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Financial Literacy and Precautionary Insurance*

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Abstract

This paper studies insurance demand for individuals with limited financial literacy. We propose uncertainty about insurance payouts, resulting from contract complexity, as a novel channel that affects decision-making of financially illiterate individuals. Then, a trade-off between second-order (risk aversion) and third-order (prudence) risk preferences drives insurance demand. Sufficiently prudent individuals raise insurance demand upon an increase in contract complexity, while the effect is reversed for less prudent individuals. We characterize competitive market equilibria that feature complex contracts since firms face costs 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 individuals' risk aversion. Finally, we discuss implications for regulation and consumer protection.

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

JEL Classification: D11, D81, D91, G22.

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1 Introduction

Many financial products confront consumers with complex information. This is particularly the case for insurance contracts, which often include legalese language (Cogan (2010)) that is rarely fully understood by consumers (Policygenius (2016), The Guardian Life Insurance Company of America (2017), Fairer Finance (2018)). At the same time, we observe low levels of financial literacy across large parts of the population worldwide (Lusardi and Mitchell (2011a), Lusardi and Mitchell (2014)), indicating a low "ability to process economic information and make informed decisions" (Behrman et al. (2012)). For example, only half of the U.S. population reads at the basic levels¹, and financial planning competence varies substantially by age and gender (Lusardi and Mitchell (2008)). However, research on the impact of financial literacy on insurance demand is very scarce, although financially illiterate consumers are confronted with highly complex insurance contracts in practice.²

To address this gap in the literature, we present a novel approach to understand insurance decisions of financially illiterate individuals and discuss implications for competitive market equilibrium. We propose a model in which individuals are uncertain about the payout (i.e., the indemnity payment) of insurance policies and argue that it is a reasonable model for financially illiterate (but otherwise rational) individuals. The main idea is that low financial literacy and high contract complexity blur the information available for decision-making. Then, less financially literate individuals are more uncertain about the unit-payout of more complex contracts, and vice versa. For example, individuals may be uncertain whether certain losses are covered by a given contract.³ To the best of our knowledge, previous theoretical models with unsophisticated individuals do not incorporate this "uncertainty dimension" of illiteracy. We attempt to fill this gap and provide a comprehensive analysis on the effect of mean-preserving changes in uncertainty - leaving aside other potential behavioral biases.

¹See the 2002 literacy survey of the U.S. Department of Education: Sum et al. (2002).

²Several field experiments, e.g., Gaurav et al. (2011) and Cole et al. (2013), examine the impact of financial literacy education on the demand for insurance.

³Note that we do not model financial illiteracy as a wealth effect because not fully understanding a contract is not necessarily the same thing as having a negative bias about the payout.

In our model, financial illiteracy and contract complexity heavily alter insurance decisions. A *precautionary insurance* motive arises for sufficiently prudent individuals, who optimally react to higher uncertainty (stemming from contract complexity) by increasing insurance coverage, which transfers the uncertain payout to higher wealth states. If individuals are less prudent, contract complexity reduces insurance demand. Thus, our model suggests that financial illiteracy does not unambiguously result in underinsurance but may also result in overinsurance (relative to optimal insurance coverage if individuals were perfectly informed), which complements industry studies that often only propose a link between financial illiteracy and underinsurance, e.g., [Schanz and Wang \(2014\)](#).

We develop a competitive equilibrium model and show that a positive level of contract complexity exists when firms face high *transparency cost* that induce costs to reduce contract complexity.⁴ Based on the equilibrium analysis, we propose a measure for the welfare cost of financial illiteracy, the *financial illiteracy premium*. Under reasonable conditions, the financial illiteracy premium amounts to 5% to 20% of individuals' expected (insurable) loss, highlighting the relevance of financial illiteracy for welfare.⁵ This result shows that financial illiteracy reduces welfare even in competitive markets. In reality, insurance markets often exhibit oligopolistic structures,⁶ and thus firms might exploit market power to offer products at inefficiently high prices and/or high contract complexity. Therefore, it seems reasonable that welfare cost of financial illiteracy are even larger in practice.

Recent regulatory efforts target at ensuring that insurance firms do not exploit (financially illiterate) individuals. We conclude with a discussion about regulatory measures to diminish the welfare cost of financial illiteracy. Since competitive market equilibrium provides a benchmark environment that features an optimal trade-off between contract complexity and insurance prices, we stress the need for regulators to target either (a) oligopolistic market structures or (b) individuals' behavioral biases in excess of uncertainty. Instead, contract complexity and financial illiteracy on

⁴Transparency cost can result, e.g., from operational costs to create additional documentation.

⁵To derive this baseline result, we assume that individuals endowed with initial wealth of \$100 maximize exponential utility with constant absolute risk aversion 0.02 for a loss of \$50 that occurs with probability 30%. We provide a sensitivity analysis for this result in Section 4.

⁶For 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.

their own are not a sufficient motive for regulation (in the form of uncertainty as in our model).

This study contributes to an increasing literature on financial illiteracy (also referred to as investor *unsophistication*) and information frictions in financial markets. [Delavande et al. \(2008\)](#), [Jappelli and Padula \(2013\)](#), [Kim et al. \(2016\)](#), [Lusardi et al. \(2017\)](#), and [Neumuller and Rothschild \(2017\)](#) study portfolio choice for individuals with information frictions. Our modeling of imperfect information is most closely related to the one of [Neumuller and Rothschild \(2017\)](#), in which individuals receive imperfect signals about the characteristics of investment opportunities. Typically, financial illiteracy is either modeled as a reduction in investment success (e.g., [Lusardi et al. \(2017\)](#)), information neglect (e.g., [Gabaix and Laibson \(2006\)](#)), or as a choice device that lets individuals choose randomly among products (e.g., [Carlin \(2009\)](#)). We complement the literature by focusing on uncertainty about payouts as a channel through which financial illiteracy affects decision-making. We develop our model of less literate individuals based on the assumption that their assessment of insurance contract payouts is blurred. A prime example are health insurance plans available at U.S. health exchanges: individuals are informed about prices and average indemnity payments depending on the "metal" level; yet, the actual percentage of reimbursed costs can widely vary depending on the treated conditions and medical provider.⁷

To sum up, we complement previous studies mainly along three lines. First, we contribute to the literature on financial literacy by focusing on insurance contracts as the previously mentioned papers focus on other financial products. Insurance is among households' most frequently used financial and risk management measure.⁸ Moreover, insurance contracts are particularly complex and not well-understood by individuals (see Section 2). Second, we present a model in which limited financial literacy results in uncertainty about insurance contract payout. We provide a comprehensive analysis that highlights the dependence between insurance demand, financial literacy and contract complexity (or, more generally, uncertain indemnity payouts), and risk attitudes. The framework provides a granular understanding of the behavior of financially illiterate individuals. Third, we provide an equilibrium analysis that yields insights into how financial illiteracy impacts the supply of financial contracts. Based on our analysis, we propose a measure for the welfare cost

⁷Metal levels range from Bronze to Platinum where Bronze plans pay 60% of expected health costs while Platinum plans reimburse 90% of expected costs, on average.

⁸Car, life, and private health insurance are among the top six financial products and services acquired by European citizens (the other three are a current bank or savings account and a credit card ([TNS opinion & social \(2016\)](#))).

of financial illiteracy that is widely applicable and guides policy reactions to financial illiteracy.

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, we provide a general tool for modeling the uncertainty-dimension of financial illiteracy that can be applied in numerous other financial decisions, such as decisions about optimal portfolio investments or optimal savings. Furthermore, it is straightforward to include other behavioral phenomena such as overconfidence or ambiguity aversion. In the latter case, ambiguity aversion directly measures the disutility from contract complexity.

The remainder of this article is organized as follows. In the following section, we relate our study to previous literature and provide a background on financial literacy. Section 3 introduces our model and derives baseline results. Section 4 adds an equilibrium model and introduces and discusses welfare cost of financial illiteracy. The final section concludes. Proofs are provided in the Appendix.

2 Background and Related Literature

Several studies provide robust empirical evidence of low financial literacy levels globally, e.g., by [Lusardi and Mitchell \(2011a\)](#) and [Sum et al. \(2002\)](#).⁹ Financial literacy levels are of public concern as economic outcomes highly depend on financial literacy: [Lusardi and Mitchell \(2007\)](#) and [Lusardi and Mitchell \(2011b\)](#) find a profound impact of financial (il-)literacy on individuals' ability to plan. Individuals with low financial literacy are found to be more likely to have problems with debt ([Lusardi and Tufano \(2015\)](#)), make inefficient portfolio choices ([Van Rooij et al. \(2011\)](#), [Hastings and Tejada-Ashton \(2008\)](#), [Guiso and Jappelli \(2009\)](#)), accumulate and manage wealth less effectively ([Stango and Zinman \(2007\)](#), [Hilgert and Beverly \(2003\)](#)), and use revolving consumer credit with high interest charges even in cases when they could immediately pay down all debt using their liquid assets ([Gathergood and Weber \(2014\)](#)).

There is ample evidence, in particular, that individuals do not fully understand their insurance contracts in almost all lines of insurance, e.g., reported by [Quantum Market Research for the Insurance Council of Australia \(2013\)](#) for Australian home insurance policies, [Policygenius \(2016\)](#)

⁹Even though, culture seems to impact levels of financial literacy, see, e.g., [Brown et al. \(2018\)](#).

for U.S. health plans, [The Guardian Life Insurance Company of America \(2017\)](#) for U.S. employee benefits packages. [Fairer Finance \(2018\)](#) describe numerous situations in which individuals are unaware of the specific risks covered under their insurance policy. One potential reason for illiteracy about insurance contracts is that insurance naturally pays out only in case of a loss, which is usually a low probability event. Hence, the return of insurance seems less easy to evaluate than that of many other financial products, as e.g. equity investments. Indeed, several studies provide empirical and experimental evidence that individuals exhibit substantial behavioral biases and high estimation errors when evaluating risks.¹⁰ Additionally, a large number of studies concedes that individuals do not read their insurance contracts *at all* ([White and Mansfield \(2002\)](#), [Ben-Shahar \(2009\)](#), [Becher and Unger-Avivram \(2010\)](#), [Cogan \(2010\)](#), [Eigen \(2012\)](#)). These empirical observations motivate our model of financial illiteracy.

Financial service providers could theoretically invest in decreasing the complexity of offered products, which may be specifically beneficial for less financially literate individuals. Yet, empirical and theoretical studies suggest that they face little incentives to do so. Several studies provide empirical evidence and rationalize that financial firms exploit unsophisticated individuals via unclear pricing methods ([DellaVigna and Malmendier \(2004\)](#), [Gabaix and Laibson \(2006\)](#), [Anagol and Kim \(2012\)](#), and [Campbell \(2016\)](#)), and that financially less literate individuals end up paying relatively higher prices because they do not completely understand the products' price structure ([Carlin \(2009\)](#)). Less financially literate individuals are typically endowed with a particular bias in theoretical studies. For example, [Carlin \(2009\)](#) distinguishes between financial experts who choose the *objectively* optimal product and uninformed customers who choose randomly. [Gabaix and Laibson \(2006\)](#) consider *myopic* individuals that neglect information about product add-ons and their price. Other studies directly assume that lower literacy maps to lower investment income, such as [Lusardi et al. \(2017\)](#). Our approach complements these models by introducing uncertainty as a channel for financial illiteracy to affect decision-making: while unsophisticated individuals may receive only partial information (e.g., about add-on prices in [Gabaix and Laibson \(2006\)](#) or the fine-print of insurance contracts), the missing information induces uncertainty. We show that the

¹⁰[Kunreuther et al. \(1978\)](#) find that individuals refrain from buying flood insurance even when it is greatly subsidized and priced below its actuarially fair value. [Johnson et al. \(1993\)](#) provide experimental evidence that individuals exhibit distortions in their perception of risk, as well as framing effects in evaluating premiums and benefits. More generally, [Kahneman and Tversky \(1979\)](#) show that individuals often overweight small probabilities.

demand effect of subjective uncertainty substantially depends on the interplay of second-order (risk aversion) and third-order (prudence) risk preferences. Uncertainty is thus an important determinant for decision-making of unsophisticated individuals.

Nudging individuals to obtain financial advice (Kramer (2016)) or investing into financial literacy education (Meier and Sprenger (2013)) have been mentioned to address issues of adverse economic outcomes for financially less literate individuals. Also, recent regulatory efforts have been targeted at ensuring that insurance companies do not exploit (financially illiterate) individuals. In 2016, the European Commission adopted new rules to increase price and cost transparency of insurance products. In order to ensure better consumer understanding, insurance contracts need to entail a one page easy-to-understand standardized insurance product information document (IPID) that explains key terms and contract details. In addition, intermediaries need to provide evidence that they only offer suitable products to their customers. The new rules became binding in October 2018 under the insurance distribution directive (IDD).¹¹ In the U.S., the NAIC formed the Transparency and Readability of Consumer Information (C) Working Group in 2010. In the following, almost all U.S. states established readability requirements, that often prescribe a maximum ratio of words per sentence and syllables per words (typically according to a minimum Flesch reading-ease score of 40), a minimum text size, and the use of definition sections.¹²

The most closely related literature to our study theoretically examines the impact of financial illiteracy on financial decision-making. Previous studies by Delavande et al. (2008), Jappelli and Padula (2013), Kim et al. (2016), Lusardi et al. (2017), and Neumuller and Rothschild (2017) predominantly focus on portfolio choice in partial equilibrium with fixed supply. We extend these studies by providing an in-depth analysis of insurance contracts and by endogenizing product complexity in a competitive equilibrium setting. Therefore, we complement, on one hand, the literature on insurance demand by the analysis of contract complexity (or, more generally, indemnity risk) and, on the other hand, the literature on equilibrium effects of financial literacy by highlighting the trade-off between individual disutility from contract complexity and firm costs to simplify insurance contracts. Building on our analysis, we propose a simple measure for the social cost of

¹¹See https://ec.europa.eu/info/business-economy-euro/banking-and-finance/insurance-and-pensions/insurance-distribution_en (last checked: April 11, 2019).

¹²Readability requirements are summarized in NAIC's Compendium of State Laws on Insurance Topics, Section III-MC-25 (2017).

financial illiteracy that is based on individuals' maximum willingness to pay to completely reduce financial illiteracy. This approach is not constrained to the insurance market but widely applicable and, thus, furthers the understanding of the economic costs of financial illiteracy.

Many studies of insurance demand interpret insurance contracts as pairs of two parameters, namely the insurance premium paid by the insured and the indemnity payment paid by insurers in case of a loss (e.g. see [Doherty \(1975\)](#)). We introduce contract complexity as a third characteristic of insurance contracts. Our modeling of contract complexity is consistent with the notion of indemnity risk introduced by [Lee \(2012\)](#). Lee derives a critical prudence level up to which partial coverage is optimal at actuarially fair premiums. We extend Lee's result in several dimensions: (a) We show the existence of a threshold for prudence such that more (less) prudent individuals demand more (less) insurance coverage due to indemnity risk - with and without premium loading -, (b) we examine comparative statics of insurance demand with respect to mean-preserving changes in indemnity risk, and (c) we derive a threshold for indemnity risk ε^* such that insurance demand *increases* with a mean-preserving increase in indemnity risk if $\varepsilon < \varepsilon^*$ for sufficiently prudent individuals and *decreases* if $\varepsilon \geq \varepsilon^*$ irrespective of prudence. Finally, we also endogenize indemnity risk in competitive equilibrium by relating it to firms' costs of simplifying insurance contracts.

Contract complexity (in the form of indemnity risk) is also similar to nonperformance risk to the extent that both feature uncertain indemnity payments.¹³ There is, however, an important difference between nonperformance risk and contract complexity, namely that nonperformance risk involves both a wealth effect and a risk effect (with lower expected and more variable payout for higher nonperformance risk), while complexity is (by our definition) a mean-preserving risk. As a consequence, as we show in [Appendix B](#), payout allocations resulting from contract complexity are disjunct from those resulting from contract nonperformance. Moreover, the comparative static of insurance demand with respect to contract nonperformance is typically ambiguous (e.g., [Doherty and Schlesinger \(1990\)](#), [Mahul and Wright \(2007\)](#)), while our model provides unambiguous comparative statics with respect to contract complexity.

One may interpret contract complexity as background risk to individuals' wealth in the loss

¹³Insurance demand in the presence of nonperformance risk is studied, e.g., by [Kahneman and Tversky \(1979\)](#), [Tapiero et al. \(1986\)](#), [Doherty and Schlesinger \(1990\)](#), [Briys et al. \(1991\)](#), [Wakker et al. \(1997\)](#), and [Zimmer et al. \(2018\)](#).

state.¹⁴ As [Fei and Schlesinger \(2008\)](#) show, prudent individuals increase insurance coverage upon the introduction of an uninsurable and coverage-independent background risk in the loss state. [Eeckhoudt and Kimball \(1992\)](#) introduce the term *precautionary insurance* to describe such an increase in insurance coverage due to background risk. The basic idea of precautionary insurance is analogous to precautionary saving ([Kimball \(1990\)](#)), namely that it transfers the background risk to a higher wealth level. In contrast to contract complexity, background risk is independent from insurance coverage, while the payout risk of complex contracts increases with insurance coverage. Therefore, our model together with its results substantially differs from background risk models. For example, [Fei and Schlesinger \(2008\)](#) show that prudence is sufficient for optimal insurance coverage to increase with coverage-independent background risk in the loss state. We show that prudence alone is not sufficient for contract complexity to raise insurance demand, but instead prudence must exceed a certain threshold in order to result in precautionary behavior. [Doherty and Eckles \(2011\)](#) examine insurance contracts with punitive damage awards, which also feature risky indemnity payouts. Such contracts can be interpreted as a combination of contracts with nonperformance risk and positive-mean background risk (see [Appendix B](#)) and, thus, also differ from contracts with complexity risk.¹⁵

3 A Model of Contract Complexity and Insurance Demand

3.1 Model

Individuals of mass one 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 twice 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.

Individuals believe that co-insurance contracts pay the indemnity $\alpha \tilde{I}$ for premium α , where

¹⁴Our model also resembles elements of general background risk ([Doherty and Schlesinger \(1983\)](#)) and basis risk in index insurance ([Clarke \(2016\)](#)). Complexity risk differs, however, in that it affects only the loss state, while general background and basis risk affect wealth in the no-loss state as well.

¹⁵Demand for actuarially fair contracts with punitive damage awards also differs, as, e.g., [Doherty and Eckles \(2011\)](#) show that partial coverage for actuarially fairly priced contracts is unambiguously optimal, while we show that complex contracts can result in demand for overinsurance.

$\alpha \geq 0$ and \tilde{I} is a non-negative (potentially degenerate) random variable. For simplicity, we focus on a symmetric binary indemnity distribution, that is without loss of generality parameterized by $\tilde{I} = I + \tilde{\vartheta}$ with $I > 1$ and $\mathbb{P}(\tilde{\vartheta} = \varepsilon) = \mathbb{P}(\tilde{\vartheta} = -\varepsilon) = 1/2$, $\varepsilon \geq 0$.¹⁶ Indeed, [Girolamo et al. \(2015\)](#) find that individuals often have symmetrically distributed beliefs about the correct answer to questions about financial and economic knowledge.¹⁷ Due to symmetry, an increase in ε is a mean-preserving increase in indemnity uncertainty ([Rothschild and Stiglitz \(1970\)](#)). To alleviate concerns about the restrictiveness of the assumption of a binary distribution for $\tilde{\vartheta}$, Appendix C shows that our main result also holds for more general distributions of $\tilde{\vartheta}$.

While it is possible to rationalize indemnity uncertainty, e.g., due to random interpretation of contract terms by claims adjusters ([Lee \(2012\)](#)) or courts ([Doherty and Eckles \(2011\)](#)), we interpret $\tilde{\vartheta}$ as the result of a behavioral bias of financially illiterate individuals that gives rise to uncertainty about an insurance contract’s terms. The complexity of contract language and exposition, low cognitive abilities, and imperfect knowledge of insurance terms blur individuals’ belief about the contract payout. Individuals form subjective beliefs about the indemnity payment $I + \tilde{\vartheta}$. We then interpret I as individuals’ subjectively expected unit indemnity payment conditional on their current information set. Thus, I does not necessarily (perfectly) reflect the actual contract terms. Individuals might underlie biases, such that $I = I^*(1 + \lambda)$ with I^* being the actual indemnity (specified by the contract) and $\lambda > -1$ being a bias by how much individuals’ expectations differ from the actual contract payment. For now, 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.¹⁸ We will make the stronger assumption that expectations are consistent with contract terms in Section 4.

Our model focuses on *uncertainty* about the indemnity as a channel for contract complexity and

¹⁶Our notation differs from classical models (such as used by [Doherty \(1975\)](#)) in the sense that we consider the indemnity payment in units of \$1 paid. This reflects the interpretation of our model as being from an individual’s perspective where prices are certain but the final indemnity payment is uncertain. The model is easily extended to allow for skewed background 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.

¹⁷Examples for these questions include “Suppose you had 100 in a savings account and the interest rate is 2% per year and you never withdraw money or interest payments. After 5 years, how much would you have on this account in total?” and “Based on 2010 National Statistics, if a man lived to be 20 in the United Kingdom, how many more years would he expect to live? Note that this is not the age he would die at, but how many more years he would expect to live.” [Girolamo et al. \(2015, p. 3\)](#).

¹⁸It is straightforward to show that optimal insurance coverage is positive if $I > 1 + \frac{1-p}{p} \frac{u'(w_0)}{u'(w_0-L)} > 1$.

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 (i.e., the larger is ε).¹⁹ We call ε the (experienced) *contract complexity* and assume that it is inversely related to the ease with which individuals understand an insurance contract (and accompanying explanatory material). Contracts with $\varepsilon > 0$ are *complex* contracts. In this section, we will fix I and vary contract complexity ε to assess the effect of a mean-preserving increase in uncertainty on insurance demand. In Section 4, we split $\varepsilon = \beta \times \nu$ (interpreted as the *experienced* complexity) into a contract's *actual* complexity ν , 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 β , namely the (inverse of the) ease at which individuals understand financial (and insurance-related) information in general (e.g., their cognitive abilities).

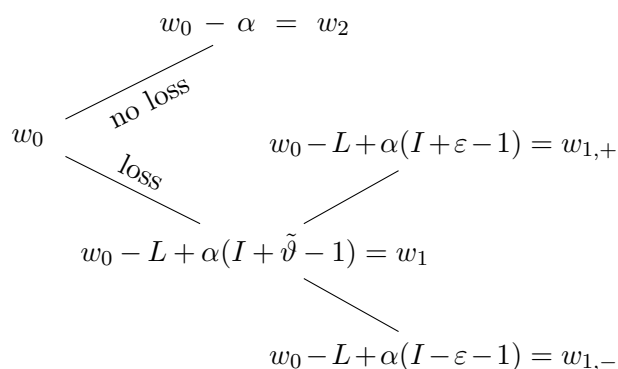


Figure 1: Distribution of individuals' wealth.

Figures 1 and 2 illustrate the resulting distribution of individuals' wealth. Upon purchasing α units of insurance, individuals pay the premium α . Without contract complexity ($\varepsilon = 0$), individuals receive the indemnity payment αI with certainty in the loss state. Otherwise ($\varepsilon > 0$), individuals face uncertainty about the actual indemnity payment and believe to receive either $\alpha(I + \varepsilon)$ or $\alpha(I - \varepsilon)$ in case the loss occurs.

The fact that individuals assign a positive probability to receiving *more* than I does not neces-

¹⁹This 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. \(2015, p.1\)](#)). In our model, ε^{-1} can be interpreted as the precision of individuals' knowledge about the insurance contract indemnity. Contract complexity as a behavioral bias implies that individual beliefs are not consistent with the ex post realization of contract payouts. It is straightforward to rationalize individual beliefs by assuming that the contract available to individuals is randomly drawn ex-ante from a large set of contracts (with different ε and indemnity payments) and is unobservable for individuals.

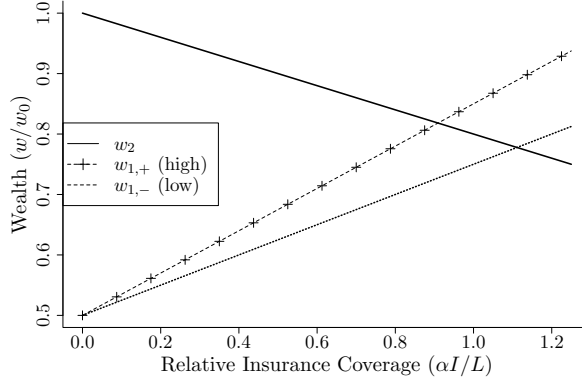


Figure 2: States of wealth for fixed coverage.

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 $\frac{1-pI}{pI} = 1/3$.

sarily imply that the insurance payment in this "good" state exceeds the 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 α , utility-maximizing coverage $\alpha^* > L/(I + \varepsilon)$ will simply imply that individuals demand the highest possible coverage up to α^* .

3.2 Insurance Demand

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

$$\begin{aligned}
 EU(\alpha, \varepsilon, I) &= p\mathbb{E}[u(\underbrace{w_0 - L + \alpha(I + \tilde{v} - 1)}_{=w_1})] + (1-p)u(\underbrace{w_0 - \alpha}_{=w_2}) \\
 &= \frac{p}{2} \left(u(\underbrace{w_0 - L + \alpha(I + \varepsilon - 1)}_{=w_{1,+}}) + u(\underbrace{w_0 - L + \alpha(I - \varepsilon - 1)}_{=w_{1,-}}) \right) + (1-p)u(\underbrace{w_0 - \alpha}_{=w_2}),
 \end{aligned} \tag{1}$$

We denote state-dependent utilities by $u_x = u(w_x)$, $u'_x = u'(w_x)$, $u''_x = u''(w_x)$, $u'''_x = u'''(w_x)$, where $x \in \{1; 1-, 1+, 2\}$. Note that the insurance contracts in our model are related - but not equivalent - to those with nonperformance risk since they involve the possibility that individuals receive less than expected (Doherty and Schlesinger (1990), Doherty and Eckles (2011)). As we

show in Appendix B, the payout structure of complex contracts with fixed $\varepsilon > 0$ is disjunct to that with nonperformance risk since the latter affects the expected indemnity payment while the first only affects uncertainty about the indemnity payment. Instead, our modeling of complexity is analogous to Lee (2012)'s modeling of indemnity risk.

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

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

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:

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

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), individuals with convex marginal utility (i.e., $u''' > 0$) are called *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. In line with the rationale of precautionary saving developed by [Rothschild and Stiglitz \(1971\)](#) and [Kimball \(1990\)](#), prudence might have two effects on insurance demand: on the one hand, risky payouts make insurance less effective in mitigating overall risk, which might reduce insurance demand. On the other hand, insurance transfers the payout risk to higher wealth levels and, thus, individuals might 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 3.1 (Insurance demand).

- (1) *If individuals are not prudent ($u'''(\cdot) \leq 0$), optimal insurance coverage decreases with the level of contract complexity ε .*
- (2) *For all $\varepsilon < I - 1$, optimal insurance coverage increases with ε if, and only if,*

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

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 ε .

The following corollary shows that condition (4) is in fact 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 3.1 (Precautionary insurance). *Let $\varepsilon < I - 1$ and $u''' > 0$. If*

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

optimal insurance coverage increases with the level of complexity ε , 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.²⁰

For insurance contracts with indemnity risk (such as stemming from contract complexity), Lee (2012) shows that a sufficiently small degree of prudence induces individuals to demand less than full coverage ($\alpha^*I < L$) when contracts are actuarially fairly priced ($pI = 1$). We extend his result and show that (a) insurance demand *increases* with indemnity risk ε if individuals are sufficiently prudent and ε sufficiently small, and (b) insurance demand *decreases* with indemnity risk ε if $\varepsilon > I - 1$ irrespective of the degree of prudence.

While Lemma 3.1 and Corollary 3.1 are for binary indemnity risk, in Appendix C we generalize the results and show that optimal insurance coverage increases with a mean-preserving increase (à la Rothschild and Stiglitz (1971)) in arbitrarily distributed indemnity risk if individuals are sufficiently prudent.

Corollary 3.1 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 $\varepsilon < I - 1$.²¹ In this case, less financially literate individuals will buy more insurance coverage in competitive equilibrium (under symmetric information) if insurance prices exclusively depend on insurance coverage.

Corollary 3.2. *Define contracts in coverage-price ($\alpha - P$) space. 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 ε at any 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.²² 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

²⁰Note 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.

²¹Following previous literature, in this corollary we slightly differ in our notation and separately vary contract price and insurance coverage for fixed expected indemnity I .

²²Calibrating 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 $RRA = 2$.

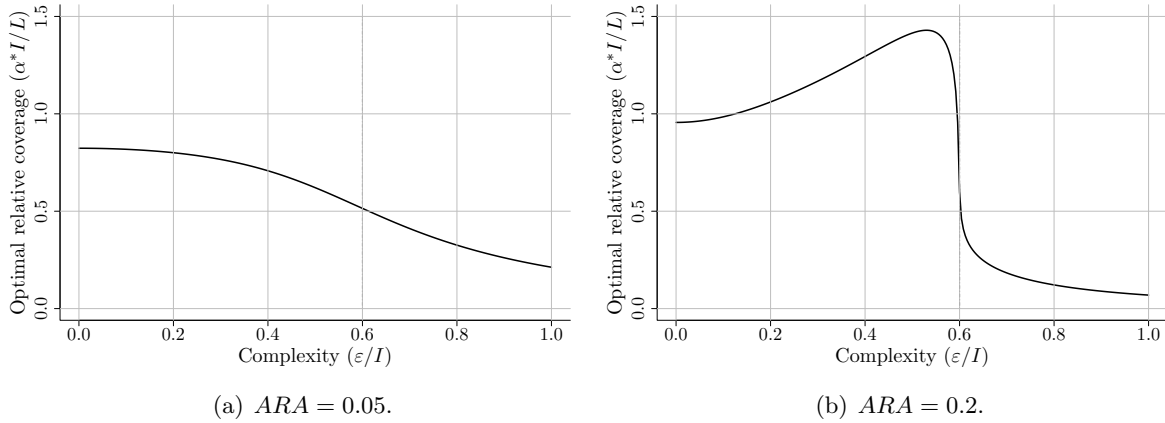


Figure 3: Optimal insurance coverage with respect to changes in complexity. The figures depict the optimal insurance coverage ($\alpha^* I$) relative to the loss size (L) for changes in the level of complexity (ε) relative to the expected indemnity payment (I). In this example, individuals with initial 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 $\frac{1-pI}{pI} = 1/3$.

with low prudence, as illustrated in Figure 3 (a). Hence, a relatively imprudent individual is not willing to accept additional overall risk 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, which is possible if $\varepsilon < I - 1$. If, however, the level of contract complexity is larger than the net payout of insurance, $\varepsilon > I - 1$, wealth in the worst possible state $w_{1,-}$ is decreasing with insurance coverage ($dw_{1,-}/d\alpha = I - \varepsilon - 1 < 0$ if $\varepsilon > I - 1$). In this case, individuals cannot raise wealth in $w_{1,-}$ by increasing insurance coverage, and 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. This finding distinguishes our results from models with insurance-independent background risk, which unambiguously results in precautionary insurance if

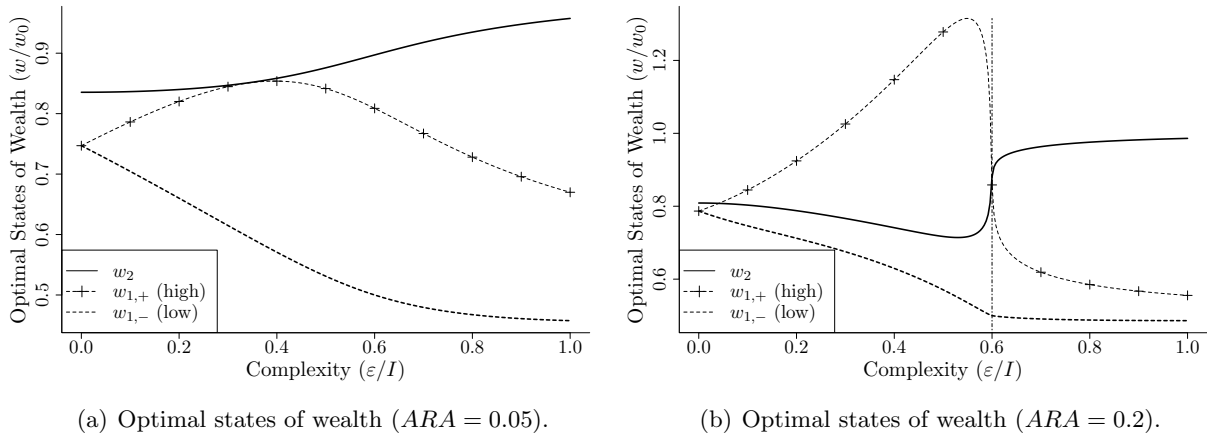


Figure 4: Optimal states of wealth with respect to changes in complexity.

The figures depict individuals' wealth (relative to the wealth endowment w_0) conditional on optimal insurance coverage for changes in the level of complexity (ε) 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 $\varepsilon = I - 1$.

individuals are prudent (e.g., [Eeckhoudt and Kimball \(1992\)](#), [Gollier \(1996\)](#), [Fei and Schlesinger \(2008\)](#)).

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, for a more prudent individual in Figure 4 (b), precautionary insurance amplifies the dispersion between the two possible loss states for $\varepsilon < I - 1$, while this effect reverses for $\varepsilon > I - 1$.

At the turning point, $\varepsilon = I - 1$, 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 $w_{1,-} = w_0 - L + \alpha(I - 1 - \varepsilon) = w_0 - L$. 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, analogous to the well-known binary insurance model ([Doherty \(1975\)](#)). In this case individuals cannot change wealth in the worst loss state $w_{1,-}$, decisions are driven by risk aversion only, and partial insurance coverage becomes optimal for $\varepsilon = I - 1$:

Corollary 3.3 ($\varepsilon = I - 1$). *Assume that $\varepsilon = I - 1$. 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 ($\alpha^*I < L$).

3.3 Overinsurance

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

Proposition 3.1 (Overinsurance). *If $\varepsilon \in (0, I - 1)$ and prudence is sufficiently large such that*

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

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

If contracts are perceived to include a proportional loading ($pI < 1$), the threshold for the average degree of prudence $-\frac{\bar{u}_1'''}{\bar{u}_1''}$ is increasing with $-\frac{u'(\mathbb{E}[w_1])}{\bar{u}_1''}$, which relates to the inverse of individuals' coefficient of absolute 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 positive level of contract complexity if they are sufficiently prudent:

Corollary 3.4. *Assume that insurance is perceived as actuarially fair ($pI = 1$) and let $\varepsilon \in (0, I - 1)$.*

Then, individuals demand overinsurance if

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

in equilibrium.

This result does not necessarily imply that, given individuals are sufficiently prudent, insurance firms *offer* overinsurance in equilibrium. Instead, the result only implies that individuals *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 3.1).²³

In practice, insurance companies usually do not offer overinsurance due to the principle of indemnity. This principle states that an indemnity payment should only replace the actual loss amount, thereby 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 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)).²⁴ Similarly, automobile insurance policies typically include the possibility to receive a fixed indemnity payment $\$K$ instead of the firm directly paying the 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.

4 Transparency Costs, Equilibrium, and the Welfare Cost of Illiteracy

Risk averse individuals prefer contracts without complexity, since

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

²³Thus, if firms offer contracts with coverage $\alpha \in \mathcal{C} \subseteq \mathbb{R}^+$ with $\max\{\mathcal{C}\} < \alpha^*$, individuals purchase $\max\{\mathcal{C}\}$, where α^* is the optimal coverage resulting from maximizing expected utility (1) for $\alpha \in \mathbb{R}^+$.

²⁴Special treatments may however be excluded from fixed per diem rating.

for all $\alpha > 0$. In this section, we address the question under which conditions contract complexity nevertheless exists in competitive equilibrium. We show that a positive level of contract complexity can occur in equilibrium if firms face transparency costs, i.e., if it is costly for firms to reduce contract complexity. Such transparency costs may arise, e.g., from preparing additional explanatory materials (such as key information documents), offering additional advice through brokers or service centers, or assessing whether the contract's terms and conditions can be simplified. New regulatory changes in the European Union make some of these measures mandatory (Hofmann et al. (2018)).

In our model, ε depicts individuals' uncertainty about the indemnity payout, i.e., the *experienced* level of contract complexity. We now split ε into two parts: contracts' *actual* complexity ν (e.g., the (inverse of the) use of simple language, figures, and tables) and individuals' financial illiteracy β (e.g., unsophistication and cognitive abilities). Then, experienced contract complexity is $\varepsilon = \beta\nu$. Firms choose the level of actual contract complexity $\nu \geq 0$, while $\beta \geq 0$ is exogenous. If $\beta = 0$, individuals do not experience any contract complexity, i.e., understand any contract regardless of its complexity ν .

4.1 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 ν with $\kappa' < 0$ and $\kappa'' > 0$. Marginally reducing the level of complexity (and thus increasing transparency) costs $-\kappa'$. Thus, the lower the complexity of contracts, the more costly it is to offer them. For example, there may exist a natural complexity level ν_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

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

Firms compete over payout I and contract complexity ν , and offer co-insurance contracts with indemnity payment αI , $\alpha > 0$, that make non-negative expected profit. Individuals choose optimal insurance coverage α among the contracts offered, while facing subjective uncertainty about the payout if they are financially illiterate ($\beta > 0$). Since we are interested 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 expected payout coincides with actual payout.²⁵

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

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

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

Since expected profit is strictly decreasing in payout I and increasing in complexity ε , 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 $\nabla^2 EU|_{\Gamma=0}$ is negative semi-definite.²⁶

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

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

²⁵Nonetheless, it is straightforward to extend our model to include a bias, e.g., that firms pay I but individuals expect it to be $(1 + \lambda)I$, on average.

²⁶While it is not straightforward to prove that $\nabla^2 EU|_{\Gamma=0}$ is negative semi-definite in general, we numerically compute the eigenvalues of $\nabla^2 EU|_{\Gamma=0}$ for the examples used below. For all relevant (α, ε) -pairs (given I to satisfy zero expected profits), we find that the eigenvalues are weakly below zero, reflecting negative semi-definiteness. Thus, in these cases, equilibrium is unique.

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

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

Since $\kappa' < 0$ and $pI < 1$ for $\Gamma = 0$ and $\kappa > 0$, the zero-profit curve is upward-sloping if transparency costs κ are sufficiently small to result in a small price loading $1-pI$ at $\Gamma = 0$ (or if insurance demand is sufficiently inelastic in payout I and sufficiently inelastic or increasing in complexity ε). Then, a reduction in complexity ε (i.e., an increase in transparency) is offset by a reduction in the payout I . If transparency costs κ 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

$$V(\varepsilon, I) = EU(\alpha^*, \varepsilon, I), \quad (14)$$

where α^* is optimal coverage for the respective (ε, I) -pair. The marginal rate of substitution between indemnity and complexity equals the slope of indifference curves,

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

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, $\left. \frac{dI}{d\varepsilon} \right|_{V=V(\varepsilon, I)} > 0$. Thus, the utility-gain from higher expected indemnity I offsets the utility-loss from higher complexity ε . The curvature of indifference curves is determined by

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

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.

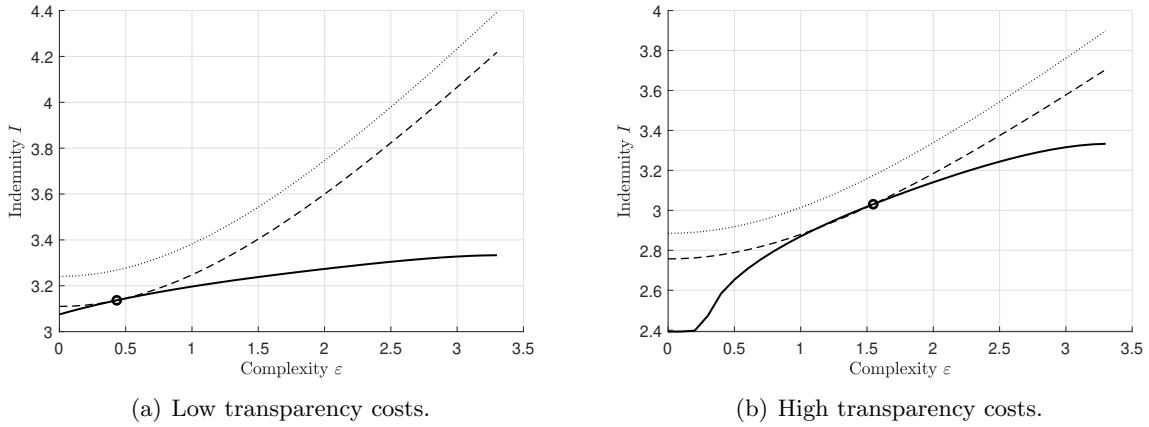


Figure 5: Break-even line (straight), indifference curves (dotted and dashed), and equilibrium contract (dot).

The zero-profit curve depicts all (ε, I) pairs of experienced complexity and expected indemnity with zero expected profit given optimal coverage α^* , respectively. An indifference curve depicts all (ε, 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.,

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

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

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

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

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 financially illiterate individuals demand a smaller level of complexity in equilibrium (as $\kappa'' > 0$). An inner 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 ε exists, it is an expected utility maximum since

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

For example, consider κ to be quadratic with a cost-minimal level of complexity ν_0 , such that $\kappa = k(\nu - \nu_0)^2$.²⁷ Then, the equilibrium level of actual contract complexity satisfies

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

and is positive if (a) transparency costs k (per unit deviation from ν_0) or (b) cost-minimizing contract complexity ν_0 are sufficiently large, and (c) the loss probability p and financial illiteracy β are sufficiently small, given positive insurance coverage $\alpha > 0$. Large marginal costs for deviating from the cost-minimal contract complexity ν_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 coverage α , loss probability p , and financial illiteracy β , the smaller is the impact of uncertainty about payout on expected utility and the larger is the reduction in indemnity I upon a decrease in ε 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.

²⁷We only consider $\nu \leq \nu_0$ in order to have transparency costs decreasing with complexity.

4.2 Welfare and the Financial Illiteracy Premium

We extend our analysis to estimate the welfare cost of financial illiteracy. For this purpose, we compare different levels of β , 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, not experiencing contract complexity at all. We assume that a unique transparency cost minimum ν_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, ν_0 might correspond to benchmark contracts that are available to firms without additional costs.

Generally, one may think about two notions of welfare. On the one hand, if only one individual increases its financial literacy (i.e., lowers β), she can improve her utility without changing the equilibrium allocation.²⁸ On the other hand, a policy intervention that increases all individuals' literacy will change the equilibrium allocation. In the following, we focus on the latter, arguably most policy-relevant, notion of welfare.

Since indifference curves in (ε, I) -space depend on experienced contract complexity $\varepsilon = \beta\nu$, a change in β does not alter the shape of indifference curves but that of zero-profit curves via the actual complexity $\nu = \varepsilon/\beta$: lower β increases the level of actual complexity ν to break even for a given ε and, thus, firms may offer higher indemnity I . Figure 6 illustrates this effect by a steeper slope of the zero-profit curve for small ε . In the case of quadratic transparency costs, for $\varepsilon > \beta\nu_0$ the implied actual complexity is larger than cost-minimum complexity, $\nu = \varepsilon/\beta > \nu_0$. Therefore, transparency cost increase again with higher contract complexity, resulting in a decreasing zero-profit curve for large ε in Figure 6. Due to the upward shift of the zero-profit curve for small ε , individuals attain a higher expected utility in equilibrium with low illiteracy β (point B) than with

²⁸For example, reducing the illiteracy to $\beta = 0$ will motivate her to maximize

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

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 the individual's willingness to pay c to reduce β to zero, namely

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

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.

large β (point A) since firms can offer more complex contracts with higher indemnity I for a given level of ε .

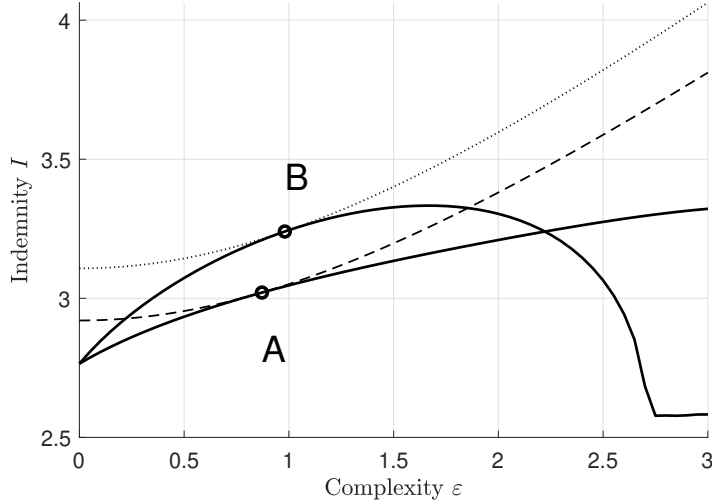


Figure 6: Break-even lines (straight), indifference curves (dotted and dashed), and optimal contracts (dots). Point A corresponds to equilibrium with $\beta = 1$, point B to equilibrium with $\beta = 0.5$.

Zero-profit curves depict all (ε, I) pairs of experienced complexity and expected indemnity with zero expected profit given optimal coverage α^* , respectively. Indifference curves depict all (ε, 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.

In the following, we focus on the welfare-loss reflected by the differential 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 (ε, I) -space is flat with $I = 1/p$ and individuals maximize

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

over coverage α . 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 as given by the *financial illiteracy premium* \mathcal{C} such that

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

where $EU^*|_{\beta=1}$ is the expected utility in equilibrium with financially illiterate individuals, $\beta = 1$. \mathcal{C} is individuals' 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 removing financial illiteracy. 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 $w_0 - L + \alpha^*(I^* - \varepsilon^* - 1) > 0$, since strictly concave utility then implies that

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

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

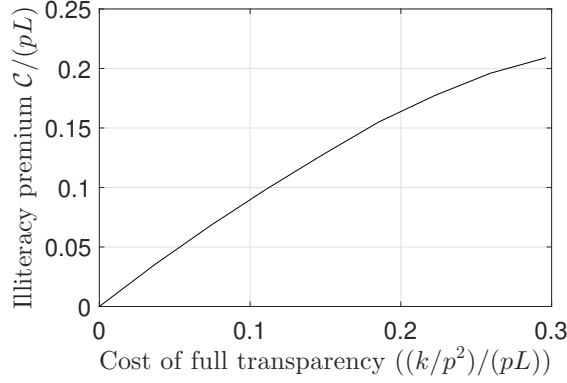
$$> p \frac{u(w_0 - L + \alpha^*(I^* + \varepsilon^* - 1)) + u(w_0 - L + \alpha^*(I^* - \varepsilon^* - 1))}{2} + (1 - p)u(w_0 - \alpha^*) \quad (28)$$

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

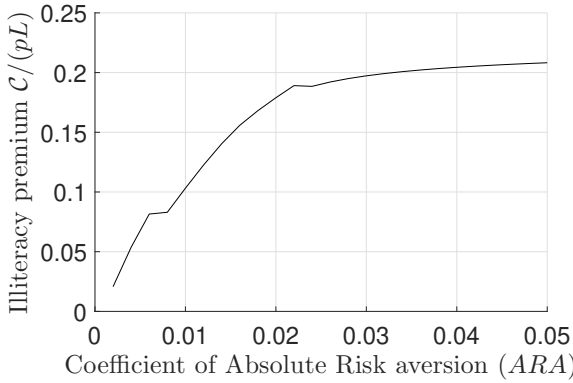
In Figure 7, we examine the sensitivity of \mathcal{C} toward different key parameters of the model. We rely on an exemplary baseline calibration: individuals have initial wealth $w_0 = 100$, maximize exponential utility with constant absolute risk aversion $ARA = 0.02$ and face a loss of $L = 50$ that 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 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 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.

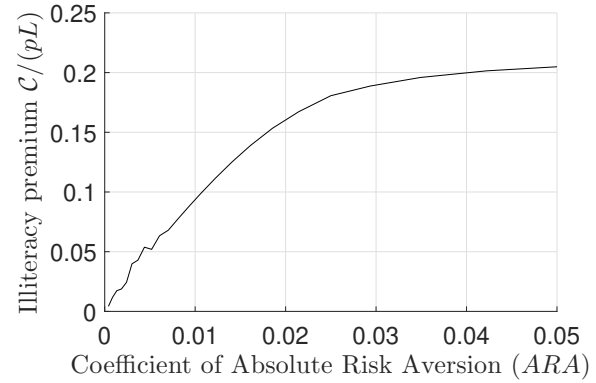
In Section 4.1 we show that financially illiterate individuals accept a high level of contract



(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) we maximize exponential utility with constant absolute risk aversion $ARA = 0.02$ which also equals the coefficient of absolute prudence, in (b) we maximize exponential utility with varying coefficient of absolute risk aversion ARA , in (c) we 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. It is $k = 0.3$ in Figures (b), and (c). Note that $ARA = 0.02$ corresponds to $RRA = 1.7$ at wealth $w_0 - pL = 85$.

complexity in equilibrium if marginal transparency costs κ' are large (in absolute terms). If marginal (absolute) transparency costs are small, firms are able to offer contracts with small complexity at low costs. Then, in equilibrium, individuals experience small complexity and purchase *close-to*-full insurance contracts at *close-to*-actuarially fair indemnity - approaching equilibrium with perfectly financially literate individuals. Therefore, the welfare cost of financial illiteracy is smaller if it is less costly for firms to reduce complexity, as Figure 7 (a) shows.

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 in payout. Therefore, in equilibrium with financially illiterate but relatively less risk averse individuals, these accept a high level of complexity in exchange for a large indemnity, while the difference in welfare to financially literate individuals is small due to small disutility from complexity.²⁹

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 (that we study in Section 3).

4.3 Policy Implications

Increasing consumers' understanding of insurance (contracts) is an important challenge and high priority objective for insurance regulators worldwide. Generally, one can think of two main ways to reduce welfare costs of financial illiteracy: 1) Transparency requirements for insurance firms to reduce 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.³⁰ 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.

²⁹In the extreme case, risk neutral individuals have no disutility from complexity.

³⁰Regulators 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> (last checked: April 13, 2019).

insurance market. Recently, the European Union mandated the creation of *Insurance Product Information Documents* (IPIDs), which overview key features of insurance contracts (i.e., obligations of all parties, claims handling, and insurance coverages) in a standardized presentation format.³¹ 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 as there is a trade-off for individuals between having lower complexity and accepting lower indemnity payouts in exchange for a further decrease in complexity. Thus, as a result from perfect competition, any deviation from the equilibrium level of contract complexity is welfare-decreasing, as the utility from smaller complexity does not offset the disutility from higher prices, and vice versa. Hence, transparency regulation that mandates firms to reduce contract complexity to levels lower than what the equilibrium dictates 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 baseline model calibration.

Nevertheless, one should not interpret our results as a pledge against transparency regulation. Instead, our analysis highlights that there is no room for welfare-increasing transparency regulation in frictionless markets 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. 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 (as, e.g., undertaken by [Gabaix and Laibson \(2006\)](#) and [Carlin \(2009\)](#)). Moreover, the insight that transparency regulation is not unambiguously welfare-increasing should motivate policymakers to

³¹See 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/> (last checked: April 13, 2019) as well as [Hofmann et al. \(2018\)](#).

define more precisely the specific market frictions and behavioral biases that regulation targets.

5 Conclusion

We examine insurance markets with individuals that are uncertain about the 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 (i.e., with a mean-preserving increase in uncertainty about indemnity payouts) if prudence exceeds this threshold, and vice versa. An increase in coverage due to increases in risk is commonly known as *precautionary insurance*.

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.

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. However, our benchmark results urge policymakers to carefully evaluate the specific frictions and biases they aim to address.

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Appendix

A Proofs

Proof of Lemma 3.1

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

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

Accordingly, we arrive at the following second order condition:

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

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

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

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

In the following, we do a case by case analysis depending on ε . Let $\underline{\varepsilon} < I - 1$. Then, it is $0 < I - \varepsilon - 1 < I + \varepsilon - 1$ and thus for $\alpha > 0$ ³²

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

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

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

³²From 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.

and thus (32) holds.

Let $\varepsilon \geq I - 1$. 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 ε .

(2) Assume that $\varepsilon < I - 1$ 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

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

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

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

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

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

□

Proof of Corollary 3.1:

Proof. Let $\varepsilon < I - 1$ and $u''' > 0$. Condition (4) in Lemma 3.1 is equivalent to

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

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). □

Proof of Corollary 3.2:

Proof. We disentangle the indemnity payment from the insurance premium, letting αI be the indemnity at coverage α 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 α at price P . The marginal rate of substitution along an indifference curve in $\alpha - P$ space is given by

$$\left. \frac{dP}{d\alpha} \right|_{EU=const} = \frac{p\mathbb{E}[u'_1(I + \tilde{\vartheta})]}{p\mathbb{E}[u'_1] + (1 - p)u'_2}. \quad (40)$$

Analogously to [Rothschild and Stiglitz \(1971\)](#), the impact of an increase in risk of $\tilde{\vartheta}$ (i.e., an increase in ε) 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 $\frac{\partial^2 u'_1}{\partial \tilde{\vartheta}^2} = \alpha^2 u'''$. $u'_1(I + \tilde{\vartheta})$ is strictly convex in $\tilde{\vartheta}$ if, and only if,

$$\frac{\partial^2 u'_1(I + \tilde{\vartheta})}{d\tilde{\vartheta}^2} = u'''(I + \tilde{\vartheta})\alpha^2 + 2u''_1\alpha > 0, \quad (41)$$

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 ε 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 α and price P the marginal rate of substitution is increasing with ε . \square

Proof of Corollary 3.3:

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

$$\frac{\partial EU}{\partial \alpha} = \frac{p}{2}u'_{1,+}2(I - 1) - (1 - p)u'_2 = 0 \quad (42)$$

$$\Leftrightarrow \frac{u'_{1,+}}{u'_2} = \frac{1-p}{I-1}. \quad (43)$$

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. \square

Proof of Proposition 3.1

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

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

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

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 $\bar{u}''' = \frac{u'_{1,+} - u'(\mathbb{E}[w_1]) - (u'(\mathbb{E}[w_1]) - u'_{1,-})}{4\alpha^2\varepsilon^2}$ 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

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

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

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

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

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

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 3.4

Proof. The result is a direct implication of Proposition 3.1. □

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

In this section, we highlight similarities and differences between our modeling 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}, π) , where $\mathcal{I} = (I_1, \dots, I_m), I_i \in [0, \infty)$, 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

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

with $\pi = (\frac{1}{2}, \frac{1}{2})$. Payout is linear in complexity ε . 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 $m \geq 0$)

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

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

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

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

Contract complexity and nonperformance risk result in different payout allocations. While contract payout is linear in the level of complexity ε , an increase in nonperformance risk (by a reduction in τ) disproportionately 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 τL , while it is linearly increasing in complexity ε 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 $\varepsilon > 0$.

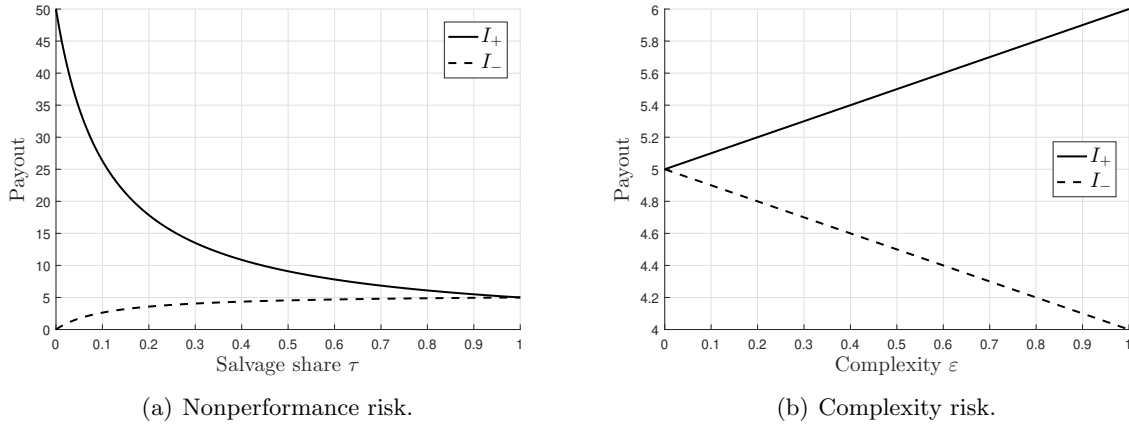


Figure 8: Comparison of contract payouts upon changes in nonperformance and complexity risk. Figures depict the dollar payout per 1\$ total premium payment of insurance contracts for loss probability $p = 0.2$.
(a) We assume a nonperformance probability of $q = 0.1$.

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 ε .*

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

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

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

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

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

[Doherty and Eckles \(2011\)](#) examine contracts with three different payouts upon loss occurrence: the insurer pays (1) the insured loss sL , (2) nothing, or (3) the insured loss and fixed punitive damages $sL + D$, with $s \in [0, 1]$ being the coverage level. The conditional probabilities are $\pi = (q_1, q_2, 1 - q_1 - q_2)$ and the premium is $P = mp(sL(1 - q_2) + D(1 - q_1 - q_2))$ with $sL(1 - q_2) + D(1 - q_1 - q_2)$ being the expected indemnity payment conditional on a loss. As [Doherty and Eckles \(2011\)](#) note, contracts with $D = 0$ are equivalent to nonperformance contracts with salvage value $\tau = 0$ and insolvency probability q_2 . Increasing $D > 0$ can be interpreted as an additional exogenous background risk with a positive mean. In a more general 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.

[Lee \(2012\)](#) examines insurance demand in the presence of indemnity risk. In his model, co-insurance contracts pay out (with the notation from above and scaled by total premium)

$$\mathcal{I}^{\text{indemnity risk}} = \left\{ \left(\frac{L + \tilde{\vartheta}}{mpL} \right)_{\tilde{\vartheta} \in \Omega} : m \geq 0 \right\} \quad (57)$$

for an arbitrary random variable $\tilde{\vartheta}$ distributed according to $F_{\tilde{\vartheta}}$ with support $\Omega \subseteq [\underline{\vartheta}, \bar{\vartheta}]$ and $\mathbb{E}[\tilde{\vartheta}] =$

0.³³ It follows that every family of complex contracts with $\varepsilon > 0$ is equivalent to a contract family with indemnity risk such that $m = (pI)^{-1}$, $\Omega = \{-\varepsilon\frac{L}{I}, +\varepsilon\frac{L}{I}\}$, and discrete distribution $F_{\tilde{\vartheta}}(\vartheta) = \frac{1}{2} \left(1_{\{-\varepsilon\frac{L}{I} \leq \vartheta\}} + 1_{\{\varepsilon\frac{L}{I} \leq \vartheta\}} \right)$. Therefore, complex contracts in our analysis are contracts with indemnity risk in the sense of Lee (2012).

Lee (2012) derives that a sufficiently small degree of prudence induces individuals to demand less than full coverage ($\alpha I < L$) when contracts are actuarially fairly priced ($pI = 1$). We extend his results and show for arbitrarily priced contracts that (a) insurance demand *increases* with indemnity risk ε if individuals are sufficiently prudent and ε is sufficiently small, and (b) insurance demand *decreases* with indemnity risk ε if $\varepsilon \geq I - 1$ irrespective of the degree of prudence.

C Generalized indemnity risk

The following proposition generalizes Lemma 3.1 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*

$$-\frac{u'''}{u''} > \frac{2}{\alpha(I - g - 1)} \quad (58)$$

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 α if

$$U_{\alpha} = pu'_1(I + \tilde{\vartheta} - 1) - (1 - p)u'_2 \quad (59)$$

³³Note that Lee (2012) focuses on continuous distributions $F_{\tilde{\vartheta}}$, while his results readily apply to discrete distributions as well.

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

$$\frac{\partial^2 U_\alpha}{\partial \tilde{\vartheta}^2} = 2p\alpha u''_1 + p\alpha^2 u'''_1(I + \tilde{\vartheta} - 1) > 0 \quad (60)$$

$$\Leftrightarrow -\frac{u'''_1}{u''_1} > \frac{2}{\alpha(I + \tilde{\vartheta} - 1)}, \quad (61)$$

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. \square