it is optimal to increase consumption to the maximum and incur as much debt as possible. If the penalty is too severe, e.g., setting it to $-\infty$, then the consumer engages in excessive precautionary savings. Our setup better reflects the real world, where excessive debt is discouraged but possible.

where $c_{\min}$ is the smallest value on the consumption grid. If $W' < 0$, we impose a smooth penalty expressed in utility units. Define:

$$\text{shortfall} \equiv \frac{|W'|^2}{y} u'(y - m^I \mathrm{E}[p])$$

and set the continuation value to:

$$V_{t+1}(p_k, W', \widetilde{L}') = V_{\text{worst}} - \text{shortfall}, \quad W' < 0$$

This quadratic-in-debt penalty function ensures that small violations of the wealth bound impose modest utility losses, while large violations are heavily discouraged.

To confirm that the quadratic penalty function prevents unrealistic borrowing behavior, we run 2,000 Monte Carlo simulations of the uninsured case, drawing shocks from the stationary distribution of the price process and evolving wealth and loans according to the policy functions. For each simulated history, we record the share of uninsured periods in which the household ends the period with negative wealth. Across simulations, the incidence of negative wealth is extremely rare: fewer than 0.01% of uninsured periods.

A.6.4 Calibration of μ and σ^2

Given $\widehat{\phi}$, the decile-specific mean and variance of prices, $\mathrm{E}[p(t)]$ and $\mathrm{Var}[p(t)]$, uniquely determine the remaining AR(1) parameters μ and σ^2, assuming the cross-sectional distribution of spending reflects the stationary distribution:

$$\begin{aligned}
\mathrm{E}[p(t)] &= \exp\left(\frac{\mu}{1-\widehat{\phi}} + \frac{1}{2}\frac{\sigma^2}{1-\widehat{\phi}^2}\right) \\
\mathrm{Var}[p(t)] &= \exp\left(\frac{2\mu}{1-\widehat{\phi}} + \frac{\sigma^2}{1-\widehat{\phi}^2}\right)\left(\exp\left(\frac{\sigma^2}{1-\widehat{\phi}^2}\right) - 1\right)
\end{aligned}$$

Here are the closed-form solutions:

$$\begin{aligned}
\mu &= (1-\phi)\Big[\ln \mathrm{E}[p(t)] - \tfrac{1}{2}\ln\big(1 + \mathrm{Var}[p(t)]/\mathrm{E}[p(t)]^2\big)\Big] \\
\sigma^2 &= (1-\phi^2)\ln\Big(1 + \tfrac{\mathrm{Var}[p(t)]}{\mathrm{E}[p(t)]^2}\Big)
\end{aligned}$$

B Data

We obtain data on annual medical expenditures from the 1996–2014 Medical Expenditure Panel Survey (MEPS), a nationally representative survey of U.S. households. We define expenditures as all direct payments, including out-of-pocket payments and payments made by private and public health insurers. Each survey has a two-year overlapping panel design, with each panel consisting of five rounds of interviews that take place over two full calendar years. The medical expenditure data are measured at the end of each calendar year, resulting in two measures per individual. We report the medical expenditure data in 2014 dollars using the "Medical care services" consumer price index (CPI). (Income is adjusted using the standard "all-items" index.)

The MEPS also provides us with information on chronic conditions, which are measured using self-reported data from respondents about their health status during each interview round. These self reports are recorded by the interview and then translated into ICD-9-CM codes by professional medical coders. These are then aggregated into 260 mutually exclusive clinical classification categories, which group together similar conditions.[3] For year 1, we define pre-existing conditions as those reported in the round 1 interview. For year 2, we use conditions reported in round 3.

The MEPS clinical classification codes for mental disorders and for alcohol and substance abuse disorders were revised in 2004 and 2007. We therefore group some of these codes together to make them comparable. After this grouping, we are left with 244 distinct clinical classification codes.

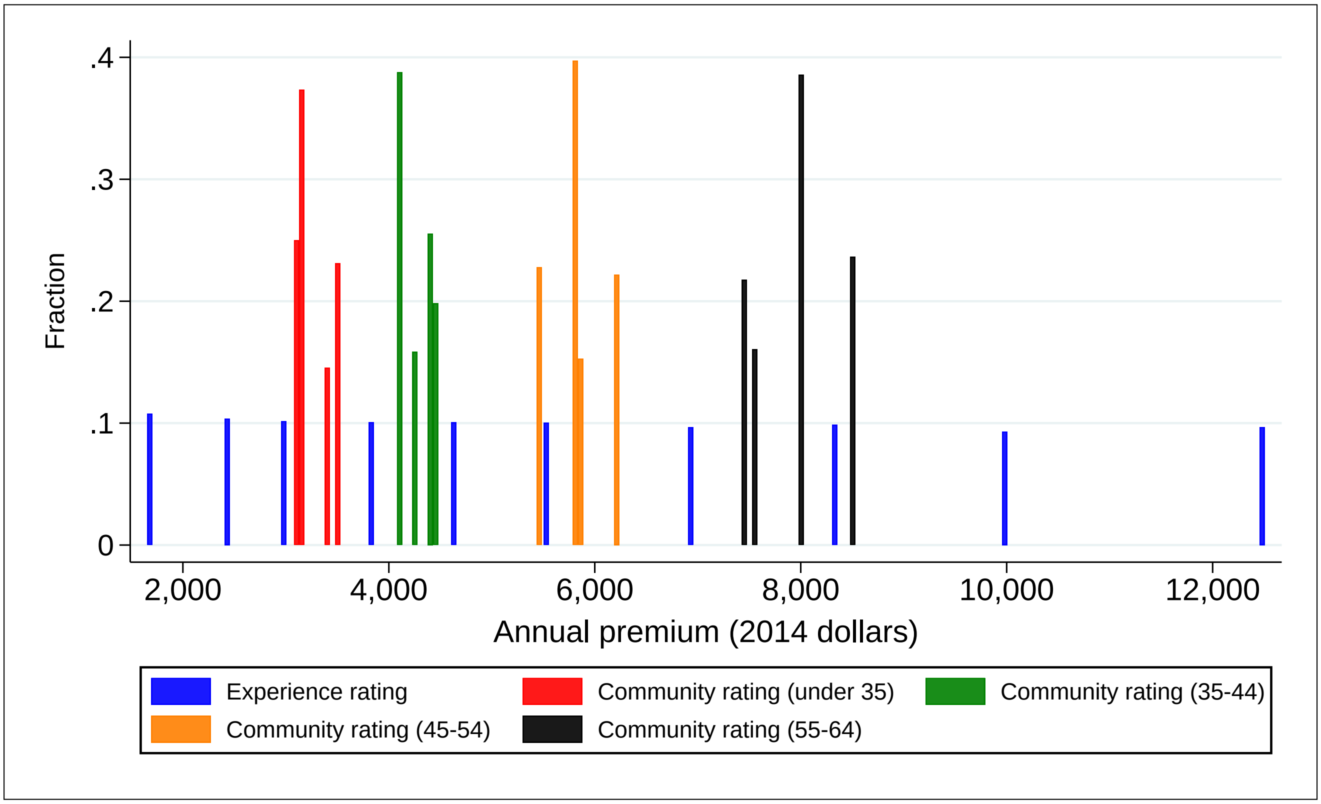
[3]There are 260 categories in the pre-2004 surveys, but this number increases slightly in later years.

We predict medical expenditures at the individual level by estimating the following regression:

$$Y_{it} = f_1(\text{Age}_{it}, \text{Sex}_{it}) + f_2(\text{Region}_{it}) + f_3(\text{Conditions}_{it}) + \epsilon_{it}$$

where Y_{it} is total medical expenditures for individual i in year t. The regression includes indicators for single years of age, an indicator for sex, and all pairwise interactions between sex and age. We also include indicators for four different Census regions. Finally, we include indicators and counts for up to 244 different clinical conditions. The regression is weighted using the MEPS-provided person-level weights. Goodness of fit measures are reported in Table A.2.

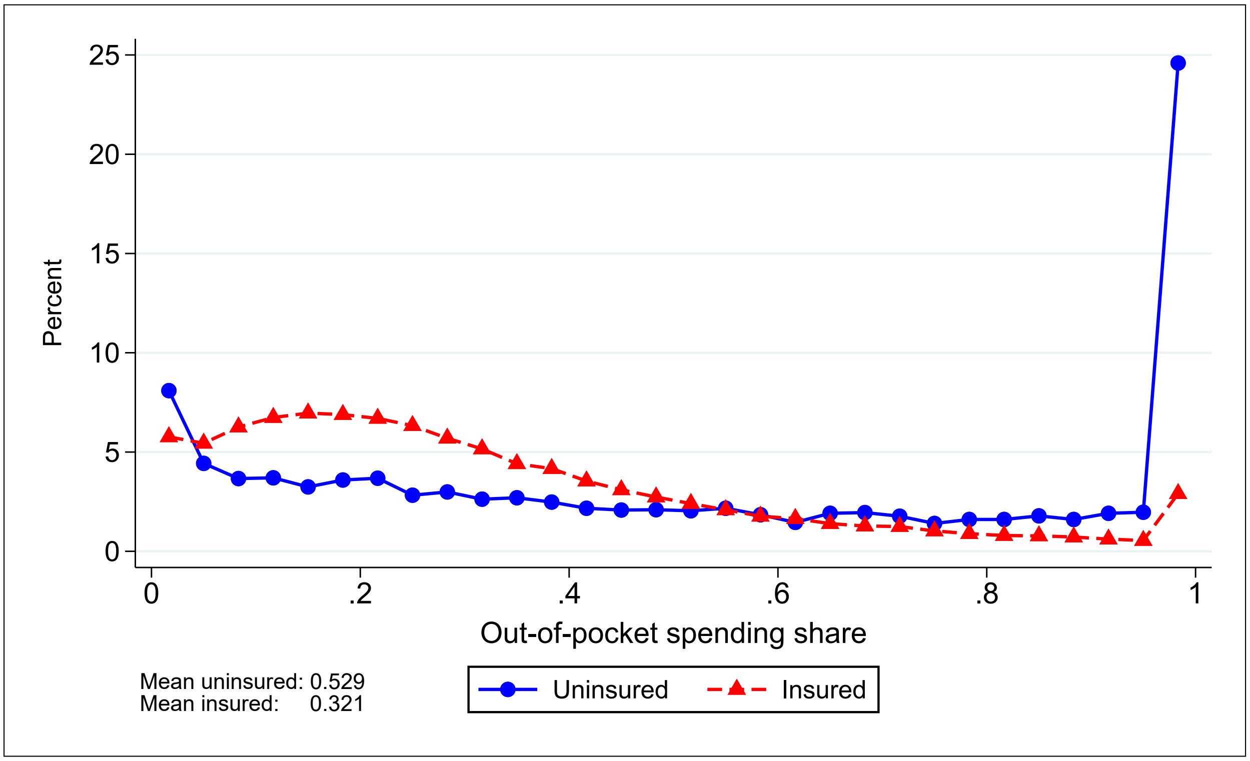
Figure A.1: Experience- and community-rated premiums, households of size 2



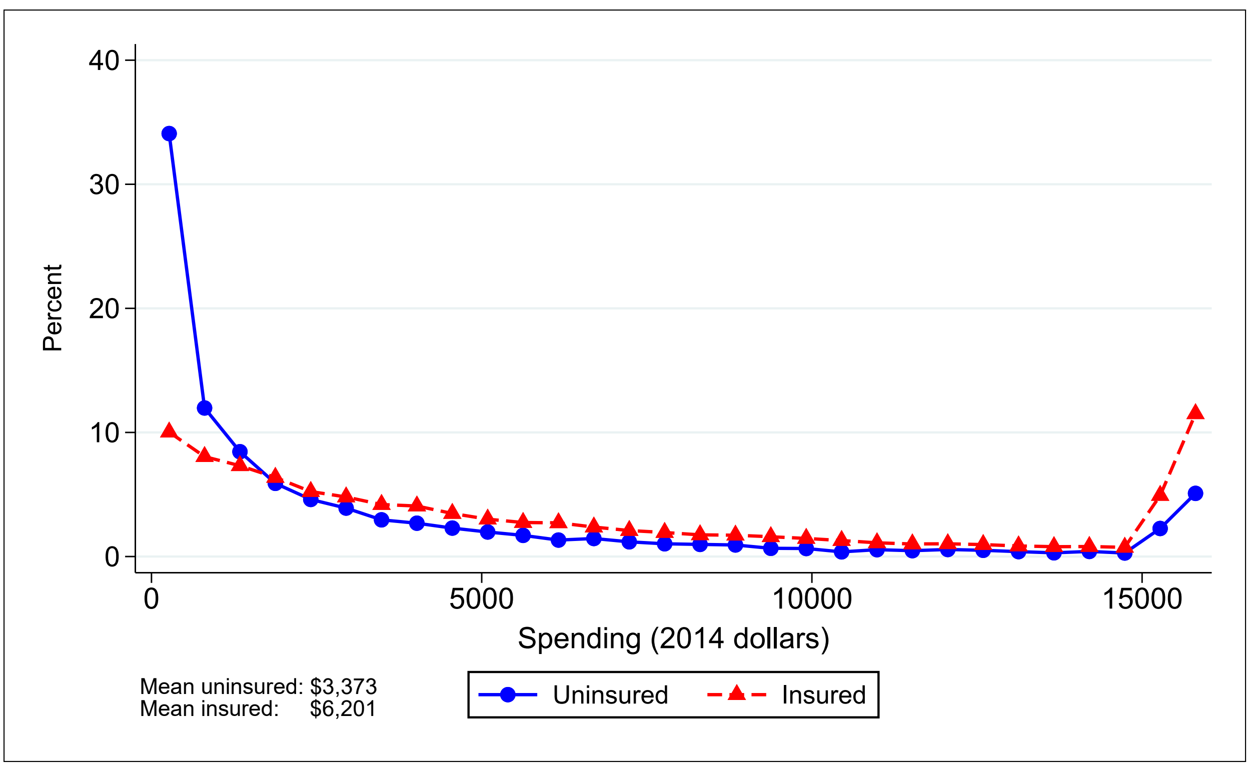
Notes: Experience-rated premiums reflect average spending by predicted spending decile. Community-rated premiums reflect population averages for two-person households, conditional on geographic (Census) region and age group.

Figure A.2: Out-of-pocket and total healthcare spending for two-person households, by insurance status

(a) Out-of-pocket spending share

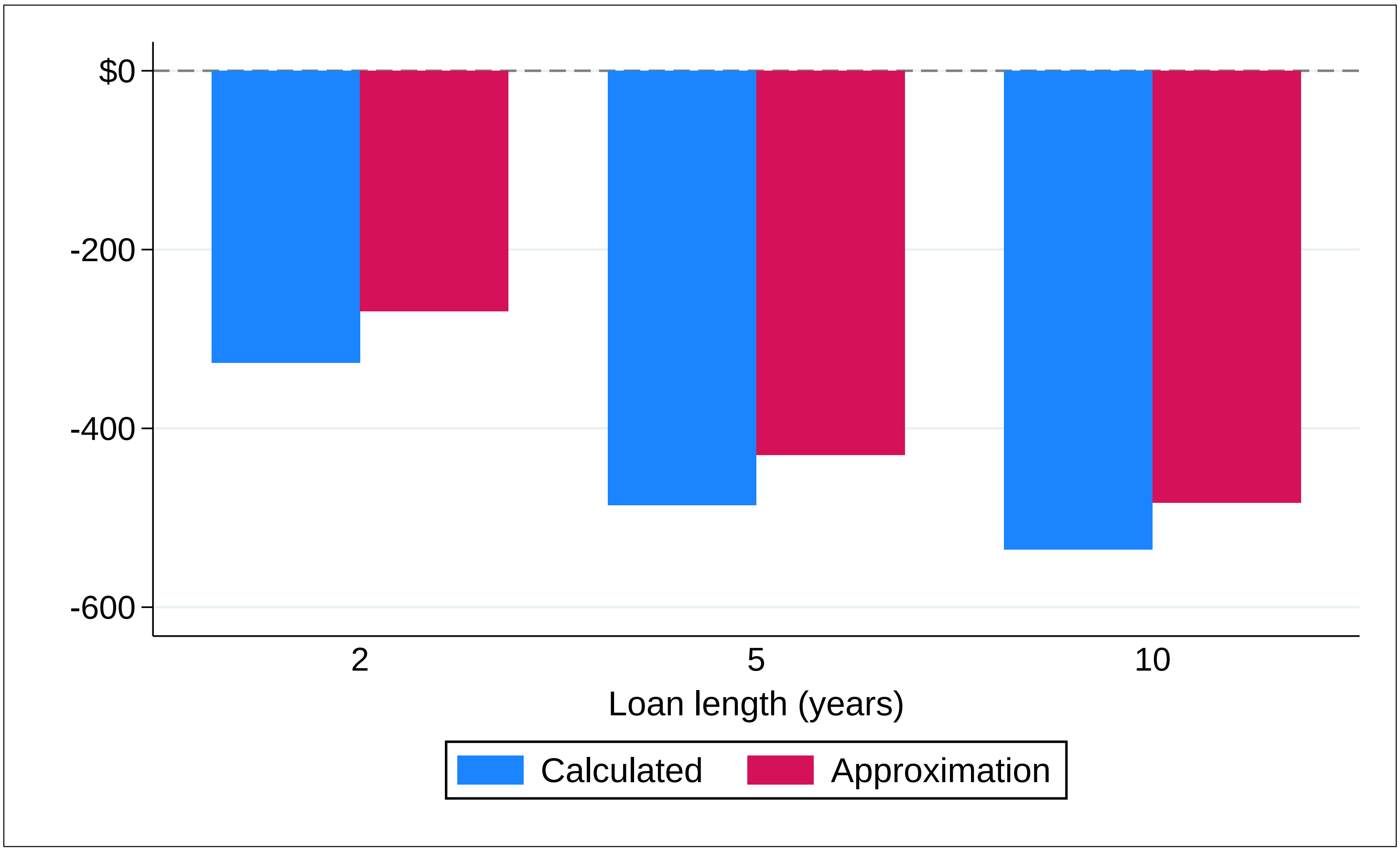


(b) Total healthcare spending



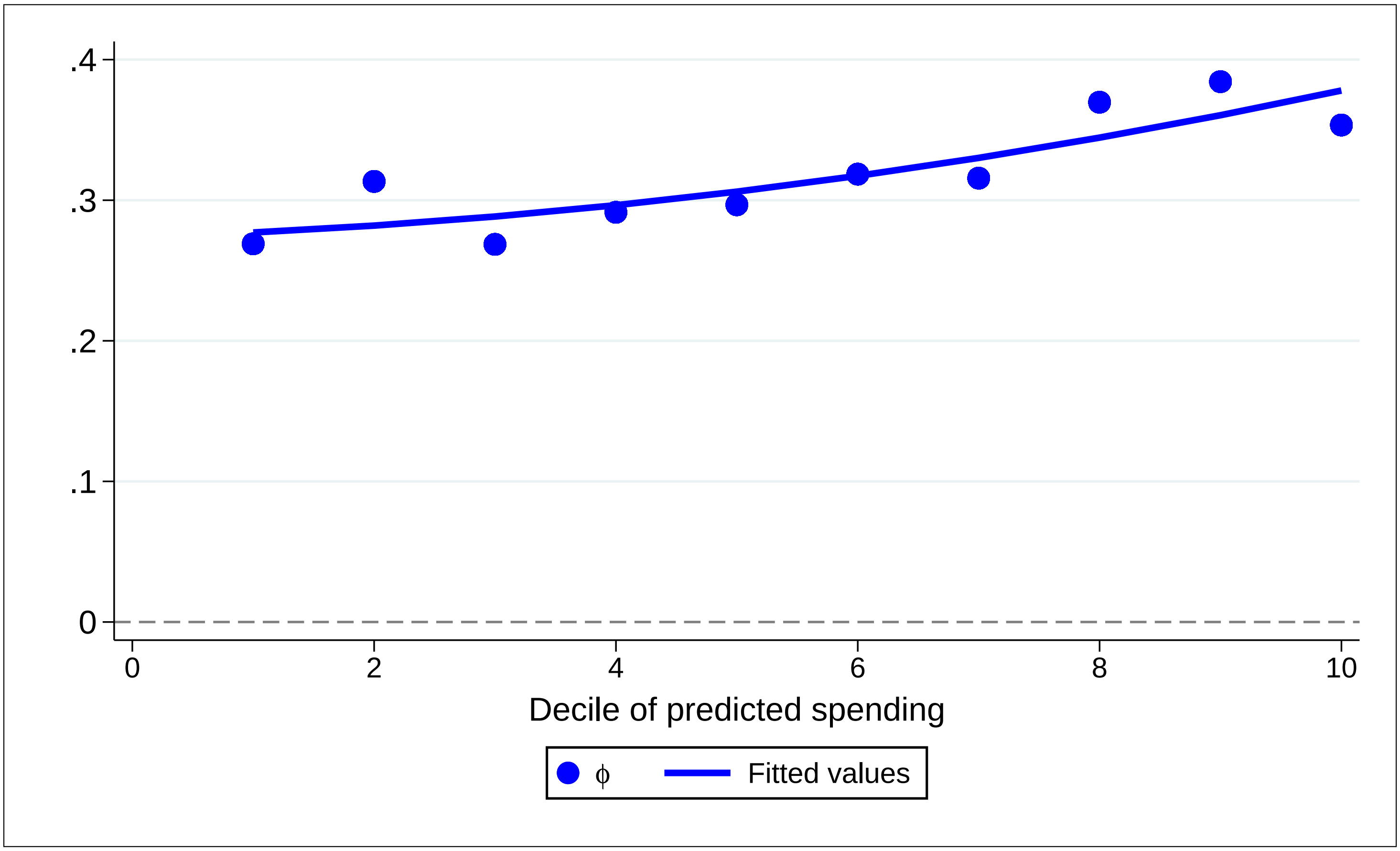
Notes: These figures show distributions of the share of spending paid out-of-pocket and total household health care spending for two-person households. A household is considered uninsured if at least one member lacked public or private health insurance during the year. Panel (a) excludes households with zero healthcare spending.

Figure A.3: The effect of introducing loan markets on the value of insurance, exact and approximate calculations



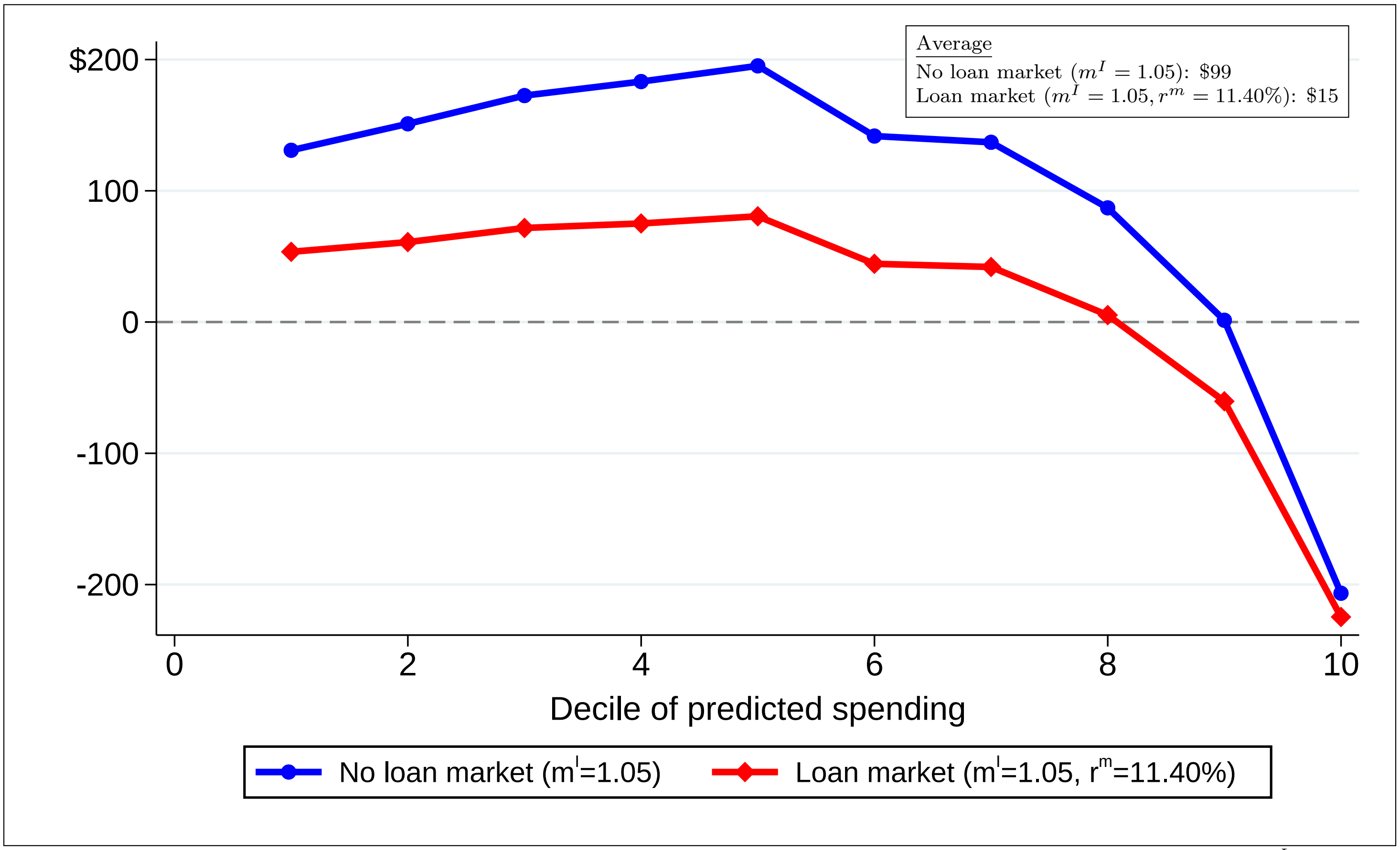
Notes: This figure shows the reduction in the value of actuarially-fair health insurance following the introduction of an actuarially-fair loan market with 2-year, 5-year, or 10-year loans. The blue bars ("Calculated") shows the exact value of the reduction, which is calculated by applying Equation (3) to individual-level data from the Medical Expenditure Panel Survey (MEPS), converting the result into dollars by dividing by the marginal utility of income, and then taking the average across all survey respondents. The red bars ("Approximation") show the Taylor approximation from Equation (4). The Taylor approximation is estimated using only aggregate statistics on the mean and variance of spending in the MEPS sample.

Figure A.4: AR(1) persistence estimates for household medical expenditures



Notes: This figure presents estimates of ϕ from Equation (8) for two-person households. The dependent variable is total healthcare spending.

Figure A.5: The value of experience-rated health insurance, with and without a two-year loan market



Notes: This figure plots the value of health insurance as calculated by Equation (5) for two-person households. "No loan market ($m^I = 1.05$)" allows only health insurance with a 5% markup. "Loan market ($m^I = 1.05, r^m = 11.40\%$)" adds a 2-year loan option with an 11.40% annual interest rate markup (5% loan markup). Experience-rated premiums reflect average spending by predicted spending decile. Initial wealth in the life-cycle model is calibrated so that the average value of "Loan market ($\phi = 0$)" in Figure 4 matches the average value of "Loan market ($m^I = 1.05, r^m = 11.40\%$)" in this figure.

Table A.1: MEPS summary statistics, 1996–2014

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Median	Mean	Std dev	Min	Max	Count
A. Individuals						
Age	33.00	31.88	17.88	0.00	64.00	334,534
Female	0.00	0.49	0.50	0.00	1.00	334,534
Income	24,937	33,933	39,881	–120,108	799,712	334,534
Number of conditions	1.00	1.32	1.68	0.00	27.00	334,534
B. Households						
Family size	2.00	2.46	1.44	1.00	14.00	135,703
Has at least one uninsured person	0.00	0.18	0.39	0.00	1.00	135,703
Income	66,671	82,301	58,200	15,652	904,973	135,703
Medical expenditures	3,206	5,729	6,345	0	50,572	135,703
OOP medical expenditures	767	1,561	2,305	0	32,585	135,703

Notes: This table reports summary statistics for individuals in the Medical Expenditure Panel Survey (MEPS). Incomes and expenditures are in 2014 dollars. Both the individual and the household samples include children. All statistics are weighted except for the count.

Table A.2: Predicting medical expenditures

	(1)	(2)	(3)	(4)
Predictors	Num regressors	Sample size	R^2	Adjusted R^2
Region	4	334,534	0.0006	0.0006
Region, Age	68	334,534	0.0264	0.0262
Region, Age, Sex	69	334,534	0.0281	0.0279
Region, Age $\times$ Sex	133	334,534	0.0300	0.0296
Region, Age $\times$ Sex, CC	376	334,534	0.1644	0.1635
Region, Age $\times$ Sex, CC, count CC	562	334,534	0.1803	0.1789

Note: This table reports goodness of fit measures for six different regressions that predict individual-level annual medical expenditures using the 1996–2014 MEPS datasets. Region predictors include indicators for four different Census regions. Age predictors include indicators for single years of age. "Age×Sex" includes all pairwise interactions between the age and sex indicators. "Age×Sex and CC" adds indicators for the presence of up to 244 different pre-existing chronic conditions. "Age×Sex, CC, and count CC" adds count measures for each chronic condition. Column (1) reports the number of non-collinear regressors in the regression, including the constant term. All regressions employ person-level survey weights.

Table A.3: The effect of accounting for loan markets on the value of health insurance, for alternative insurance markup values

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				Experience rated insurance			Community rated insurance		
Insurance markup (ratio)	Loan markup (ratio)	Loan interest rate markup (%)	Loan length (yrs)	Baseline value (dollars)	Reduction (dollars)	Reduction (%)	Baseline value (dollars)	Reduction (dollars)	Reduction (%)
1.1	0.95	–10.26	2	-195.8	-213.3	-	-5.1	-316.9	-
1.1	0.95	–2.77	5	-195.8	-267.3	-	-5.1	-402.9	-
1.1	0.95	–1.30	10	-195.8	-283.5	-	-5.1	-428.5	-
1.1	1	0	2	-195.8	-131.7	-	-5.1	-216.1	-
1.1	1	0	5	-195.8	-192.1	-	-5.1	-312.4	-
1.1	1	0	10	-195.8	-210.1	-	-5.1	-340.9	-
1.1	1.05	11.40	2	-195.8	-76.8	-	-5.1	-128.2	-
1.1	1.05	2.78	5	-195.8	-135.5	-	-5.1	-224.6	-
1.1	1.05	1.28	10	-195.8	-153.7	-	-5.1	-254.2	-
1.1	1.15	38.49	2	-195.8	-34.1	-	-5.1	-54.4	-
1.1	1.15	8.40	5	-195.8	-79.9	-	-5.1	-130.7	-
1.1	1.15	3.81	10	-195.8	-95.4	-	-5.1	-156.0	-
1.15	0.95	–10.26	2	-486.1	-194.9	-	-301.1	-292.6	-
1.15	0.95	–2.77	5	-486.1	-244.1	-	-301.1	-372.0	-
1.15	0.95	–1.30	10	-486.1	-258.9	-	-301.1	-395.7	-
1.15	1	0	2	-486.1	-120.2	-	-301.1	-198.7	-
1.15	1	0	5	-486.1	-175.3	-	-301.1	-287.7	-
1.15	1	0	10	-486.1	-191.7	-	-301.1	-314.1	-
1.15	1.05	11.40	2	-486.1	-70.2	-	-301.1	-113.2	-
1.15	1.05	2.78	5	-486.1	-123.8	-	-301.1	-200.8	-
1.15	1.05	1.28	10	-486.1	-140.3	-	-301.1	-227.9	-
1.15	1.15	38.49	2	-486.1	-31.3	-	-301.1	-44.6	-
1.15	1.15	8.40	5	-486.1	-73.1	-	-301.1	-111.7	-
1.15	1.15	3.81	10	-486.1	-87.3	-	-301.1	-134.6	-

Notes: This table reports the average value (2014 dollars) of health insurance, $V^{\Delta,L}$, for two-person households. Columns (1) and (2) report the parameter values for insurance and loan markups, m^I and m^L. Column (3) reports the loan annual interest rate markup, r^m, which is a function of the loan markup, m^L, and the consumer rate of time preference, β. Actuarially fair insurance corresponds to $m^I = 1$ and actuarially fair loans correspond to $r^m = 0\%$ (equivalently, $m^L = 1$). Column (4) reports the loan length, n, in years. Community-rated premiums reflect population averages for two-person households, conditional on geographic region and age group. Percentage changes are not reported when the baseline value of insurance is negative.

Table A.4: The annual value of health insurance by decile of predicted spending, with and without serial correlation in spending shocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Decile	y	E[p]	Var[p]	ϕ	μ	σ^2	V^I	$V^{\Delta,L}$
1	69.7	1.54	6.62	0	–0.232	1.330	974.2	197.1
2	82.8	2.31	10.68	0	0.285	1.102	1,257.5	320.7
3	86.2	2.90	13.46	0	0.588	0.954	1,251.4	307.8
4	86.9	3.81	17.05	0	0.948	0.777	922.0	214.6
5	90.0	4.59	19.59	0	1.195	0.658	469.9	110.0
6	95.4	5.48	21.13	0	1.434	0.533	168.2	–70.5
7	94.5	6.74	24.46	0	1.694	0.430	81.6	–122.2
8	97.1	8.15	26.17	0	1.933	0.332	–57.8	–186.9
9	95.6	9.80	25.40	0	2.165	0.235	–205.1	–264.2
10	87.1	12.38	20.15	0	2.455	0.123	–364.3	–373.3
1	69.7	1.54	6.62	0.277	–0.168	1.228	1,539.3	409.3
2	82.8	2.31	10.68	0.282	0.204	1.014	1,702.3	627.6
3	86.2	2.90	13.46	0.288	0.419	0.875	1,494.9	615.9
4	86.9	3.81	17.05	0.296	0.667	0.709	1,055.7	471.5
5	90.0	4.59	19.59	0.306	0.829	0.596	535.0	302.5
6	95.4	5.48	21.13	0.317	0.979	0.479	213.3	–26.4
7	94.5	6.74	24.46	0.330	1.134	0.383	134.0	–75.5
8	97.1	8.15	26.17	0.345	1.267	0.293	–2.2	–144.5
9	95.6	9.80	25.40	0.360	1.384	0.204	–153.4	–228.0
10	87.1	12.38	20.15	0.378	1.527	0.106	–330.0	–347.5

Notes: Units for y (average income) and E[p] (average spending) are thousands of dollars. Values of V^I (value of insurance), and $V^{\Delta,L}$ (incremental value of insurance with loan markets) are reported in dollars. Both measures were normalized using the marginal utility of income, as described in Equation (10). The parameters ϕ (which governs serial correlation), μ, and σ^2 are described by Equation (8) and calibrated using data from MEPS as detailed in Appendix A.6.4. Columns (7)–(8) report the estimates shown in Figure 4.

Table A.5: Parameter values and sources for the life-cycle model calibration

(1)	(2)	(3)	(4)
Parameter	Description	Value	Literature/data sources
γ	Coefficient of relative risk aversion	2	Its value is conventionally set below 2 (Chetty, 2009). We select a conservative (higher) value that raises the value of insurance.
β	Rate of time preference	0.95	0.95 is a common value for annual periods (e.g., Chien, Cole and Lustig, 2011).
m^I	Insurance markup	1.05	See discussion in Section 4.2.
r^m	Loan interest rate markup	0.114	This value is equivalent to a loan markup of $m^L = 1.05$ (see Section 3.1).
W_1	Initial wealth	\$70,000	Calibrated so that the incremental value of insurance in the no-serial-correlation loan-market scenario from the life-cycle model matches the corresponding average from the one-period model.
L_0	Initial (pre-existing) loans	\$0	
N_w	Number of grid points for wealth	250	
N_c	Number of grid points for consumption	200	
N_p	Number of grid points for price shocks	10	
N_L	Number of grid points for the loan state	5	
m	The half-width (in standard deviations) of the price grid	4	

Notes: This table displays the parameter values used in the life-cycle model described in Section 5.1 and Appendix A.6.