# Financial Literacy and Precautionary Insurance*

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**Abstract**

We study insurance markets with individuals that have limited financial literacy. In our model, complexity of insurance contracts causes individuals to be uncertain about insurance payouts. As a result, a trade-off between second-order (risk aversion) and third-order (prudence) risk preferences drives insurance demand. Very prudent individuals desire more insurance coverage when contract complexity increases, while the effect is reversed for less prudent individuals. We characterize the competitive market equilibrium with complex contracts when firms can exert costly effort to reduce complexity. Based on the equilibrium analysis, we propose a monetary measure for the welfare cost of financial illiteracy and show that it is mainly driven by risk aversion. We conclude with a discussion about implications for policy interventions and consumer protection.

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**Keywords:** Financial literacy, insurance demand, prudence, precautionary insurance.

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# 1 Introduction

Insurance is the main financial product that households use for risk management – across different levels of education, income, and other socioeconomic factors (TNS opinion & social (2016), Berchick et al. (2018)). However, it is difficult for consumers to completely understand insurance contracts.[1] This non-comprehension of insurance is likely driven by a combination of limited financial literacy of consumers and the complexity of insurance contracts.[2] In this paper, we develop a theoretical model that sheds light on the interaction between equilibrium insurance take-up and prices, consumers' financial literacy and risk attitudes, and insurance contracts' complexity.

In our model, financially illiterate (but otherwise rational) consumers do not fully understand the terms of offered insurance contracts and, as a result, face uncertainty about the insurance payout in case of losses. For example, individuals may be uncertain which specific losses are covered by a given contract. A prime example are health insurance plans available at U.S. health exchanges: individuals are informed about prices and average indemnity payments; yet, the actual percentage of reimbursed claims can widely vary depending on treated conditions and medical providers.[3]

First, in a partial equilibrium analysis, we show that the effect of contract complexity on illiterate consumers' insurance demand is driven by third-order risk attitudes, namely prudence. Very prudent consumers demand more insurance when facing more complex insurance contracts, a behavior often called *precautionary insurance* (e.g., by Eeckhoudt and Kimball (1992)). We derive conditions for the existence of *precautionary insurance*, which depend on the level of prudence as well as the level of contract complexity. Specifically, we show that financial illiteracy can result in inefficiently large insurance coverage. This result is consistent

[1] Nelson et al. (2000), Policygenius (2016), The Guardian Life Insurance Company of America (2017), and Fairer Finance (2018) review surveys that show that insurance policyholders rarely understand the terms of their contracts. Gaurav et al. (2011) and Cole et al. (2013) find a positive correlation between financial literacy and demand for rainfall insurance in a field experiment in rural India. In a lab experiment, Bateman et al. (2016) find that cognitive abilities are important determinants for insurance decisions. Cogan (2010, p. 2009f.) argues that "consumers do not fully grasp their health insurance coverage because the jargon found in many health insurance contracts is impenetrable to most Americans."

[2] Lusardi and Mitchell (2011, 2014) and Girolamo et al. (2015) provide empirical evidence for substantial variation in financial literacy with an overall low level across different subject populations.

[3] Average indemnity payments depend on the "metal" level, which ranges from Bronze to Platinum, where Bronze plans pay 60% of expected health costs while Platinum plans pay 90% of expected costs, on average.

with Harrison et al. (2020)'s finding that welfare-reducing insurance decisions by financial illiterate individuals often result from *too much*–and not too low–insurance take-up.

Second, we extend the model to a competitive market equilibrium by allowing firms to engage in costly effort that reduces the complexity of insurance contracts. This exercise highlights a simple but important difference between the effects of consumers' financial literacy and of contract complexity: in a frictionless competitive equilibrium, policy interventions that alter the level of contract complexity are not welfare-increasing since firms' marginal effort cost of reducing complexity offsets consumers' marginal utility gain from lower complexity in equilibrium. In contrast, interventions that increase the level of financial literacy may increase welfare since they (1) reduce consumers' uncertainty about product payout and, thereby, (2) allow them to make better decisions.

Third, we build on the equilibrium analysis to provide a novel measure for the welfare-impact of financial illiteracy, the *financial illiteracy premium*. This measure computes the maximum amount that a social planner would be willing to pay to eliminate financial illiteracy. Importantly, the *financial illiteracy premium* accounts for changes in the market equilibrium in response to changes in the level of consumers' financial literacy. This approach is not constrained to the insurance market but widely applicable, for example to estimate the cost of financial illiteracy in experiments or surveys. It is thus helpful beyond its purpose in our theoretical measure. We provide comparative statics of the premium and show that its key driver is risk aversion since more risk averse consumers are more exposed to changes in their uncertainty about insurance contract payouts. We conclude with a discussion about possible policy interventions that aim to reduce the welfare cost of financial illiteracy.

This paper contributes mainly to three lines of research. First, we contribute to studies on the effect of financial literacy in insurance markets. To the best of our knowledge, our paper is the first to present a theoretical analysis on this topic. Compared to other financial products, insurance is particularly relevant from a policy perspective since it concerns the vast majority of the population – regardless of income and education. For instance, more than 70% of U.S. consumers were covered by health insurance in 2017, regardless of their educational attainment (Berchick et al. (2018)).[4] Other studies on insurance and financial literacy either conduct field (Gaurav et al. (2011), Cole et al. (2013), Hill et al. (2016)) or

[4]For example, Berchick et al. (2018) report that 74% of consumers without a high school diploma were covered by health insurance. Penetration was larger for those with high school diploma, an associate's, bachelor's, graduate, or professional degree. More than half of each of these groups' coverage was provided in the private market.

laboratory experiments (Harrison et al. (2020)). Interestingly, Harrison et al. (2020) find that the welfare-effect of insurance decisions positively correlates with financial literacy, and that welfare-reducing decisions typically result from *too much* insurance take-up, i.e., overinsurance. This is consistent with the prediction of our model for sufficiently prudent individuals.

Second, we add to a growing literature that incorporates financial literacy in models of financial decision-marking. Previous studies by Jappelli and Padula (2013), Kim et al. (2016), Neumuller and Rothschild (2017), and Lusardi et al. (2017) focus on investment choices in partial equilibrium with fixed supply, which we extend by our focus on insurance contracts and with a general equilibrium analysis. Several studies incorporate limited financial literacy as a specific bias.[5] Other studies directly assumed that literacy increases expected income (e.., Lusardi et al. (2017)). Our approach complements these studies by introducing uncertainty as a channel for (limited) financial literacy to affect decision-making. We argue that, because consumers only partially process existing information (e.g., the fine-print of insurance contracts), they are left uncertain about a product's final payout. Due to this channel, there is an important interaction between risk attitudes and financial (il-)literacy in our model.

Although consumers dis-like complexity, firms offer complex contracts in our model because it is costly to reduce complexity, e.g., due to preparing additional explanatory materials.[6] This differs, e.g., from Oehmke and Zawadowski (2019)'s model, in which complexity is costly since it requires consumers' attention, while complexity is also beneficial since it enables customization. This set-up is arguably realistic in markets with sophisticated participants (e.g., derivatives markets). Instead, we focus on the case where consumers are not sufficiently sophisticated to understand – and to value – complex contracts, which appears to be an accurate description of most retail insurance markets.

Third, our modeling of contract complexity builds on the literature of decision-making under uncertainty, specifically when insurance contract payouts are risky. Traditionally, studies have focused on nonperformance risk of insurance contracts (e.g., Doherty and Schlesinger (1990), Briys et al. (1991), Wakker et al. (1997), and Zimmer et al. (2018)). In contrast to nonperformance risk, contract complexity does not have a wealth-effect, i.e., larger complexity does

[5]For example, unsophisticated consumers in Carlin (2009) choose randomly among products, and in Gabaix and Laibson (2006) they neglect information about product add-ons and their prices.

[6]In our model, there is no possibility for firms to exploit the unsophistication of consumers. Possible extensions of our model could take this into account, e.g., by allowing firms to engage in opaque pricing (as in the models of DellaVigna and Malmendier (2004), Gabaix and Laibson (2006), Carlin (2009), Anagol and Kim (2012), and Campbell (2016)).

not reduce the insurance contract's *expected* payout but only increases *uncertainty* about the payout. Therefore, the effect of contract complexity on insurance demand differs from that of nonperformance risk.[7] It also differs from models with additive background risk (e.g., Doherty and Schlesinger (1983), Eeckhoudt and Kimball (1992), Fei and Schlesinger (2008)) since the uncertainty from contract complexity is multiplicative to the (endogenous) level of insurance. Similar to indemnity uncertainty in Lee (2012), the presence of contract complexity implies that partial insurance coverage is optimal when consumers exhibit low levels of prudence and prices are actuarially fair. We significantly generalize this result in several dimensions as we derive (1) comparative statistics of insurance demand with respect to contract complexity, (2) the critical level of prudence such that more (less) prudent individuals increase (decrease) insurance coverage upon an increase in contract complexity, and (3) the critical level of contract complexity such that a further increase in complexity reduces insurance demand regardless of prudence. Finally, we extend the previously mentioned studies by endogenizing the level of contract complexity in competitive equilibrium.

The remainder of this article is organized as follows. Section 2 introduces and examines a partial equilibrium model for insurance demand. In Section 3, we endogenize the level of contract complexity in competitive equilibrium and propose a new measure for the welfare cost of financial illiteracy. The final section concludes. Proofs are provided in the Appendix.

# 2 A Model of Contract Complexity and Insurance Demand

## 2.1 Model

Individuals are endowed with initial wealth $w_0 > 0$ and face the risk of a loss $L$, $0 < L < w_0$. The loss occurs with probability $p \in (0,1)$. Individuals are risk averse with a thrice differentiable and concave standard utility function $u(\cdot)$, $u'(\cdot) > 0$ and $u''(\cdot) < 0$. Firms offer co-insurance contracts and have financial resources such that they are willing and able to sell any number of contracts that they think will make non-negative expected profit. Co-insurance contracts pay indemnity $\tilde{I}$ per unit price conditional on a loss, and zero otherwise. Individuals

[7] In Appendix B we show that the set of payout distributions under contract complexity differs substantially from that with contract nonperformance. Moreover, our model provides unambiguous comparative statics with respect to contract complexity, while the comparative static of insurance demand with respect to contract nonperformance is typically ambiguous (e.g., Doherty and Schlesinger (1990)).

pay the premium \$$\alpha$ and receive the indemnity payment \$$\alpha\tilde{I}$ in case of a loss, where $\alpha \geq 0$ is the chosen insurance coverage.

Our model introduces *uncertainty* about the indemnity as a channel for contract complexity and financial illiteracy to affect decision-making: the less individuals understand an insurance contract (e.g., about the losses covered), the more uncertain they are about the indemnity payment.[8] Accordingly, we assume that individuals form subjective beliefs about the indemnity payment $\tilde{I}$, where $\tilde{I}$ is a non-negative random variable. We assume that individuals' beliefs are parameterized by $\tilde{I} = I + \tilde{\vartheta}$, where $I > 0$ is the expected payout and $\tilde{\vartheta}$ a mean-zero risk, $\mathbb{E}[\tilde{\vartheta}] = 0$.

Individuals' beliefs about the indemnity $\tilde{I}$ are conditional on the individuals' imperfect perception of the insurance contract and, thus, may be biased. For example, the contract might actually pay $I^* > 0$, while individuals expect it to pay $\mathbb{E}[\tilde{I}] = I = I^*(1 + \lambda)$, where $\lambda > -1$. We only require that $I$ is sufficiently large to result in positive insurance demand and, in particular, that $I > 1$, implying that individuals expect to receive more than \$1 (in case of a loss) per \$1 premium paid.[9] We will make the stronger assumption that expectations are consistent in expectation with contract terms, $I = I^* > 0$, in the general equilibrium analysis in Section 3.

For simplicity, we assume a symmetric binary distribution of beliefs about $\tilde{I}$.[10] Without loss of generality, we parameterize $\tilde{I} = I + \tilde{\vartheta}$ with $I > 1$ and $\mathbb{P}(\tilde{\vartheta} = \varepsilon) = \mathbb{P}(\tilde{\vartheta} = -\varepsilon) = 1/2$, $\varepsilon \geq 0$. Consistent with this assumption of symmetric beliefs, Girolamo et al. (2015) find that individuals often have symmetrically distributed beliefs about the correct answer to questions about financial and economic knowledge.[11] We call $\varepsilon$ the experienced *contract complexity* and

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[8] This interpretation of financial literacy is consistent with Girolamo et al. (2015)'s notion of financial literacy as the *precision* of "subjective beliefs that someone has over possible responses to some question" (Girolamo et al. (2015, p.1)). Accordingly, individuals form beliefs about the payout of their insurance contract while being aware that actual payouts from their contract include a random component. Complexity of contract language and exposition, low cognitive abilities, and imperfect knowledge of insurance terms blur individuals' belief about the contract payout.

[9] It is straightforward to show that optimal insurance coverage is positive if $I > 1 + \frac{1-p}{p} \frac{u'(w_0)}{u'(w_0 - L)} > 1$.

[10] To alleviate concerns about the restrictiveness of the assumption of a binary distribution for $\tilde{I}$, Appendix C shows that our main results also hold for more general distributions.

[11] Due to symmetry, an increase in $\varepsilon$ is a mean-preserving increase in uncertainty about the indemnity payment in the sense of Rothschild and Stiglitz (1970). The model is easily extended to allow for non-symmetric, biased risk $\tilde{\vartheta}$, e.g., by reducing the probability of the "good" state with payment $\alpha(I+\varepsilon)$. Importantly, imposing a bias $\mathbb{E}[\tilde{\vartheta}] \neq 0$ will induce a wealth effect on top of the risk effect of complexity. For example, $\mathbb{E}[\tilde{\vartheta}] < 0$ biases insurance demand toward zero, everything else equal.

assume that it is inversely related to the ease with which individuals understand an insurance contract (and accompanying explanatory material).

Throughout the paper, we treat the uncertainty $\tilde{\vartheta}$ caused by contract complexity as a behavioral bias of individuals with limited financial literacy, explicitly allowing for individuals' beliefs to be inconsistent with the ex post realization of contract payouts.[12] It would be straightforward to rationalize beliefs, e.g., by assuming that there is random interpretation of terms by claims adjusters or courts, or that the contract available to individuals is randomly drawn ex-ante from a large set of contracts (with different $\varepsilon$ and indemnity payments) and is unobservable for individuals.

In this section, we fix $I$ and vary the experienced contract complexity $\varepsilon$ to assess its effect on insurance demand. In Section 3, we split experienced complexity into a contract's *actual* complexity $\nu$, reflecting the (inverse of the) accessibility of the contract and explanatory material (such as the use of simple language or explanatory figures), and individuals' financial illiteracy $\beta$, namely the (inverse of the) ease at which individuals understand financial (and insurance-related) information in general (e.g., their cognitive abilities), such that $\varepsilon = \beta \times \nu$.

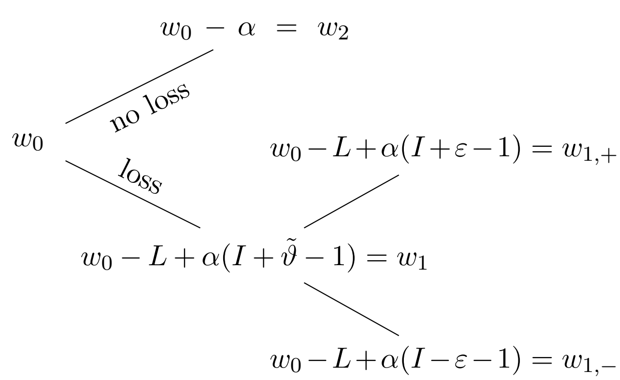



Figure 1: Distribution of individuals' wealth.

Figures 1 and 2 illustrate the resulting distribution of individuals' wealth. Note that the analysis of insurance demand is from individuals' perspective, i.e., conditional on their beliefs about $\tilde{I}$. Upon purchasing $\alpha$ units of insurance, individuals pay the premium \$$\alpha$. Without contract complexity ($\varepsilon = 0$), individuals receive the indemnity payment \$$\alpha I$ with certainty

[12] At the same time, individuals are aware that they face uncertainty about the indemnity payout, i.e. they are not completely myopic. Many studies provide evidence that behavioral biases and heuristics affect insurance decisions, e.g., affection (Hsee and Kunreuther (2000)), heuristic thinking (Jaspersen and Aseervatham (2017)).

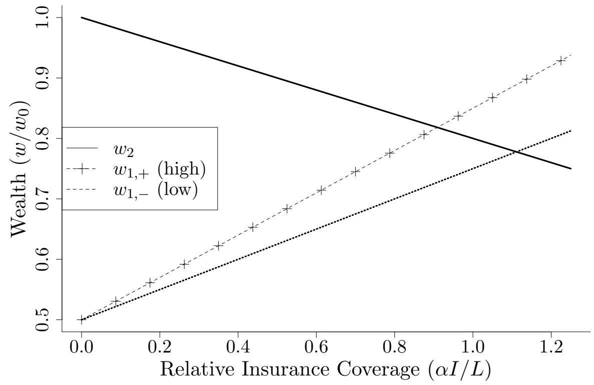



Figure 2: States of wealth for fixed coverage.
Distribution of individuals' wealth with changing level of relative insurance coverage $\alpha I/L$ (which is the expected relative payment in case of a loss) for expected unit indemnity payment $I = 2.5$ and fixed complexity $\varepsilon = 0.1 \times I = 0.25$, implying a relative premium loading on the actuarially fair price of $\frac{1-pI}{pI} = 1/3$.

in the loss state. Otherwise ($\varepsilon > 0$), individuals face uncertainty about the actual indemnity payment and (belief to) receive either \$$\alpha(I + \varepsilon)$ or \$$\alpha(I - \varepsilon)$ in case the loss occurs.[13]

The fact that individuals assign a positive probability to receiving *more* than $I$ does not necessarily imply that the insurance payment in this "good" state exceeds the actual loss, i.e., that $\alpha(I + \varepsilon) > L$. Insurance companies might in fact restrict insurance payments to not exceed $L$ and individuals may be aware of that. In this case, individuals would maximize expected utility over $\alpha \in [0, L/(I + \varepsilon)]$. In the following, we will let individuals choose among unbounded insurance take-up to shed light on the *demand* for complex insurance contracts in general. Since expected utility will be strictly concave in $\alpha$, utility-maximizing coverage $\alpha^* > L/(I + \varepsilon)$ will simply imply that individuals demand the highest possible coverage up to $\alpha^*$.

[13]Note that this model of insurance contracts is different from contracts with nonperformance risk, as we show in Appendix B.

## 2.2 Insurance Demand

Upon the purchase of $\alpha$ units of insurance, an individual's expected utility is given by

$$EU(\alpha,\varepsilon,I) = p\mathbb{E}[u(\underbrace{w_0 - L + \alpha(I+\tilde{\vartheta}-1)}_{=w_1})] + (1-p)u(\underbrace{w_0-\alpha}_{=w_2}) \tag{1}$$
$$= \frac{p}{2}\Big(u(\underbrace{w_0 - L + \alpha(I+\varepsilon-1)}_{=w_{1,+}}) + u(\underbrace{w_0 - L + \alpha(I-\varepsilon-1)}_{=w_{1,-}})\Big) + (1-p)u(\underbrace{w_0-\alpha}_{=w_2}),$$

where we denote state-dependent utilities by $u_x = u(w_x)$, $u'_x = u'(w_x)$, $u''_x = u''(w_x)$, $u'''_x = u'''(w_x)$ with $x \in \{1;\ 1,-;\ 1,+;\ 2\}$.

Without contract complexity, our model collapses into the standard model for insurance demand as in Mossin (1968) and Doherty (1975). The first-order condition (FOC) then equals

$$(I-1)u'_1 = \frac{1-p}{p}u'_2, \tag{2}$$

and full insurance ($\alpha I = L$) is optimal if the premium is perceived as actuarially fair, i.e., if $1 = pI$, implying $I - 1 = \frac{1-p}{p}$ and thus $u'_1 = u'_2$ by the FOC. This standard result is often referred to as *Mossin's Theorem*. Partial insurance ($\alpha I < L$) is optimal with a positive proportional premium loading, i.e., if $pI < 1$, implying $I - 1 < \frac{1-p}{p}$ and thus $u'_1 > u'_2$.

Insurance demand changes with the introduction of contract complexity. If $\varepsilon > 0$, the insurance payout becomes uncertain itself, increasing an individual's risk in the loss state upon purchasing insurance (see Figure 2). With contract complexity, the FOC does not only depend on marginal utility in the loss and no-loss states, but also on differential marginal utility within the loss state:

$$\underbrace{(I-1)\mathbb{E}[u'_1]}_{\text{(I)}} - \underbrace{\varepsilon\frac{u'_{1,-}-u'_{1,+}}{2}}_{\text{(II)}} = \frac{1-p}{p}u'_2. \tag{3}$$

Larger contract complexity does not affect marginal utility in the no-loss state $u'_2$, where no indemnity is paid. Instead, complexity raises (II) the differential marginal utility in the loss state, $u'_{1,-} - u'_{1,+}$, since $u''(\cdot) < 0$, reflecting that insurance is less valuable with higher contract complexity. It also raises (I) the expected marginal utility in the loss state if marginal utility is convex. Since $u'_2$ is increasing with insurance coverage, contract complexity then results in a trade-off between (I) more and (II) less insurance coverage to reduce (I) risk across the loss and no-loss state and (II) risk within the loss state. As a result, introducing contract complexity implies that *Mossin's Theorem* may not hold any more. The ultimate effect depends on the convexity of marginal utility.

Following Kimball (1990), we call individuals with convex marginal utility (i.e., with $u''' > 0$) *prudent*. Eeckhoudt et al. (1995) and Eeckhoudt and Schlesinger (2006) show that prudent individuals are characterized by a preference for attaching a mean-preserving risk to the best outcomes of a lottery rather than to the worst ones. Similar to the rationale of precautionary saving developed by Rothschild and Stiglitz (1971) and Kimball (1990), complexity can have two effects on insurance demand: on the one hand, uncertain payouts make insurance less effective in mitigating overall risk, which might reduce insurance demand for risk-averse individuals. On the other hand, insurance transfers the payout risk to higher wealth levels and, thus, prudent individuals might want to insure more as a response to increased risk. The final effect depends on the degree of prudence as well as the level of contract complexity, as the following lemma shows.

**Lemma 2.1** (Insurance demand)**.** *Let $I > 1$.*

*(1) If individuals are not prudent ($u'''(\cdot) \leq 0$), optimal insurance coverage decreases with the level of contract complexity $\varepsilon$.*

*(2) For all $\varepsilon < I - 1$, optimal insurance coverage increases with $\varepsilon$ if, and only if,*

$$-\frac{\bar{u}_1'''}{\bar{u}_1''} > \frac{1 - \alpha\varepsilon \frac{u''_{1,+} + u''_{1,-}}{u'_{1,-} - u'_{1,+}}}{\alpha(I - 1)} \tag{4}$$

*in equilibrium, where $\bar{u}_1''' = \frac{u''_{1,-} - u''_{1,+}}{w_{1,-} - w_{1,+}}$ and $\bar{u}_1'' = \frac{u'_{1,-} - u'_{1,+}}{w_{1,-} - w_{1,+}}$. If $\varepsilon \geq I - 1$, optimal insurance coverage decreases with $\varepsilon$.*

The following corollary shows that condition (4) can be transformed into a condition for the coefficient of absolute prudence, $PR = -\frac{u'''}{u''}$ (as introduced by Kimball (1990)). If prudence is sufficiently large and $\varepsilon < I - 1$, optimal insurance coverage increases with the level of complexity:

**Corollary 2.1** (Precautionary insurance)**.** *Let $I > 1$, $\varepsilon < I - 1$, and $u''' > 0$. If*

$$-\frac{\bar{u}_1'''}{u''_{1,-}} > \frac{2}{\alpha(I - 1)} \tag{5}$$

*in equilibrium, optimal insurance coverage increases with the level of complexity* $\varepsilon$*, where* $\bar{u}_1''' = \frac{u''_{1,-} - u''_{1,+}}{w_{1,-} - w_{1,+}}$ *is the average slope of* $u''$ *in the loss state.*

The corollary finds that precautionary insurance is driven by the average curvature relative to the slope of marginal utility in the loss state. Since $-\frac{\bar{u}_1'''}{u''_{1,-}}$ is increasing with the coefficient of absolute prudence $PR$ for $w \in [w_{1,-}, w_{1,+}]$, prudence indeed drives precautionary insurance.[14]

While Lemma 2.1 and Corollary 2.1 are for binary indemnity risk, in Appendix C we generalize the results and show that optimal insurance coverage increases with a mean-preserving increase (á la Rothschild and Stiglitz (1971)) of arbitrarily distributed indemnity uncertainty if individuals are sufficiently prudent.

Corollary 2.1 also implies that individuals' marginal willingness to pay for an increase in coverage (i.e., the marginal rate of substitution between price and coverage) increases with contract complexity if individuals are sufficiently prudent and $\varepsilon < I - 1$.[15] In this case, less financially literate individuals buy more insurance coverage in competitive equilibrium (with symmetric information) if insurance prices are linear in insurance coverage.

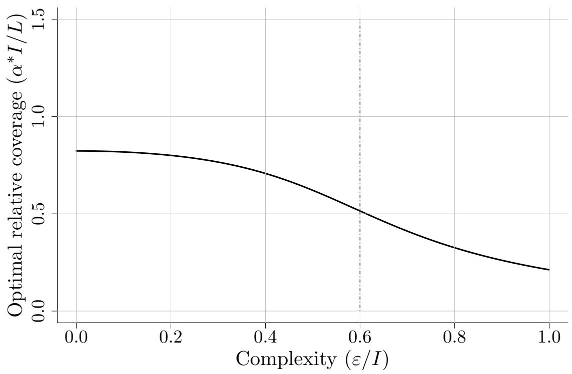
**Corollary 2.2.** *Define contracts in coverage-price* ($\alpha - P$) *space, where the indemnity is* $\alpha I$ *for fixed* $I > 1$*. If individuals are sufficiently prudent and* $\varepsilon < I - 1$*, the marginal rate of substitution between price and coverage along indifference curves in* $\alpha - P$*-space increases with* $\varepsilon$ *for every coverage-price pair.*

To illustrate our findings, assume that individuals maximize exponential utility with constant absolute risk aversion. Exponential utility allows for a straightforward assessment of individuals' degree of prudence since then the coefficient of absolute risk aversion $ARA$ equals the coefficient of absolute prudence.[16] As illustrated in Figure 3, we show the existence of two opposing effects of contract complexity: on one hand, an increase in complexity reduces optimal insurance coverage with low prudence, as illustrated in Figure 3 (a). Hence, a relatively

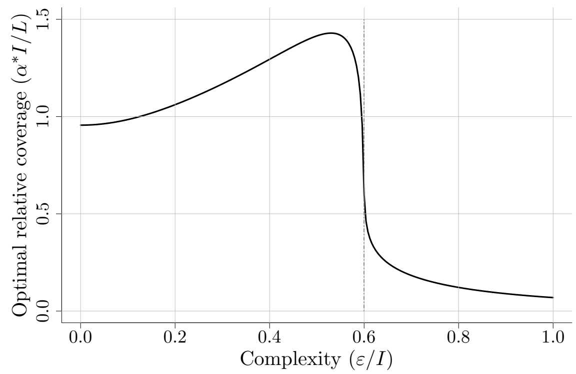
[14] Note that a larger degree of prudence also changes the shape of the utility function and therefore the equilibrium allocation. Conditions (4) and (5) must hold in equilibrium.

[15] Following previous literature, in this corollary we slightly differ in our notation and separately vary contract price and insurance coverage for fixed expected indemnity $I$.

[16] Calibrating $ARA$ for exponential utility is also complicated by the fact that it reflects both risk aversion and prudence. To highlight the effects of prudence, we sometimes consider a value of $ARA$ that seems large compared to experimental evidence for risk aversion (e.g., by Holt and Laury (2002) and Harrison and Rutström (2008)), such as $ARA = 0.2$. However, the calibration is consistent with empirical estimates for prudence. For example, in Ebert and Wiesen (2014)'s experiment to elicit prudence, the average individual behaves roughly consistently to $ARA = 0.18$ and $RRA = 2$.




(a) $ARA = 0.05$.



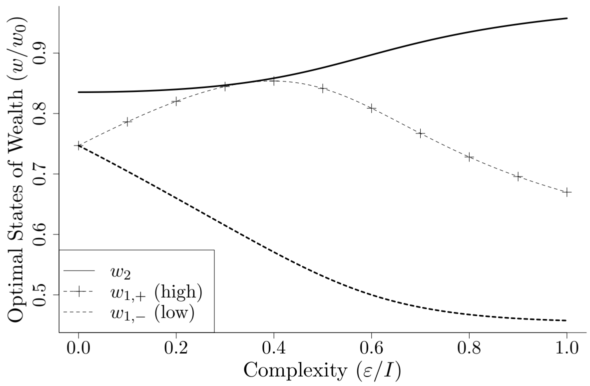

(b) $ARA = 0.2$.

Figure 3: Optimal insurance coverage with respect to changes in complexity.
The figures depict the optimal insurance coverage ($\alpha^* I$) relative to the loss size ($L$) for changes in the level of complexity ($\varepsilon$) relative to the expected indemnity payment ($I$). In this example, individuals with initial endowment $w_0 = 100$ maximize exponential utility with the coefficient of absolute risk aversion $ARA$ for a loss $L = 50$ that occurs with probability $p = 0.3$ and expected insurance unit indemnity payment $I = 2.5$, which implies a relative premium loading on the actuarially fair price of $\frac{1-pI}{pI} = 1/3$.

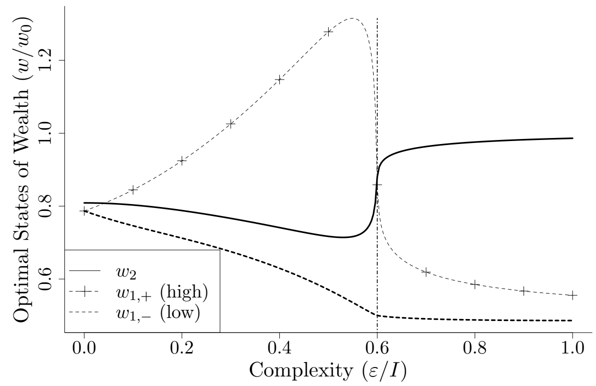
imprudent individual is not willing to accept additional overall uncertainty resulting from more complex insurance. On the other hand, contract complexity raises insurance demand if prudence is large and complexity is low, which is the situation in Figure 3 (b). Following Fei and Schlesinger (2008), we call this effect *precautionary insurance*. The reason for precautionary insurance is that, for sufficiently prudent individuals, marginal utility of insurance, $pu_1'(I + \tilde{\vartheta} - 1) - (1-p)u_2'$, is convex in complexity risk $\tilde{\vartheta}$. Then, the marginal benefit of insurance is increasing with the variability of $\tilde{\vartheta}$, resulting in higher demand for insurance.

Precautionary insurance occurs when individuals prepare for an increase in uncertainty by increasing wealth in both loss states via increasing insurance coverage. This is possible only if the level of contract complexity is lower than the net payout of insurance $\varepsilon < I - 1$. If instead $\varepsilon > I - 1$, wealth in the worst possible state $w_{1,-}$ is decreasing with insurance coverage, i.e., $dw_{1,-}/d\alpha = I - \varepsilon - 1 < 0$ if $\varepsilon > I - 1$. In this case, individuals cannot raise wealth in $w_{1,-}$ by increasing insurance coverage. As a result, insurance demand unambiguously decreases with contract complexity, as Figure 3 illustrates for $\varepsilon/I > 0.6$. Hence, precautionary insurance does not only depend on the level of prudence but also on the level of contract complexity itself.[17]

[17] This finding is different from models with additive background risk, which unambiguously raises insurance demand if individuals are prudent (e.g., Eeckhoudt and Kimball (1992), Gollier (1996), Fei and Schlesinger (2008)).




(a) Optimal states of wealth ($ARA = 0.05$).




(b) Optimal states of wealth ($ARA = 0.2$).

Figure 4: Optimal states of wealth with respect to changes in complexity.
The figures depict individuals' wealth (relative to the wealth endowment $w_0$) conditional on optimal insurance coverage for changes in the level of complexity ($\varepsilon$) relative to the expected indemnity payment ($I$). In this example, individuals with initial endowment $w_0 = 100$ maximize exponential utility with a coefficient of absolute risk aversion $\gamma = 0.2$ for a loss $L = 50$ that occurs with probability $p = 0.3$. The expected indemnity per unit paid for insurance is $I = 2.5$ which implies a relative premium loading on the actuarially fair price equals $\frac{1-pI}{pI} = 1/3$. The vertical line in Figure (b) corresponds to $\varepsilon = I - 1$.

In Figure 4, we show the optimal wealth associated with the optimal insurance coverage from Figure 3. With a relatively low degree of prudence, individuals reduce insurance coverage to maintain a relatively small risk within the loss state, as Figure 4 (a) illustrates. In contrast, precautionary insurance demand of a more prudent individual in Figure 4 (b) increases the lowest possible wealth realization but amplifies risk within loss state for $\varepsilon < I - 1$, while this effect reverses for $\varepsilon > I - 1$.

At the threshold, $\varepsilon = I - 1$, contract complexity offsets the net insurance payout: in this case, wealth in the least favorable (loss) state, $w_{1,-}$, is independent of insurance coverage, since $w_{1,-} = w_0 - L + \alpha(I - 1 - \varepsilon) \equiv w_0 - L$ for all $\alpha$. Thus, optimal insurance coverage is determined only by the trade-off between a large indemnity payment in $w_{1,+}$ and suffering no loss in $w_2$. This reduces the individual's optimization problem to a two-state problem.In this case of $\varepsilon = I - 1$, individuals cannot change wealth in the worst loss state $w_{1,-}$, decisions are driven by risk aversion only, and partial insurance coverage is optimal:

**Corollary 2.3** ($\varepsilon = I - 1$)**.** *Assume that $\varepsilon = I - 1 > 0$. If insurance is perceived as actuarially fair ($pI = 1$), optimal insurance coverage is determined by $\alpha^* = \frac{p}{2-p}L$ and results in an average indemnity payment of $\alpha^* I = L/(2 - p) < L$. If insurance includes a subjective loading ($pI < 1$), partial insurance is also optimal ($\alpha^* I < L$).*

### 2.3 Overinsurance

As shown in the previous section, prudence is a motive for precautionary insurance at small levels of contract complexity. In this section, we show that such precautionary insurance can incentivize individuals to demand an expected indemnity payment that exceeds the actual loss, $\alpha I > L$. We refer to this case as *overinsurance*. The following Proposition shows that overinsurance occurs if individuals are sufficiently prudent:

**Proposition 2.1** (Overinsurance)**.** *If $\varepsilon \in (0, I-1)$, $I > 1$, and prudence is sufficiently large such that*

$$-\frac{\bar{u}_1'''}{\bar{u}_1''} > \frac{1}{2\alpha(I-1)}\left(1 + \frac{1-pI}{\alpha\varepsilon^2 p}\left(-\frac{u'(\mathbb{E}[w_1])}{\bar{u}_1''}\right)\right) \tag{6}$$

*in equilibrium, then individuals demand overinsurance ($\alpha^* I > L$), where $\bar{u}_1'' = \frac{u_{1,-}' - u_{1,+}'}{w_{1,-} - w_{1,+}}$ and $\bar{u}_1''' = \frac{u_{1,+}' - u'(\mathbb{E}[w_1]) - \left(u'(\mathbb{E}[w_1]) - u_{1,-}'\right)}{(w_{1,-} - w_{1,+})^2}$.*

If contracts are perceived to include a proportional loading ($pI < 1$), the threshold for the average degree of prudence $-\frac{\bar{u}_1'''}{\bar{u}_1''}$ on the right hand side of (6) is increasing with $-\frac{u'(\mathbb{E}[w_1])}{\bar{u}_1''}$. The latter is decreasing with the slope of marginal utility ($-u''$), and thus describes the inverse of individuals' risk aversion. Stronger risk aversion reduces the minimum degree of prudence to result in overinsurance. The intuition is that more risk averse individuals exhibit a relatively higher willingness-to-pay for insurance and, thus, more easily demand overinsurance in the presence of complex contracts.

If insurance is perceived as actuarially fair, individuals already demand full insurance ($\alpha I = L$) in the case without contract complexity, i.e., for $\varepsilon = 0$. In this case, the threshold in (6) is independent from risk aversion and individuals demand overinsurance for any small nonzero level of contract complexity if they are sufficiently prudent:

**Corollary 2.4.** *Assume that individuals expect insurance contracts to be actuarially fair ($pI = 1$) and let $\varepsilon \in (0, I-1)$, $I > 1$. Then, individuals demand overinsurance if*

$$-\frac{\bar{u}_1'''}{\bar{u}_1''} > \frac{1}{2\alpha(I-1)} \tag{7}$$

*in equilibrium.*

This result does not necessarily imply that, given individuals are sufficiently prudent, insurance firms *offer* overinsurance in equilibrium. Instead, the result only provides a condition for individuals to *demand* overinsurance. If overinsurance is not offered by firms, individuals demand the highest possible coverage up to the optimal level since marginal expected utility is monotonically decreasing in insurance coverage (see the proof of Lemma 2.1).[18]

In practice, insurance companies usually follow the principle of indemnity, which states that an indemnity payment should only replace actual losses occurred, putting the insured back financially into his or her pre-loss situation. This is common practice in the U.S. and many European countries (Pinsent Masons (2008)). It is, however, noteworthy that overinsurance may still result from differences between insured's and insurer's assessment of the loss. New-for-old-insurance (reinstatement) contracts or fire insurance contracts may feature an indemnity that differs from exceeds the actual present value of what has been lost, since indemnity payments are fixed before the loss occurs. For example, U.S. health insurers typically pay a fixed rate per diem for hospital stays, regardless of the actual costs of treatments (Reinhardt (2006)). Similarly, automobile insurance policies typically include the possibility to receive a fixed indemnity payment $\$K$ instead of the insurer directly paying the actual repair costs. Thus, if one is able to repair damages for less than $\$K$ or, more generally, if an individual's disutility from having a damaged car is smaller than receiving $\$K$, the individual is - from her own perspective - overinsured.

# 3 Transparency Costs, Equilibrium, and the Welfare Cost of Illiteracy

Risk averse individuals prefer contracts without complexity, since

$$\frac{\partial EU}{\partial \varepsilon} = \alpha \frac{p}{2}(u'_{1+} - u'_{1-}) < 0 \tag{8}$$

for all $\alpha > 0$. In this section, we analyze under which conditions contract complexity nevertheless exists in competitive equilibrium. We allow firms to undertake costly effort to reduce contract complexity, e.g., by preparing additional explanatory materials (such as information documents), offering additional advice through brokers or service centers, or assessing

[18]Thus, if firms offer contracts with coverage $\alpha \in \mathcal{C} \subseteq \mathbb{R}^+$ with $\max\{\mathcal{C}\} < \alpha^*$, individuals purchase $\max\{\mathcal{C}\}$, where $\alpha^*$ is the optimal coverage resulting from maximizing expected utility (1) for $\alpha \in \mathbb{R}^+$.

whether the contract's terms and conditions can be simplified.[19] We call the costs for effort *transparency costs.*

As in the previous section, insurance demand is driven by individuals' *experienced* level of contract complexity, $\varepsilon$. We now split $\varepsilon$ into two parts: contracts' *actual* complexity $\nu$ (e.g., the (inverse of the) use of simple language, figures, and tables) and individuals' financial illiteracy $\beta$ (e.g., unsophistication and cognitive abilities). Experienced contract complexity is $\varepsilon = \beta\nu$, which reflects that the marginal impact of actual contract complexity on decision-making increases with individuals' level of illiteracy. Firms choose the level of actual contract complexity $\nu \geq 0$, while individuals' illiteracy $\beta \geq 0$ is exogenous. If $\beta = 0$, individuals do not experience any contract complexity, i.e., understand any contract regardless of its complexity $\nu$.

### 3.1 Contract Complexity in Competitive Equilibrium

We consider a market with free entry and homogeneous risk-neutral firms who offer insurance contracts. Contracts generate transparency costs $\kappa = \kappa(\nu) \geq 0$ that depend on their complexity $\nu$ with $\kappa' < 0$ and $\kappa'' > 0$. Firms pay $-\kappa' > 0$ to marginally reduce the level of complexity $\nu$ (and thus increasing transparency). Thus, the lower the complexity of contracts, the more costly it is to offer them. For example, there may exist a benchmark complexity level $\nu_0$ associated with small (possibly zero) transparency costs $\kappa(\nu_0)$, e.g., by offering contracts without explanatory material. Preparing additional explanatory material reduces complexity to $\nu < \nu_0$ but increases transparency costs to $\kappa(\nu) > \kappa(\nu_0)$. Individuals prefer smaller experienced complexity $\nu\beta < \nu_0\beta$, however, in competitive equilibrium they need to compensate firms for higher transparency costs. Therefore, equilibrium is characterized by the trade-off between lower complexity and larger transparency costs (and prices). $\kappa'' > 0$ implies that, with smaller complexity, it becomes increasingly costly for firms to further reduce complexity. Expected firm profit is given by

$$\Gamma(\nu, I) = \alpha(1 - pI) - \kappa(\nu). \tag{9}$$

Firms compete over payout $I$ and contract complexity $\nu$, and offer co-insurance contracts with indemnity payment $\$\alpha I, \alpha > 0$, that make non-negative expected profit. Individuals choose

[19] New regulatory changes in the European Union make some of these measures mandatory (Hofmann et al. (2018)).

optimal insurance coverage $\alpha$ among the contracts offered, while facing subjective uncertainty about the payout if they are financially illiterate ($\beta > 0$). Since we are interested primarily in uncertainty as a channel for financial illiteracy - but not biases toward actuarial fairness -, we now assume that individuals' expectation about the indemnity payment is unbiased in the sense that the payout they expect coincides with the actual payout.[20]

The equilibrium allocation maximizes individuals' expected utility subject to a non-negative expected profit constraint,

$$\max_{\alpha\geq 0, \varepsilon\geq 0, I\geq 0} EU(\alpha, \varepsilon, I) \tag{10}$$

$$\text{s.t. } \Gamma(\varepsilon/\beta, I) \geq 0. \tag{11}$$

Since expected profit is strictly decreasing in payout $I$ and increasing in complexity $\varepsilon$, firms exactly break even in equilibrium, with $\Gamma = \alpha(1 - pI) - \kappa = 0$. Due to continuity, equilibrium exists on every closed interval. It is unique if $EU|_{\Gamma=0}$ is concave, i.e., if $\nabla^2 EU\big|_{\Gamma=0}$ is negative semi-definite.[21]

To simplify the illustration in the following, we will consider equilibrium in $(\varepsilon, I)$-space by computing zero-profit curves and indifference curves given optimal insurance coverage $\alpha^*$ for each $(\varepsilon, I)$-pair, where $\alpha^*$ maximizes individuals' expected utility:

$$\begin{aligned}\alpha^* &= \arg\max_{\alpha\geq 0} EU(\alpha, \varepsilon, I) && (12)\\ &= \arg\max_{\alpha\geq 0} p\frac{u(w_0 - L + \alpha(I + \varepsilon - 1)) + u(w_0 - L + \alpha(I - \varepsilon - 1))}{2} + (1-p)u(w_0 - \alpha).\end{aligned}$$

The slope of the zero-profit curve in $(\varepsilon, I)$ space is then given by

$$\left.\frac{dI}{d\varepsilon}\right|_{\Gamma=0} = \frac{\frac{\partial\alpha^*}{\partial\varepsilon}(1-pI) - \frac{1}{\beta}\kappa'(\varepsilon/\beta)}{p\alpha^* - \frac{\partial\alpha^*}{\partial I}(1-pI)}. \tag{13}$$

Since $\kappa' < 0$ and $pI < 1$ for $\Gamma = 0$ and $\kappa > 0$, the zero-profit curve is upward-sloping if transparency costs $\kappa$ are sufficiently small to result in a small price loading $1 - pI$ at $\Gamma = 0$ (or

[20] Nonetheless, it is straightforward to extend our model to include a biased expectation, e.g., that firms pay $I$ but individuals expect it to be $(1 + \lambda)I$, on average.

[21] While it is not straightforward to proof that $\nabla^2 EU\big|_{\Gamma=0}$ is negative semi-definite in general, we numerically compute the eigenvalues of $\nabla^2 EU\big|_{\Gamma=0}$ for the examples used below. For all relevant $(\alpha, \varepsilon)$-pairs along (given $I$ to satisfy zero expected profits), we find that the eigenvalues are weakly below zero. Thus, in these cases, equilibrium is unique.

if insurance demand is sufficiently inelastic in payout $I$ and sufficiently inelastic or increasing in complexity $\varepsilon$). Then, a reduction in complexity $\varepsilon$ (i.e., an increase in transparency) is offset by a reduction in the payout $I$. If transparency costs $\kappa$ are sufficiently convex, i.e., $\kappa'' > 0$ sufficiently large, the zero-profit curve is also concave.

Indifference curves $(\varepsilon, I)|_{V=V(\varepsilon,I)}$ depict all pairs of experienced contract complexity $\varepsilon = \beta\nu$ (assuming that financial illiteracy $\beta > 0$) and expected indemnity $I$ that result in the same level of indirect utility

$$V(\varepsilon, I) = EU(\alpha^*, \varepsilon, I), \tag{14}$$

where $\alpha^*$ is the optimal coverage for the respective $(\varepsilon, I)$-pair defined above. The marginal rate of substitution between indemnity and complexity equals the slope of indifference curves,

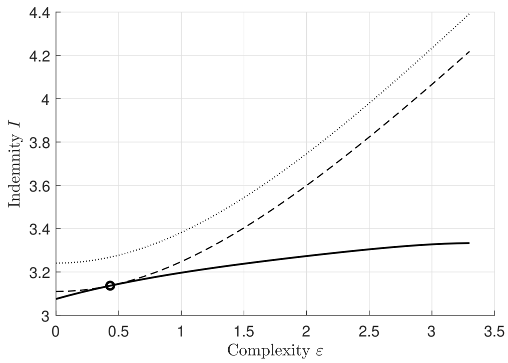
$$\left.\frac{dI}{d\varepsilon}\right|_{V=V(\varepsilon,I)} = -\frac{\frac{\partial V}{\partial \varepsilon}}{\frac{\partial V}{\partial I}} = \frac{u'_{1,-} - u'_{1,+}}{u'_{1,-} + u'_{1,+}}. \tag{15}$$

Note that the first equality follows from the implicit function theorem and the second from the envelope theorem. Due to risk aversion, indifference curves are upward sloping, $\frac{dI}{d\varepsilon}\Big|_{V=V(\varepsilon,I)} > 0$. Thus, the utility-gain from higher expected indemnity $I$ offsets the utility-loss from higher complexity $\varepsilon$. The curvature of indifference curves is determined by

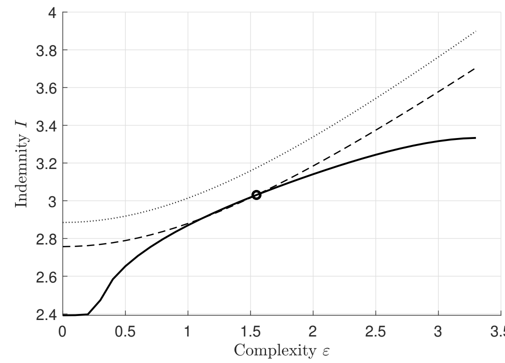
$$\left.\frac{d^2 I}{d\varepsilon^2}\right|_{V=V(\varepsilon,I)} = \frac{2}{(u'_{1,+} + u'_{1,-})^2}\left[(-\alpha^*)\underbrace{(u''_{1,+}u'_{1,-} + u''_{1,-}u'_{1,+})}_{<0} - \frac{\partial \alpha^*}{\partial \varepsilon}\underbrace{(u''_{1,+}u'_{1,-} - u''_{1,-}u'_{1,+})}_{=A}\right]. \tag{16}$$

Thus, if $\frac{\partial \alpha^*}{\partial \varepsilon} \times A$ in (16) is sufficiently small or negative, indifference curves are convex. For example, this is the case if individuals have constant absolute risk aversion, implying $A = 0$. When individuals have increasing (decreasing) absolute risk aversion, it is $A < 0$ ($A > 0$) and thus indifference curves are convex if $\frac{\partial \alpha^*}{\partial \varepsilon}$ is either positive or negative and sufficiently small in absolute value (either negative, or positive and sufficiently small). Convex indifference curves reflect that with higher complexity it becomes increasingly more difficult to offset the disutility from complexity by increasing payout.

Figure 5 depicts an illustrative example with constant absolute risk aversion. Below and on the zero-profit curve, contracts make non-negative expected profit, and vice versa. The zero-profit curve is upward sloping since higher contract complexity reduces transparency costs, enabling firms to offer larger payout. It is concave since an increase in complexity reduces marginal transparency costs. Indifference curves are increasing with complexity since the utility gain from a higher indemnity payment offsets the disutility from higher complexity. A North-West shift of indifference curves reflects an increase in expected utility. In equilibrium, indifference curve and zero-profit curve are tangential.




(a) Low transparency costs.




(b) High transparency costs.

Figure 5: Break-even line (straight), indifference curves (dotted and dashed), and equilibrium contract (dot).

The zero-profit curve depicts all $(\varepsilon, I)$ pairs of experienced complexity and expected indemnity with zero expected profit given optimal coverage $\alpha^*$, respectively. An indifference curve depicts all $(\varepsilon, I)$ pairs that result in the same level of indirect utility $V$. In this example, individuals have exponential utility with constant absolute risk aversion $ARA = 0.02$ for an initial wealth $w_0 = 100$, loss $L = 50$, and loss probability $p = 0.3$. Transparency cost are $\kappa(\nu) = k(\min(\nu - \nu_0, 0))^2$ with $\nu_0 = 1/p$ and (a) $k = 0.1$ and (b) $k = 0.3$. $k/p^2$ is the cost to entirely remove contract complexity.

Equilibrium maximizes expected utility among contracts on the zero-profit curve, i.e.,

$$\begin{aligned} EU =& \frac{p}{2}\left(u\left(w_0 - L + \frac{\alpha - \kappa}{p} + \alpha(\varepsilon - 1)\right) + u\left(w_0 - L + \frac{\alpha - \kappa}{p} - \alpha(\varepsilon + 1)\right)\right) \\ &+ (1-p)u(w_0 - \alpha). \end{aligned} \tag{17}$$

In equilibrium, experienced contract complexity thus satisfies the first-order condition

$$\frac{\partial EU}{\partial \varepsilon} = \frac{p}{2}\left(u'_{1,+}\left(\alpha - \frac{\kappa'}{p\beta}\right) - u'_{1,-}\left(\alpha + \frac{\kappa'}{p\beta}\right)\right) = 0 \tag{18}$$

$$\Leftrightarrow \kappa' = -p\beta\alpha\frac{u'_{1,-} - u'_{1,+}}{u'_{1,-} + u'_{1,+}}. \tag{19}$$

The right-hand-side of Equation (19) is negative if $\alpha > 0$ and decreasing with individuals' risk aversion and financial illiteracy. More risk averse and more financially illiterate individuals demand a smaller level of complexity in equilibrium (since $\kappa'' > 0$). An interior solution ($\nu\beta > 0$) exists only if $\beta > 0$ and transparency costs are decreasing with complexity (and thus increasing with transparency): $\kappa' < 0$. Otherwise, $\frac{\partial EU}{\partial \varepsilon} < 0$ for all $\varepsilon, \alpha > 0$ and thus $\varepsilon = 0$ and $\nu = 0$ are optimal.

Assume that $\beta > 0$ and $\kappa' < 0$. If an interior solution for $\varepsilon$ exists, it is an expected utility maximum since

$$\frac{\partial^2 EU}{\partial \varepsilon^2} = \frac{p}{2}\left(u''_{1,+}\left(\alpha - \frac{\kappa'}{p\beta}\right)^2 + u''_{1,-}\left(\alpha + \frac{\kappa'}{p\beta}\right)^2\right) - \frac{\kappa''}{\beta^2}\mathbb{E}[u'_1] < 0. \tag{20}$$

For example, consider $\kappa$ to be quadratic with a cost-minimal level of complexity $\nu_0$, such that $\kappa = k(\nu - \nu_0)^2$.[22] Then, the equilibrium level of actual contract complexity satisfies

$$\nu = \nu_0 - p\beta\alpha\frac{u'_{1,-} - u'_{1,+}}{2k(u'_{1,-} + u'_{1,+})} \tag{21}$$

and is positive if (a) transparency costs $k$ (per unit deviation from $\nu_0$) or (b) cost-minimizing contract complexity $\nu_0$ are sufficiently large, and (c) the loss probability $p$ and financial illiteracy $\beta$ are sufficiently small, given positive insurance coverage $\alpha > 0$. Large marginal costs for deviating from the cost-minimal contract complexity $\nu_0$ result in a larger reduction in the expected indemnity payment and, thus, increase the zero-profit curve's slope (see Figure 5). The smaller the coverage $\alpha$, loss probability $p$, and financial illiteracy $\beta$, the smaller is the impact of payout uncertainty on expected utility and the larger is the reduction in indemnity $I$ upon a decrease in $\varepsilon$ along the zero-profit curve (i.e., the steeper are zero-profit curves). Then, individuals are willing to accept a larger level of actual contract complexity in exchange for a higher payout in equilibrium.

### 3.2 Welfare and the Financial Illiteracy Premium

We use our equilibrium definition to estimate the welfare cost of financial illiteracy. Generally, one can think of two types of welfare costs. On the one hand, if only one (atomistic) individual increases its financial literacy (i.e., lowers $\beta$), she can improve her utility without changing the equilibrium allocation.[23] On the other hand, a policy intervention that increases a population's level of literacy will change the equilibrium allocation. In the following, we

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[22] We only consider $\nu \leq \nu_0$ in order to have transparency costs decreasing with complexity.

[23] For example, upon reducing the illiteracy to $\beta = 0$ she would maximize expected utility

$$EU(\alpha) = pu\left(w_0 - L + \frac{\alpha - \kappa}{p} - \alpha\right) + (1-p)u(w_0 - \alpha), \tag{22}$$

focus on the latter notion of welfare since it is arguably the more policy-relevant one. Thus, to evaluate the effect of (a population's) financial illiteracy on welfare it is important to also take its effect on equilibrium insurance demand into account.

We compare different levels of $\beta$, reflecting different levels of financial literacy. In the most extreme cases, if $\beta = 1$, contract complexity is fully passed on to individuals, while individuals with $\beta = 0$ are perfectly financially literate and are not affected by contract complexity at all. We assume that a unique transparency cost minimum $\nu_0$ exists, $\kappa'(\nu_0) = 0$ and $\kappa''(\nu_0) > 0$. For simplicity and without loss of generality, we assume that $\kappa(\nu_0) = 0$. For example, $\nu_0$ might correspond to a benchmark contract that is costlessly available to firms.

Since indifference curves in $(\varepsilon, I)$-space depend on experienced contract complexity $\varepsilon = \beta\nu$, we can fix indifference curves and vary zero-profit curves with changes in $\beta$: a reduction in $\beta$ increases the level of actual complexity $\nu = \varepsilon/\beta$ that is sufficient for firms to break even for a given $\varepsilon$. Then, transparency costs decrease and firms can raise the break-even indemnity payment $I$. In Figure 6, this effect is reflected by a steeper zero-profit curve for small $\beta$. However, since the zero-profit curve decreases with financial illiteracy $\beta$ for low level of experienced complexity $\varepsilon$, individuals attain a higher expected utility in equilibrium with low illiteracy $\beta$ (point B) than with large $\beta$ (point A). In the case of quadratic transparency costs $\nu = k(\nu - \nu_0)^2$ as in Figure 6, if $\varepsilon > \beta\nu_0$, the implied actual complexity is larger than the cost-minimal complexity, $\nu = \varepsilon/\beta > \nu_0$. Therefore, transparency costs are increasing with contract complexity if $\varepsilon$ is sufficiently large, resulting in a decreasing zero-profit curve for large $\varepsilon$ in Figure 6.

In the following, we focus on the welfare loss that results from the difference in equilibrium utility between perfectly financially literate ($\beta = 0$) and illiterate ($\beta = 1$) individuals. If $\beta = 0$, individuals do not experience disutility from actual contract complexity and thus, in equilibrium, firms offer contracts with minimal transparency cost, $\nu^* = \nu_0$, and actuarially fair payout $I^* = 1/p$ (since we assume $\kappa(\nu_0) = 0$). Thus, for $\beta = 0$ the zero-profit curve in

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given that contracts break even. The optimal insurance coverage is $\alpha^* = pL + \kappa$, which equalizes wealth $w_1 = w_2 = w_0 - pL - \kappa$. The welfare cost of *not* being perfectly financially literate but instead having $\beta = h > 0$ can be measured by this individual's willingness to pay $c$ to reduce $\beta$ to zero, namely

$$u(w_0 - pL - \kappa - c) = EU^*|_{\beta=h} \,. \tag{23}$$

Since contracts break even in equilibrium, expected wealth equals $w_0 - pL - \kappa$ regardless of the level of coverage and financial literacy. Therefore, $c$ is simply the risk premium for equilibrium insurance coverage with $\beta = h$. An important assumption of this welfare notion is that the individual is aware of her financial illiteracy.

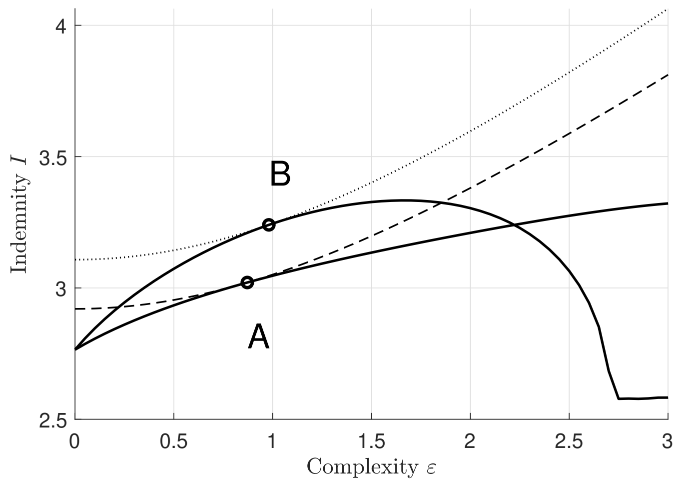



Figure 6: Break-even lines (straight), indifference curves (dotted and dashed), and optimal contracts (dots). Point A corresponds to equilibrium with $\beta = 1$, point $B$ to equilibrium with $\beta = 0.5$.
Zero-profit curves depict all $(\varepsilon, I)$ pairs of experienced complexity and expected indemnity with zero expected profit given optimal coverage $\alpha^*$, respectively. Indifference curves depict all $(\varepsilon, I)$ pairs that result in the same level of indirect utility $V$. In this example, individuals maximize exponential utility with constant absolute risk aversion $ARA = 0.02$ for an initial wealth $w_0 = 100$, loss $L = 50$, and loss probability $p = 0.3$. Transparency cost are $\kappa(\nu) = k(\nu - \nu_0)^2$ with $\nu_0 = 1/p$ corresponding to benchmark contracts with minimal transparency costs and $k = 0.2$. $k/p^2$ is the cost to entirely remove contract complexity.

$(\varepsilon, I)$-space is flat with $I = 1/p$ and individuals maximize

$$EU|_{\beta=0} = pu(w_0 - L + \alpha(I^* - 1)) + (1 - p)u(w_0 - \alpha) \tag{24}$$

over coverage $\alpha$. It is well-known that the solution to this program is full coverage, $\alpha^* I^* = L$ (e.g., see Doherty (1975)), such that expected utility in equilibrium is $EU^*|_{\beta=0} = u(w_0 - pL)$.

To compare welfare with and without financial illiteracy, we translate the welfare-loss from financial illiteracy into monetary costs. For this purpose, we define the *financial illiteracy premium* $\mathcal{C}$ as

$$u(w_0 - pL - \mathcal{C}) = EU^*|_{\beta=1}\,, \tag{25}$$

where $EU^*|_{\beta=1}$ is the expected utility in equilibrium with financially illiterate individuals, $\beta = 1$. $\mathcal{C}$ is a social planner's maximum willingness-to-pay to completely remove financial illiteracy, i.e., the welfare cost of financial illiteracy. It reflects the maximum cost that policymakers should be willing to invest into educating consumers.

It is straightforward to show that $\mathcal{C} > 0$ if the equilibrium with $\beta = 1$ entails a non-negative price loading ($pI^* \leq 1$) and a positive but small level of complexity such that $w_0 - L + \alpha^*(I^* - \varepsilon^* - 1) > 0$. In this case, strict concavity of an individual's utility function implies that

$$EU|_{\beta=0} = u(w_0 - pL) = u\left(p(w_0 - L + \alpha^*(I^* - 1)) + (1-p)(w_0 - \alpha^*) + \alpha^*(1 - pI^*)\right) \quad (26)$$

$$> pu(w_0 - L + \alpha^*(I^* - 1)) + (1-p)u(w_0 - \alpha^*) \quad (27)$$

$$> p\frac{u(w_0 - L + \alpha^*(I^* + \varepsilon^* - 1)) + u(w_0 - L + \alpha^*(I^* - \varepsilon^* - 1))}{2} + (1-p)u(w_0 - \alpha^*) \quad (28)$$

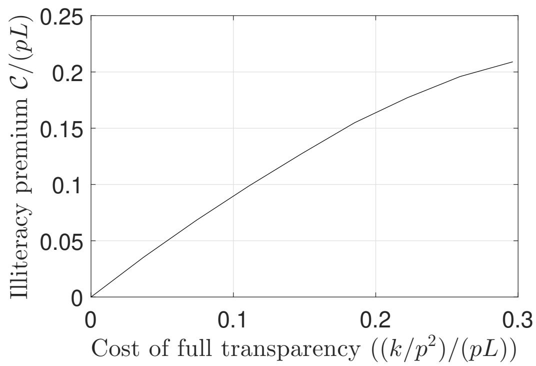
$$= EU^*|_{\beta=1}\,, \quad (29)$$

and, thus, $\mathcal{C} > 0$.

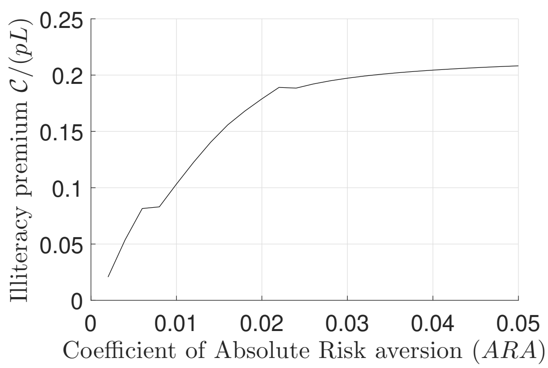
In Figure 7, we examine the sensitivity of $\mathcal{C}$ toward different primitives of the model. We rely on an exemplary baseline calibration: individuals have initial wealth $w_0 = 100$, maximize exponential utility with constant absolute risk aversion $ARA = 0.02$ and face a loss of $L = 50$ that occurs with probability $p = 0.3$. The implied coefficient of relative risk aversion is $RRA = 1.7$ for expected uninsured wealth, which is consistent with the degree of risk aversion revealed by subjects in Ebert and Wiesen (2014)'s experiment during tasks that aim to elicit their degree of prudence. Firms face quadratic transparency costs $\kappa(\nu) = k(\nu - \nu_0)^2$, such that offering a contract without complexity costs $\kappa(0) = k\nu_0^2$. In the baseline calibration we set $k = 0.3$ and $\nu_0 = 1/p$, such that $\kappa(0) = 1/p = 10/3$.

The illiteracy premium $\mathcal{C}$ can be relatively large compared to the expected loss $pL$: for reasonable calibrations, the illiteracy premium increases to up to 20% of the expected loss (i.e., the actuarially fair premium), which seems substantial. On the flip side, the illiteracy premium vanishes if (a) transparency costs are small or (b+c) individuals exhibit low levels of risk aversion.

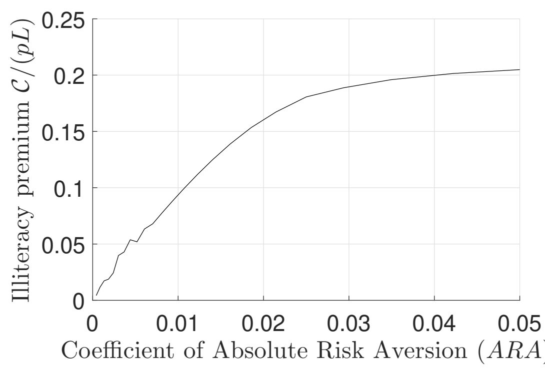
In Section 3.1 we show that financially illiterate individuals accept a high level of contract complexity in equilibrium if marginal transparency costs $\kappa'$ are large (in absolute terms). If marginal (absolute) transparency costs are small, firms are able to reduce complexity at a low cost. Due to competition among firms, individuals experience small complexity and purchase *close-to*-full insurance contracts at *close-to*-actuarially fair indemnity in equilibrium. At the limit, equilibrium with perfectly financially literate individuals is reached. Therefore, the welfare cost of financial illiteracy is smaller if it is less costly for firms to reduce complexity, as Figure 7 (a) shows.




(a) Illiteracy premium ($\mathcal{C}$) and cost to offer contracts without complexity ($k/p^2$).




(b) Illiteracy premium $\mathcal{C}$ and absolute risk aversion $ARA$ (which equals prudence) with exponential utility.




(c) Illiteracy premium $\mathcal{C}$ and absolute risk aversion with quadratic utility (no prudence) at expected uninsured wealth $w_0 - pL$.

Figure 7: Sensitivity of financial illiteracy premium towards changes in (a) transparency costs, (b) risk aversion and prudence, and (c) risk aversion without prudence. In Figures (a) individuals maximize exponential utility with constant absolute risk aversion $ARA = 0.02$ which also equals the coefficient of absolute prudence, in (b) individuals maximize exponential utility with varying coefficient of absolute risk aversion $ARA$, in (c) individuals maximize quadratic utility $u(w) = aw - \gamma w^2$ for $\frac{a}{2w_0} > \gamma$ such that $u' > 0$ for all attainable values. Initial wealth is $w_0 = 100$, the loss is $L = 50$, and the loss probability is $p = 0.3$. Transparency costs are given by $\kappa(\nu) = k(\nu - \nu_0)^2$ with $\nu_0 = 1/p$ such that $k/p^2$ is the cost to entirely remove contract complexity. In Figure (a), we vary $k$, and it is $k = 0.3$ in Figures (b), and (c). Note that $ARA = 0.02$ corresponds to $RRA = 1.7$ at wealth $w_0 - pL = 85$.

Figures 7 (b) and (c) illustrate that the illiteracy premium is increasing with risk aversion. The less risk averse individuals are, the smaller is the disutility from contract complexity and, thus, the less elastic is insurance demand with respect to complexity but more elastic it is with respect to payout. Therefore, financially illiterate but relatively less risk averse individuals accept a high level of complexity in exchange for a large indemnity in equilibrium, while the difference in welfare to financially literate individuals is small due to the small disutility from complexity.[24]

Figures 7 (b) and (c) differ with respect to preferences: we use exponential utility (i.e., constant absolute risk aversion) in Figure 7 (b) and quadratic utility in Figure 7 (c). Exponential utility implies that we cannot alter risk aversion and prudence separately: the coefficient of absolute risk aversion equals the coefficient of absolute prudence (Eeckhoudt and Schlesinger (1994)). Thus, in Figure 7 (b) it is challenging to disentangle the effects of prudence and risk aversion. To overcome this drawback, we compare the illiteracy premium with exponential utility to that with quadratic utility in Figure 7 (c) where $u'''(\cdot) = 0$, i.e., individuals are not prudent for any level of absolute risk aversion $ARA$. We find that changes in risk aversion have a similar effect for quadratic utility in Figure 7 (c) as for exponential utility in Figure 7 (b). Therefore, we conclude that risk aversion and not prudence drives the illiteracy premium $\mathcal{C}$. Intuitively, larger risk aversion raises the disutility from contract complexity. This effect dominates the impact of changes in insurance demand due to prudence on the elasticity of insurance demand.

### 3.3 Empirical predictions and policy implications

Our analysis on insurance demand predicts that very prudent individuals react to an increase in contract complexity or financial illiteracy by raising insurance take-up. This prediction has been partially tested by Harrison et al. (2020). In a large-scale experiment, the authors find that welfare-reducing mistakes of financially illiterate consumers typically manifest in too *large* – and not too small – insurance take-up. This is consistent with our model's prediction that financial illiteracy may result in overinsurance.[25] Motivated by a strong interaction in our model, it would be interesting to further investigate the role of prudence and risk aversion on insurance decisions of financially illiterate consumers.

Moreover, our model predicts that risk aversion is an important driver for the equilibrium level of contract complexity. The more risk averse individuals are, the larger is their willingness to pay a larger insurance premium to reduce contract complexity. Similarly, a higher probability of loss increases individuals' exposure to contract complexity, and thus increases

[24] In the most extreme case, risk neutral individuals have no disutility from complexity.

[25] Interestingly, this result implies that financial illiteracy does not necessarily result in "underinsurance", as is suggested be.g., by Schanz and Wang (2014).

their willingness-to-pay. As a result, our model predicts a relatively smaller equilibrium level of contract complexity and larger insurance premiums in insurance markets with relatively more risk averse individuals and with a relatively larger probability of insured loss events.

Increasing consumers' understanding of insurance (contracts) is an important challenge and high priority objective for insurance regulators worldwide. Generally, one can mainly think of two ways to reduce welfare costs of financial illiteracy: 1) Transparency requirements for insurance firms that mandate a maximum level of contract complexity, and 2) increasing financial literacy of individuals (e.g., via financial education). In recent years, policymakers have undertaken substantial effort in pursuing the first way by imposing regulatory transparency standards.[26] For example, the National Association of Insurance Commissioners (NAIC) founded the Transparency and Readability of Consumer Information (C) Working Group in 2010 in order to develop best practices for increasing transparency in the U.S. insurance market. Recently, the European Union mandated the creation of *Insurance Product Information Documents* (IPIDs), which overview key features of insurance contracts (e.g., claims handling, and covered losses) in a standardized presentation format.[27] Yet, such transparency regulation requires insurers to implement costly measures to increase contract transparency (German Insurance Association (GDV) (2016)). Insurers are likely to recover these additional costs from individuals via increasing insurance prices, as in our model.

In our model, complexity exists in equilibrium since there is a trade-off for individuals between facing lower complexity and accepting higher prices. As a result from perfect competition in the model, any deviation from the equilibrium level of contract complexity is welfare-decreasing, since the utility from smaller complexity does not offset the disutility from higher prices, and vice versa. Hence, binding transparency regulation that mandates firms to reduce contract complexity to less-than-equilibrium levels is welfare-decreasing, particularly if marginal transparency cost are large. In contrast, an increase in financial literacy, e.g., via financial education, unambiguously raises welfare as long as the associated cost of completely removing illiteracy does not exceed the financial illiteracy premium, which amounts to 5-20% of the expected loss in our exemplary model calibration.

[26]Regulators have also undertaken measures to increase financial literacy; e.g., see EIOPA's "Report on Financial Literacy and Education Initiatives by Competent Authorities" (2011), available at `https://eiopa.europa.eu/consumer-protection/financial-literacy-and-education`.

[27]See Article 20 of the Insurance Distribution Directive (EU Directive 2016/97) and EIOPA's "Final Report on Consultation Paper no. 16/007 on draft Implementing Technical Standards concerning a standardized presentation format for the Insurance Product Information Document of the Insurance Distribution Directive" (2017) available at `https://eiopa.europa.eu/Publications/Reports/` as well as Hofmann et al. (2018).

Nevertheless, one should not interpret our results as a pledge against transparency regulation. Instead, our analysis highlights that transparency regulation is not welfare-increasing in our frictionless world, in which insurers compete over the complexity of products and (financially illiterate) individuals costlessly choose among the products offered. Nonetheless, market frictions like search costs, asymmetric information, an oligopolistic market structure of firms, or behavioral biases of individuals (that, e.g., let them favor products of well-known firms despite higher complexity) may still provide a rationale for transparency regulation.[28] Therefore, our model provides a benchmark that may be treated as a starting point for further exploration of equilibria and transparency regulation with additional behavioral biases and different market environments. Moreover, the insight that transparency regulation is not unambiguously welfare-increasing should motivate policymakers to define more precisely the specific market frictions and behavioral biases that regulation targets.

# 4 Conclusion

We examine insurance markets with individuals that are uncertain about the actual indemnity payout of insurance contracts. We argue that such uncertainty is a reasonable bias of financially illiterate (but otherwise rational) individuals that are confronted with complex insurance contracts. For example, individuals may be uncertain about the types of losses that are covered since these are specified in complex and complicated language. The more complex insurance contracts and the less financially literate individuals, the more uncertain are individuals about indemnity payouts in our model.

Adopting this model of contract complexity, we show that contract complexity has a profound impact on insurance market outcomes. In particular, insurance demand strongly interacts with second- and third-order risk preferences (namely, risk aversion and prudence), which might both increase or decrease demand for insurance. We identify a threshold for prudence such that optimal insurance coverage increases with contract complexity if prudence exceeds this threshold, and vice versa. Such an increase in coverage due to increases in risk is commonly known as *precautionary insurance.*

[28]For example, according to the National Association of Insurance Commissioners (NAIC) (2017), the largest five insurers had a joint market share of more than 30% of the U.S. and Canadian property & casualty insurance market in 2017. In the total private passenger auto insurance market, four insurers had a joint market share of more than 50% in 2017.

Our findings reveal important insights about the impact of contract complexity and financial literacy on insurance markets as well as decision-making under risk, more generally. Typically, underinsurance (relative to optimal insurance coverage if individuals were perfectly informed) is interpreted as a sign for a low level of financial literacy (e.g., Quantum Market Research for the Insurance Council of Australia (2013), Fairer Finance (2018)). However, our results imply that financial illiteracy might as well result in excessive demand for insurance by prudent individuals, who desire to raise the (subjectively) uncertain payout in case of a loss. This finding is consistent with recent experimental evidence by Harrison et al. (2020).

We endogenize contract complexity in competitive equilibrium by assuming that firms can exert costly effort to reduce complexity (e.g., by preparing explanatory material). Based on the equilibrium analysis, we propose a measure for the welfare cost of financial illiteracy, the *financial illiteracy premium*, which reflects the maximum willingness-to-pay to gain perfect understanding of insurance contracts. For a reasonable calibration, the illiteracy premium amounts to 5-20% of the expected loss and is mainly driven by risk aversion.

Our analysis provides benchmark results for the impact of regulatory actions that tackle welfare costs of limited financial literacy, particularly minimum transparency standards (for firms) vs. financial education (of consumers). Financial education unambiguously increases consumer welfare in our model if its cost does not exceed the financial illiteracy premium. However, if firms compete over contract complexity and markets are perfectly competitive and frictionless (as in our model), transparency requirements that bind in equilibrium lead to an overinvestment in transparency. Thus, financial illiteracy alone (if it solely results in uncertainty as in our model) is not a sufficient reason for transparency regulation in this benchmark case. Since markets are often not frictionless and consumers exhibit various behavioral biases in practice, transparency regulation may still increase welfare in practice. However, our benchmark results urge policymakers to carefully evaluate the specific frictions and biases they aim to address.

The results and the model framework of this study are not limited to the insurance market or the assumption of rational individuals. On the contrary, it can also be applied to decisions about optimal portfolio investments or optimal savings. Furthermore, it is straightforward to include additional behavioral phenomena such as overconfidence or ambiguity aversion.

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# Appendix

## A Proofs

### Proof of Lemma 2.1

*Proof.*

(1) Assume that individuals are not prudent, i.e. $u'''(\cdot) \leq 0$. Let $I > 1$ and $\varepsilon \geq 0$. The FOC for optimal insurance coverage is

$$\frac{\partial EU}{\partial \alpha} = \frac{p}{2}\left(u'_{1,+}(I+\varepsilon-1) + u'_{1,-}(I-\varepsilon-1)\right) - (1-p)u'_2 \stackrel{!}{=} 0. \tag{30}$$

Accordingly, we arrive at the following second order condition:

$$\frac{d^2EU}{d\alpha^2} = \frac{p}{2}\left(u''_{1,+}(I+\varepsilon-1)^2 + u''_{1,-}(I-\varepsilon-1)^2\right) + (1-p)u''_2 < 0, \tag{31}$$

which is negative as $u'' < 0$, and thus the solution $\alpha^*$ to (30) is unique. Optimal insurance coverage is decreasing with $\varepsilon$ if $\frac{\partial EU}{\partial \alpha}$ is decreasing with $\varepsilon$. This is the case if

$$\frac{d^2EU}{d\alpha d\varepsilon} = \frac{p}{2}\left(u''_{1,+}\alpha(I+\varepsilon-1) - u''_{1,-}\alpha(I-\varepsilon-1) + u'_{1,+} - u'_{1,-}\right) < 0, \tag{32}$$

where $u'_{1,+} - u'_{1,-} < 0$ due to risk aversion.

In the following, we do a case by case analysis depending on $\varepsilon$. Let $\underline{\varepsilon < I - 1}$. Then, it is $0 < I - \varepsilon - 1 < I + \varepsilon - 1$ and thus for $\alpha > 0$[29]

$$u''_{1,+}\alpha(I+\varepsilon-1) - u''_{1,-}\alpha(I-\varepsilon-1) < 0 \tag{33}$$

$$\Leftrightarrow \quad \frac{I+\varepsilon-1}{I-\varepsilon-1} > \frac{u''_{1,-}}{u''_{1,+}}. \tag{34}$$

$u'''(\cdot) \leq 0$ implies that $u''_{1,-} \geq u''_{1,+} \Leftrightarrow \frac{u''_{1,-}}{u''_{1,+}} \leq 1$. Since the LHS of (34) is larger than unity, (34) and thus (32) holds.

[29] From the FOC follows that $\alpha > 0$ is optimal if $I - 1 > \frac{1-p}{p}\frac{u'(w_0)}{u'(w_0-L)}$, which we assume in the following.

Let $\underline{\varepsilon \geq I - 1}$. Then, it is $I - \varepsilon - 1 \leq 0 < I + \varepsilon - 1$ and thus $-u''_{1,-}\alpha(I - \varepsilon - 1) \leq 0$ and $u''_{1,+}\alpha(I + \varepsilon - 1) < 0$, implying (34) and thus (32). Therefore, (32) holds if $u''' \leq 0$ and thus optimal insurance coverage is decreasing with contract complexity $\varepsilon$.

(2) Assume that $\underline{\varepsilon < I - 1}$ and let $\mathbb{P}(\tilde{\vartheta} = \varepsilon) = \mathbb{P}(\tilde{\vartheta} = -\varepsilon) = 1/2$. The proof aims at finding a boundary for the level of prudence such that (32) $> 0$. This can be rewritten as

$$u''_{1,+}\alpha(I + \varepsilon - 1) - u''_{1,-}\alpha(I - \varepsilon - 1) > \quad -\left(u'_{1,+} - u'_{1,-}\right) \tag{35}$$

$$\Leftrightarrow \quad \alpha(I - 1)\left(u''_{1,+} - u''_{1,-}\right) + \alpha\varepsilon\left(u''_{1,+} + u''_{1,-}\right) > \quad -\left(u'_{1,+} - u'_{1,-}\right) \tag{36}$$

$$\Leftrightarrow \quad \alpha(I - 1)\frac{u''_{1,+} - u''_{1,-}}{u'_{1,-} - u'_{1,+}} + \alpha\varepsilon\frac{u''_{1,+} + u''_{1,-}}{u'_{1,-} - u'_{1,+}} > \quad 1 \tag{37}$$

$$\Leftrightarrow \quad -\frac{\left(u''_{1,-} - u''_{1,+}\right)/\left(w_{1,-} - w_{1,+}\right)}{\left(u'_{1,-} - u'_{1,+}\right)/\left(w_{1,-} - w_{1,+}\right)} > \quad \frac{1 - \alpha\varepsilon\frac{u''_{1,+} + u''_{1,-}}{u'_{1,-} - u'_{1,+}}}{\alpha(I - 1)} \tag{38}$$

Assume that $\underline{\varepsilon \geq I - 1}$. The proof is analogous to above.

$\square$

**Proof of Corollary 2.1:**

*Proof.* Let $\varepsilon < I - 1$ and $u''' > 0$. Condition (4) in Lemma 2.1 is equivalent to

$$\bar{u}'''_1 > \frac{1}{2\alpha\varepsilon}\frac{u'_{1,-} - u'_{1,+} - \alpha\varepsilon(u''_{1,+} + u''_{1,-})}{\alpha(I - 1)}, \tag{39}$$

for which the RHS is smaller than $\frac{(-u''_{1,-})}{\alpha(I-1)} - \frac{1}{2\alpha\varepsilon}\frac{2\varepsilon u''_{1,-}}{(I-1)}$ since $u''' > 0$. Thus, $-\frac{\bar{u}'''_1}{u''_{1,-}} > \frac{2}{\alpha(I-1)}$ is sufficient to satisfy (4). $\square$

**Proof of Corollary 2.2:**

*Proof.* We disentangle the indemnity payment from the insurance premium, letting $\alpha I$ be the indemnity at coverage $\alpha$ at price $P$. Fix $I > 1$ and let $\varepsilon < I - 1$. Individuals derive utility $EU = p\mathbb{E}[u(w_0 - L - P + \alpha(I + \tilde{\vartheta}))] + (1-p)u(w_0 - P)$ from buying coverage $\alpha$ at price $P$. The marginal rate of substitution along an indifference curve in $\alpha - P$ space is given by

$$\left.\frac{dP}{d\alpha}\right|_{EU=const} = \frac{p\mathbb{E}[u_1'(I+\tilde{\vartheta})]}{p\mathbb{E}[u_1'] + (1-p)u_2'}. \tag{40}$$

Analogously to Rothschild and Stiglitz (1971), the impact of an increase in risk of $\tilde{\vartheta}$ (i.e., an increase in $\varepsilon$) on $\mathbb{E}[u_1']$ and $\mathbb{E}[u_1'(I+\tilde{\vartheta})]$ depends on whether $u_1'$ and $u_1'(I+\tilde{\vartheta})$ are convex or concave in $\tilde{\vartheta}$. If both are strictly convex in $\tilde{\vartheta}$, an increase in risk leads to an increase in $\mathbb{E}[u_1']$ and $\mathbb{E}[u_1'(I+\tilde{\vartheta})]$. $u_1'$ is strictly convex in $\tilde{\vartheta}$ if $u''' > 0$ because $\frac{\partial^2 u_1'}{\partial \tilde{\vartheta}^2} = \alpha^2 u_1'''$. $u_1'(I+\tilde{\vartheta})$ is strictly convex in $\tilde{\vartheta}$ if, and only if,

$$\frac{\partial^2 u_1'(I+\tilde{\vartheta})}{d\tilde{\vartheta}^2} = u_1'''(I+\tilde{\vartheta})\alpha^2 + 2u_1''\alpha > 0, \tag{41}$$

which is equivalent to $-\frac{u_1'''}{u_1''} > \frac{2}{(I+\tilde{\vartheta})\alpha}$ since $I + \tilde{\vartheta} \geq I - \varepsilon > I - (I-1) > 0$. Hence, if individuals are sufficiently prudent such that $-\frac{u_1'''}{u_1''} > \frac{2}{(I-\varepsilon)\alpha} \geq \frac{2}{(I+\tilde{\vartheta})\alpha}$ in equilibrium, an increase in contract complexity $\varepsilon$ leads to an increase in $\mathbb{E}[u_1'(I+\tilde{\vartheta})]$. Because $I > 1$, upon an increase in risk of $\tilde{\vartheta}$, the increase in the numerator of (40), and particularly of $\mathbb{E}[u_1']I$, is at least as large as the increase in the denominator of $\mathbb{E}[u_1']$. Therefore, for any contract $\alpha$ and price $P$ the marginal rate of substitution is increasing with $\varepsilon$. □

**Proof of Corollary 2.3:**

*Proof.* Assume that $\varepsilon = I - 1$. Then, it is $w_{1,-} = w_0 - L$, $w_{1,+} = w_0 - L + \alpha(I + \varepsilon - 1) = w_0 - L + 2\alpha(I-1)$, and $w_2 = w_0 - \alpha$. Optimal insurance coverage satisfies

$$\frac{\partial EU}{\partial \alpha} = \frac{p}{2}u_{1,+}' 2(I-1) - (1-p)u_2' = 0 \tag{42}$$

$$\Leftrightarrow \quad \frac{u_{1,+}'}{u_2'} = \frac{\frac{1-p}{p}}{I-1}. \tag{43}$$

If insurance is (subjectively) actuarially fair, it is $pI = 1$, implying that $I - 1 = \frac{1-p}{p}$ and, thus, $u_{1,+}' = u_2'$, which is equivalent to $-L + 2\alpha\frac{1-p}{p} = -\alpha \Leftrightarrow \alpha\frac{2-p}{p} = L \Leftrightarrow \alpha = L\frac{p}{2-p}$ and results in an expected indemnity payment $\alpha I = L/(2-p)$.

If insurance includes a (subjective) premium loading, it is $pI < 1$, implying that $I - 1 < \frac{1-p}{p}$ and, thus, $\frac{u'_{1,+}}{u'_2} > 1$ or equivalently $w_{1,+} < w_2 \Leftrightarrow -L + 2\alpha(I-1) < -\alpha \Leftrightarrow \alpha(1 + 2(I-1)) = \alpha(2I-1) < L \Leftrightarrow \alpha < \frac{L}{2I-1} < \frac{L}{I}$, which implies partial insurance. □

**Proof of Proposition 2.1**

*Proof.* Overinsurance occurs if wealth in the no-loss state is smaller than expected wealth in the loss state, $w_2 < \mathbb{E}[w_1]$, or, equivalently, $u'(w_2) > u'(\mathbb{E}[w_1])$. Let $\varepsilon < I - 1$. Using the first-order condition for insurance demand, overinsurance is optimal if

$$u'(\mathbb{E}[w_1]) < \frac{p}{1-p}\mathbb{E}[u'(w_1)](I-1) + \frac{p}{1-p}\frac{\varepsilon}{2}\left(u'_{1,+} - u'_{1,-}\right) \tag{44}$$

$$\Leftrightarrow \; -\frac{p}{1-p}\frac{\varepsilon}{2}\left(u'_{1,+} - u'_{1,-}\right) < \frac{p(I-1)}{2(1-p)}\left[u'_{1,+} - u'(\mathbb{E}[w_1]) - \left(u'(\mathbb{E}[w_1]) - u'_{1,-}\right) + 2u'(\mathbb{E}[w_1])\right] - u'(\mathbb{E}[w_1]). \tag{45}$$

Define by $\bar{u}'' = \frac{u'_{1,+} - u'_{1,-}}{2\alpha\varepsilon} < 0$ the first order difference quotient of $u'$, reflecting the average slope of $u'(w)$ for $w \in (w_{1,-}, w_{1,+})$, and by $\bar{u}''' = \frac{u'_{1,+} - u'(\mathbb{E}[w_1]) - \left(u'(\mathbb{E}[w_1]) - u'_{1,-}\right)}{4\alpha^2\varepsilon^2}$ the second order difference quotient of $u'$, reflecting the average curvature of $u'(w)$ for $w \in (w_{1,-}, w_{1,+})$ in equilibrium. Then, overinsurance is optimal if

$$-\frac{p}{1-p}\varepsilon^2\alpha\bar{u}'' < \frac{2\alpha^2\varepsilon^2 p}{(1-p)}(I-1)\bar{u}''' - \frac{1-pI}{1-p}u'(\mathbb{E}[w_1]) \tag{46}$$

$$\Leftrightarrow \frac{p}{1-p}\varepsilon^2\alpha < \frac{2\alpha^2\varepsilon^2 p}{(1-p)}(I-1)\left(-\frac{\bar{u}'''}{\bar{u}''}\right) - \frac{1-pI}{1-p}\left(-\frac{u'(\mathbb{E}[w_1])}{\bar{u}''}\right) \tag{47}$$

$$\Leftrightarrow p\varepsilon^2\alpha + (1-pI)\left(-\frac{u'(\mathbb{E}[w_1])}{\bar{u}''}\right) < 2\alpha^2\varepsilon^2 p(I-1)\left(-\frac{\bar{u}'''}{\bar{u}''}\right) \tag{48}$$

$$\Leftrightarrow \frac{1}{2\alpha(I-1)} + \frac{(1-pI)}{2\alpha^2\varepsilon^2 p(I-1)}\left(-\frac{u'(\mathbb{E}[w_1])}{\bar{u}''}\right) < -\frac{\bar{u}'''}{\bar{u}''}, \tag{49}$$

$$\Leftrightarrow \frac{1}{2\alpha(I-1)}\left(1 + \frac{1-pI}{\alpha\varepsilon^2 p}\left(-\frac{u'(\mathbb{E}[w_1])}{\bar{u}''}\right)\right) < -\frac{\bar{u}'''}{\bar{u}''}, \tag{50}$$

where $-\frac{\bar{u}'''}{\bar{u}''}$ approximates the degree of prudence and $-\frac{u'(\mathbb{E}[w_1])}{\bar{u}''}$ the inverse of the degree of risk aversion.

□

**Proof of Corollary 2.4**

*Proof.* The result is a direct implication of Proposition 2.1. □

# B Insurance demand in the presence of contract complexity, nonperformance and background risk

In this section, we highlight similarities and differences between our model of contract complexity and well-known models of insurance demand in the presence of background and contract nonperformance risk. We consider co-insurance contracts that insure (part of) a loss $L > 0$ that occurs with probability $p \in (0, 1)$. Insuring proportion $s \geq 0$ of the loss requires premium $sP$ and pays indemnity $s\tilde{D}$ conditional on loss occurrence, where $P > 0$ and $\tilde{D}$ is a (potentially degenerate) nonnegative random variable. We scale payouts by premiums, denoting by $\tilde{I} = \tilde{D}/P$ the (potentially random) payout per unit-premium. A family of co-insurance contracts is the set of contracts with the same unit-payout distribution $(\mathcal{I}, \pi)$, where $\mathcal{I} = (I_1, ..., I_m), I_i \in [0, \infty)$, is the allocation of contract payouts per unit premium in $m \in \mathbb{N}$ payout states and $\pi \in [0, 1]^m, \sum_i \pi_i = 1$, are the probability weights of payouts $\mathcal{I}$ conditional on loss occurrence. Contracts do not pay out if the loss does not occur. Following previous literature, we focus on a binary payout structure ($m = 2$) with $\mathcal{I} = (I_+, I_-)$ being the relevant payouts.

Contracts with complexity have payout allocations

$$\mathcal{I}^{\text{complexity}} = \{(I + \varepsilon, I - \varepsilon) : I > 1, \varepsilon \geq 0\}, \tag{51}$$

with $\pi = (\frac{1}{2}, \frac{1}{2})$. Payout is linear in complexity $\varepsilon$. In contrast, Doherty and Schlesinger (1990) characterize contracts with nonperformance risk by premium $P = pL(q + (1 - q)\tau)m$ and payout $sL$ upon loss occurrence and solvency, and salvage value $s\tau L$ upon loss occurrence and insolvency of the insurer. The payout distribution is then given by $\pi = (q, 1 - q)$ and payouts (scaled by total premium payment and with premium loading $m \geq 0$)

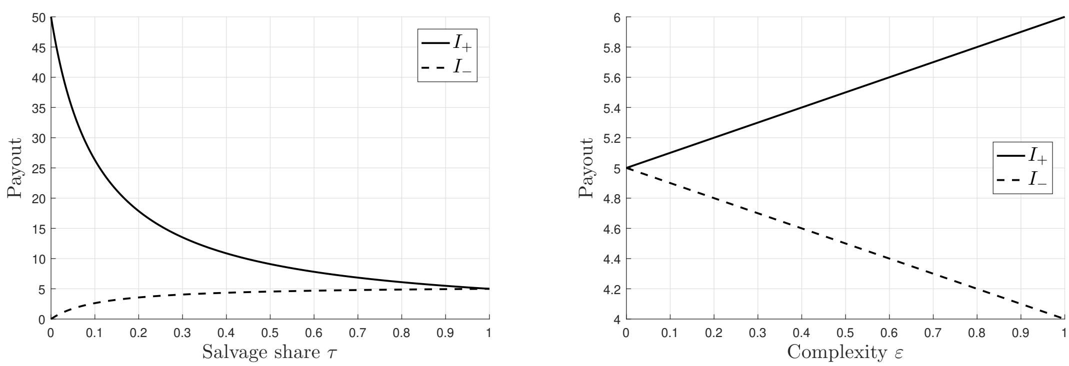
$$\mathcal{I}^{\text{nonperformance}} = \left\{ \frac{1}{p(q + (1 - q)\tau)m} (1, \tau) : m \geq 0;\, \tau, q \in [0, 1] \right\}. \tag{52}$$

The expected payout (given a loss) per unit premium is $I$ for complex contracts and

$$\frac{q+(1-q)\tau}{p(q+(1-q)\tau)m} = \frac{1}{pm} \tag{53}$$

for contracts with nonperformance risk. Actuarially fairly priced contracts feature expected unit payout $pI = 1$ and $m = 1$, which is independent of complexity $\varepsilon$ and nonperformance risk $\tau$ and $q$.

Contract complexity and nonperformance risk result in different payout allocations. While contract payout is linear in the level of complexity $\varepsilon$, an increase in nonperformance risk (by a reduction in $\tau$) disproportionally subsidizes wealth in the solvency state via a convex increase in $I_+$ (upon insurer solvency) and concave decrease in $I_-$ (upon insurer insolvency). The reason is that nonperformance risk reduces the salvage value in the insolvency state and the unit premium $P = pL(q+\tau(1-q))m$ in all states at the same time. As a result, the decrease in $P$ partially offsets the payout reduction in the insolvency state. Figure 8 (a) illustrates that payout variability $I_+ - I_-$ is convexly increasing with a reduction in the salvage value $\tau L$, while it is linearly increasing in complexity $\varepsilon$ in Figure 8 (b). As a result, the following proposition shows that the set of nonperformance contract families is disjunct from the set of complex contract families with $\varepsilon > 0$.




(a) Nonperformance risk.

(b) Complexity risk.

Figure 8: Comparison of contract payouts upon changes in nonperformance and complexity risk.
Figures depict the dollar payout per 1$ total premium payment of insurance contracts for loss probability $p = 0.2$. (a) We assume a nonperformance probability of $q = 0.1$.

**Proposition B.1.** *Let $\varepsilon > 0$. Then, no contract family with nonperformance risk $\tau \geq 0$ and non-negative premium ($m \geq 0$) provides the same payout distribution as the family of complex contracts with $\varepsilon$.*

*Proof.* For the expected payout to coincide, it must hold that $I = \frac{1}{pm}$. For payouts in both states to coincide it must hold that

$$\frac{1}{pm} - \varepsilon = \frac{1}{p(q + (1-q)\tau)m} \tag{54}$$

$$\frac{1}{pm} + \varepsilon = \frac{\tau}{p(q + (1-q)\tau)m} \tag{55}$$

$$\Rightarrow 2\varepsilon = \frac{\tau - 1}{p(q + (1-q)\tau)m}, \tag{56}$$

which is not satisfied if $\varepsilon, m \geq 0$ and $\tau \leq 1$. $\square$

In a different set up, Fei and Schlesinger (2008) study insurance demand in the presence of additive background risk in the loss state that is exogenous to contracts. Exogenous, additive background risk does not depend on insurance coverage and, thus, also results in a different payout allocation than contract complexity in our model.

# C General complexity risk distribution

The following proposition generalizes Lemma 2.1 by deriving a threshold for prudence above which a mean-preserving increase in complexity risk leads to an increase in optimal insurance coverage for an arbitrary (but bounded) complexity risk distribution.

**Proposition C.1.** *Let $\tilde{\vartheta} \sim F$ with support $\Omega \subseteq [-g, g]$, where $g > 0$, and $\mathbb{E}[\tilde{\vartheta}] = 0$. Assume that contracts pay $I + \tilde{\vartheta}$ per unit premium and let $g < I - 1$. Consider, a (small) mean-preserving increase in the risk of $\tilde{\vartheta}$ such that the support does not exceed $[-g, g]$. Then, optimal insurance coverage is increasing with this increase in risk if*

$$-\frac{u'''}{u''} > \frac{2}{\alpha(I - g - 1)} \tag{57}$$

*in a neighborhood of optimal insurance coverage.*

*Proof.* Following Rothschild and Stiglitz (1971), a mean-preserving increase in the risk of $\tilde{\vartheta}$ increases optimal insurance coverage $\alpha$ if

$$U_\alpha = pu_1'(I + \tilde{\vartheta} - 1) - (1-p)u_2' \tag{58}$$

is strictly convex in $\tilde{\vartheta}$, where $u_1' = u(w_0 - L + \alpha(I + \tilde{\vartheta} - 1))$ and $u_2' = u'(w_0 - \alpha)$. This is the case if

$$\frac{\partial^2 U_\alpha}{\partial \tilde{\vartheta}^2} = 2p\alpha u_1'' + p\alpha^2 u_1'''(I + \tilde{\vartheta} - 1) > 0 \tag{59}$$

$$\Leftrightarrow -\frac{u_1'''}{u_1''} > \frac{2}{\alpha(I + \tilde{\vartheta} - 1)}, \tag{60}$$

which holds if $-\frac{u_1'''}{u_1''} > \frac{2}{\alpha(I - g - 1)} \geq \frac{2}{\alpha(I + \tilde{\vartheta} - 1)}$ in a neighborhood of optimal insurance coverage.

□