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Background Risk and Insurance Take-up under Limited Liability

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Abstract

We study the effect of a non-insurable background risk (BGR) on insurance take-up choices over insurable risks made by risk-averse agents under limited liability laws. This economic environment applies, for example, to the consumer's decision to purchase medical insurance in the face of non-insurable income risk under limited liability provided by bankruptcy. We consider two types of BGR - a wealth deteriorating risk and a mean-preserving risk. We show that the magnitude of both BGR types has a non-monotonic effect on the rate of uninsured consumers. This is in contrast with the standard monotonic effect of background risk on the demand for insurance, obtained for risk-averse agents under full liability.

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Key-words: Insurance take-up, Bankruptcy, Background Risk.

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†We have benefitted from comments by seminar participants at the ASHE 2018 conference at Emory and the Midwest Theory 2018 Spring and Fall meetings at Drexel and Vanderbilt.

‡This article is dedicated to the memory of Harris Schlesinger, a pioneer in the analysis of background risk and a mentor to many young researchers, including one of the authors.

1 Introduction

Developed economies use various legal rules that, intended or otherwise, serve to guarantee minimum levels of wealth to consumers, and to limit the ability of creditors to seize the property of impecunious persons. A prominent example is consumer bankruptcy law. In the United States and elsewhere, an adjudication of bankruptcy serves to discharge the debts of the insolvent creditor, who is simultaneously allowed to retain a certain amount of exempt property[1]. Such exemptions are often understood to facilitate a "fresh start" by the bankrupt debtor, and it is argued that it is in the public interest to allow such debtor forgiveness[2].

From the mathematical point-of-view, the presence of a liability limit which may be exceeded by the nominal value of debts introduces a truncation in possible outcomes/wealth levels, with an associated loss of concavity of expected utility. This complication has several important consequences. Sinn (1982) has shown that limited liability decreases the demand for insurance. Keeton and Kwerel (1984) derived similar results for a more detailed specification of drivers' demands for liability insurance. Gollier, et al. (1997) showed that limited liability induces (risk averse) firms to increase their exposure to risky investments, a finding generalizing the results of Golbe (1981). Beard (1990) demonstrated the a-intuitive effects limited liability can have on self-protection choice. Most relevant to our model, Sorek and Benjamin (2016) studied the implications of limited liability in health care markets arising from consumers' abilities to avoid paying medical bills under bankruptcy.

The present work elaborates on the previous studies of the implications of limited liability for a consumer's willingness to hedge against an insurable risk by introducing an additional, non-insurable, background risk - hereafter "BGR". Although most analyses of choice under uncertainty focus on a single source of risk, in the "real world" agents must invariably make such choices against a background of other, independent risks which may not be hedged. Such complications have attracted increasing theoretical scrutiny.

Doherty and Schlesinger (1983) were the first to study the implications of an uninsurable background risk for the demand for insurance (against insurable risk), showing that the effect depends crucially on the correlation between the two risks: a positive correlation between the two risks increases demand for insurance as a hedge against the additional correlated risk. When the two risks are negatively correlated, they are "offsetting", and the demand for insurance decreases.

Nevertheless, a recent work by Hoffman et al. (2018) shows that the effect of a correlation between risks on the demand for insurance may flip in the presence of limited liability. There, a positive correlation between the two risks increases the likelihood of bankruptcy under which actual losses are bounded, and thus the demand for insurance decreases. Their analysis, however, focuses on the case where the insurable risk is non-bankrupting and the BGR is.

The present work proposes three contributions to the literature on the effects of limited liability and BGR on the demand for insurance. First, it complements the studies by Dohertey and

[1] Jackson (1986), Chapter 2, gives an extensive analysis of such exemptions.
[2] See Currie (2009) for a discussion.

Schlesinger (1983) and by Hoffman et al. (2018), by analyzing the three remaining unexplored cases: 1) the case where both the BGR and the insurable-risk are bankrupting; 2) the case where only the insurable risk is bankrupting, and; 3) the case where only the joint realization of the two risks is bankrupting.

Second, the present work analyzes the effect of BGR on insurance take-up decisions under limited liability, made by heterogenous consumers over an insurance policy with a given defined coverage (i.e., the extensive margin), whereas the aforementioned studies focus on individual optimal insurance coverage choice (i.e., the intensive margin).

Third, whereas the aforementioned studies are confined to downside BGR, we generalize our main results also to the case of a mean preserving BGR.

Our analysis of insurance take-up decisions under limited liability is motivated by a contemporary debate that surrounds American healthcare policy. Prior to the implementation of the Affordable Care Act (ACA) in 2010, the large number of uninsured people in the United States was a focus of academic study and policy concern (Gruber 2008). The ACA provided health insurance coverage for about half of these 45 million uninsured American adults. Now, however, steps to eliminate the individual mandates and related mechanisms in the ACA, coupled with all-out efforts to repeal the entire law, again focus attention on the insurance take up decision.

Therefore, the present paper can be interpreted as an examination of the effects of non-insurable income (or wealth) risk on consumer decisions to purchase medical insurance when bankruptcy protection is available. Recent studies have provided both theoretical and empirical evidence on the importance of personal bankruptcy laws in the health insurance take up decision (Mahoney 2015; Sorek and Benjamin 2016), and the effects of a lack of medical insurance on consumers' financial stability (Gross and Notowidigdo 2011, Mazumder and Miller 2016, Hu et al. 2018, Gallagher et al. 2019). In particular, bankruptcy itself provides an informal (and incomplete) form of insurance against sufficiently large medical bills. However, the protection given by bankruptcy decreases with the consumer's wealth level, or her level of attachable assets. This, in turn, implies that bankruptcy serves as a substitute for medical insurance primarily for lower income families.

The BGR we study is bankrupting for consumers with sufficiently low income, but may not be bankrupting for high income consumers.[3] A medical insurance policy is typically designed by the insurers, and consumers cannot choose its coverage as freely as other insurance policies[4]. Hence, in this context our modelling of a uniform coverage policy seems appropriate. The non-insurable risk we have in mind is related to aggregate-macroeconomic uncertainty[5]. Therefore, we focus primarily on the case where insurable risk and non-insurable risk are not correlated (though we consider the possible implications of correlation in Section 4). Our goal in this analysis is to assess how medical insurance take-up is likely to change due to changes in the aggregate background risk, such as macroeconomic slow down, increased uncertainty in the financial (stock) markets, etc.

[3] By comparison, Hoffman et al. (2008) consider a non-bankrupting insurable risk along with a bankrupting background risk.

[4] In comparison, life insurance and automobile insurance typically offer a wide variety of policy limits.

[5] Job losses, employer pension defaults, and so on.

Our analysis yields a set of novel results. First, we show that, under limited liability, and in the presence of a bankrupting insurable-risk, introducing a small, non-bankrupting, wealth deteriorating BGR decreases a consumer's gains from insurance purchases, whereas the introduction of a large wealth deteriorating BGR decreases both postive gains from insurance and losses from insurance. Moreover, we show that if the limited liability becomes effective only under the joint realization of the insurable risk and the BGR, the effect of the BGR on consumers' gains from insurance depend's the relative size of the two risks and the consumer's wealth.

Next, we show the latter results establish a "non-monotonic" principle of insurance demand: the effect of the magnitude of the wealth deteriorating BGR on aggregate insurance take-up is not monotone. As the magnitude of the BGR increases, the rate of uninsured consumers is first increasing, but at a certain loss level it starts decreasing, and for a sufficiently large wealth deteriorating BGR, the proportion of consumers who buy insurance simply returns to its level in the absence of any BGR. We show also that the effect of the likelihood of the BGR (the probability of realization) on the rate of uninsured consumers depends on the magnitude of the risk. Then, we generalize the aforementioned results for the case of a mean-preserving spread BGR,[6] and for correlated risks.

Our finding of non-monotone effects for the introduction of background risks reinforces the finding of Fei and Schlesinger (2008) on the effect of a state-dependent BGR on the demand for insurance. In their work, the size of a zero mean BGR can vary in different insurable-loss states. They show that a prudent individual could buy either more insurance or less insurance than with no BGR, depending on the relative size of the BGR in the loss states vis-a-vis the no-loss states.

The remainder of the paper is organized as follows: Section 2 models the economic environment; Section 3 studies the effect of wealth deteriorating BGR and mean-preserving BGR on insurance take up choices under limited liability; Section 4 extends the analysis for the case where the insurable risk and the BGR are correlated; Section 5 concludes.

2 The Model

Agents act to maximize their expected utilities. All agents have the same preferences, but differ in their initial wealth levels. An agent's utility from wealth is $u(\cdot)$, where $u'(\cdot) > 0$ and $u''(\cdot) < 0$, so agents are assumed to be risk averse. Initial wealth, denoted w, is subject to a medical risk ("MR") that is insurable, and a non-insurable BGR to wealth to be further specified below. The MR is discrete, imposing medical expense $M > 0$ with probability $\pi \in (0, 1)$. The stochastic medical expense can be insured against for an actuarially fair premium $p = \pi M$. Any downward risk is bounded by limited liability, such as consumer bankruptcy, under which net wealth cannot fall below the level B. We assume that wealth is subject also to a discrete, non-insurable risk which hits consumers with probability ρ and magnitude L, the BGR.

We are elaborating on the framework developed by Sorek and Benjamin (2016) to study insurance purchase decisions on the extensive margins. However, our modeling approach of the insurable

[6] A related study by Eeckhoudt et al. (1996) highlights the effects of both wealth deteriorating BGR and mean preserving BGR, on the degree of risk aversion toward the insurable risk.

risk and the BGR is similar to that employed by Doherty and Shclesinger (1983), Fei and Schlesinger (2008), and Hoffman et al. (2018) in their studies of the individual consumer's intensive demand for insurance in the face of a BGR. The exact nature of the modeled BGR is clarified in the following section.

3 Insurance take up with non-correlated risks

3.1 The benchmark model with no background risk

Under the above specifications, we study consumers' insurance take up choices. We denote the consumer's expected utility with and without medical insurance $E_I(u)$ and $E_{UI}(u)$, respectively, and the the consumer's utility gain from buying insurance, $\triangle E(u) \equiv E_I(u) - E_{UI}(u)$. Under limited liability with no BGR, the consumer's utility gain from buying insurance is $\triangle E(u) = \underbrace{u(w-p)}_{E_I(u)} - [\underbrace{(1-\pi)\,u(w) + \pi u(B)}_{E_{UI}(u)}]$.

Lemma 1 *Under limited liability with no BGR, the consumer's gain from buying insurance is increasing with wealth level.*

Proof. The derviative $\frac{\partial \triangle E(u)}{\partial w}$ is given by $u'(w-p) - (1-\pi)\,u'(w)$, which is positive for risk averse consumers (i.e. under the assumption $u''(\cdot) < 0$). ■

For the wealth level $w > B + M$ the bankruptcy option is not viable and consumer liability for uninsured medical bills is complete, i.e., unlimited. Then the utility gain from buying insurance for a fair risk premium is positive for any risk averse consumer, i.e., $\triangle E(u) = \underbrace{u(w-p)}_{E_I(u)} - [\underbrace{(1-\pi)\,u(w) + \pi u(w-M)}_{E_{UI}(u)}]$.

Lemma 2 *Under unlimited liability with no BGR, the utility gain from buying insurance is positive for risk averse consumers, and may be increasing, decreasing (or constant) in wealth, depending on whether the marginal utility from wealth, $u'(\cdot)$, is a concave, convex, or linear function.*

Proof. When facing a financial risk and an actuarially fair risk premium, the utility of a risk averse consumer is maximized under complete insurance coverage, i.e. the gain from insurance purchase is positive. The derivative $\frac{\partial \triangle E(u)}{\partial w}$ is given by $u'(w-p) - [(1-\pi)\,u'(w) + \pi u'(w-M)]$, which is positive, negative, or zero, depending on whether the marginal utility form wealth, $u'(\cdot)$, is a concave, convex, or linear function (i.e. if $u'''(\cdot) < 0$, $u'''(\cdot) > 0$, or $u'''(\cdot) = 0$), respectively. ■

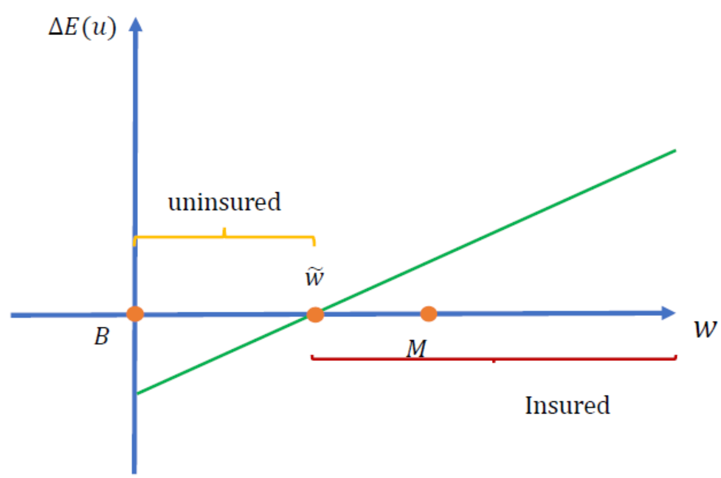
Lemmas 1 and first part of Lemma 2 imply that[7], under limited liability with no BGR, there exists a unique wealth level $\tilde{w} \in (B, B+M)$ above (below) which everyone (no one) buys insurance. This is because limited liability provides partial insurance (by limiting potential losses) which is decreasing with initial wealth level. For a wealth level that approaches the exception level B,

[7] The second part of Lemma 2 will be useful for the analysis of cases #4-5 below.

bankruptcy provides full insurance at no cost, hence the gain from insurance purchase at this wealth level is negative. However, as a consumer's wealth approaches the level $B+M$, the protection provided by the bankruptcy option goes to zero and, therefore, the gain from buying insurance is positive. Then, the continuity of $\triangle E(u)$ in w implies the unique $\tilde{w} \in (B, B+M)$ above (below) which everyone (no one) buys insurance. Lemma #2 implies that, for a prudent consumer, the utility gain from insurance under unlimited liability, with no BGR, is decreasing in consumer's wealth.

Figure 1 illustrates the insurance take-up choices made by consumers of different wealth levels, and the wealth cutoff level that separates the insured consumers population from the uninsured ones. For the sake of simplicity, the exact shape of the curve (as defined in Lemma 2) is abstracted in all figures presented below, and the curves are drawn in a linear fashion[8].

Figure 1: Insurance take-up with no background risk



In what follows, we study the effect of a non-uninsurable BGR on consumers' willingness to buy actuarially fair medical insurance. We start with a wealth deteriorating BGR, and then move to a mean preserving spread. In this section we focus on the case were the insurable risk and the BGR are uncorrelated. In Section 4 we explore the implications of correlation.

3.2 Wealth deteriorating background risk

We study a discrete wealth deteriorating BGR which decreases wealth by L. The BGR hits each consumer, independently, with probability $\rho \in (0,1)$. We will explore the impact of introducing uninsurable BGR on consumers' gains from purchasing medical insurance, as presented in Figure 1.

[8] By Lemma 2, for prudence consumers, the gain from insurance purchase curve is decreasing in wealth beyond the wealth level $w = B+M$ (where consumer liability for uninsured medical bills is not limited under bankruptcy). It can be further shown that in this case the curve is concave below this wealth level (and yet monotonically increasing) .

For any given MR, M, the introduction of a given wealth deteriorating risk may have different implications for consumers of different wealth levels. Any given magnitude L defines a wealth range over which the risk is bankrupting on its own ($w < B+M, B+L$); a wealth range over which only a joint realization of both risks is bankrupting ($B+M, B+L < w < B+M+L$); and a wealth range over which bankruptcy is not a possible outcome ($B+M+L < w$). For $L < M$ ($L > M$), there is a wealth range for which the MR is bankrupting and the BGR is not ($B+L < w < B+M$). Conversely, for $L > M$ there is also a wealth range over which the BGR is bankrupting and the MR is not ($B+M < w < B+L$).

Figure 2 illustrates the relation between a consumer's wealth, risk magnitudes, and the possiblity of bankruptcy (the wealth axis is normalized to the bankrupcty level B).

Figure 2: Wealth and bankrupting risks

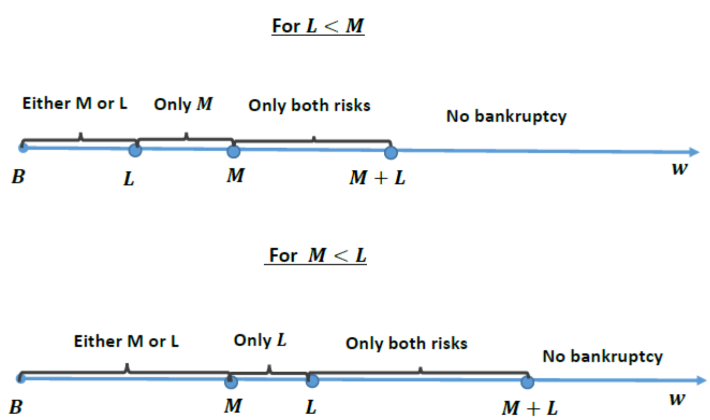


Figure 2 shows five alternative combinations of risk realization and bankruptcy (or non-bankruptcy) outcomes. Whenever a risk $R_j = \{M, L\}$ is bankrupting (not bankrupting) on its own, i.e. $B + R_j < w$ ($B + R_j > w$), we will consider it as "Small" ("Large") and denote it "SMR" or "SBGR" ("LMR" or "LBGR").

Each of the four alternative combinations of risk magnitude has a corresponding wealth range in Figure 2. In reference to the wealth range for which each risk is too small to cause bankruptcy but their joint realizing is bankrupting, we will consider the BGR as "jointly bankrupting", and will denote it as JBGR. In what follows, we will consider the effect of introducing MRs and BGRs of different magnitudes on the consumer's gain from purchasing medical insurance.

Case 1: SBGR and LMR ($B+L<w<B+M$).

For this case, a consumer's expected utilities with and without medical insurance can be written as

$$\begin{aligned} E_I(u) &= \rho u(w-p-L)+(1-\rho)\,u(w-p) \\ E_{UI}(u) &= [(1-\rho)\,\pi+\rho\pi]\,u(B)+(1-\pi)\,(1-\rho)\,u(w)+\rho\,(1-\pi)\,u(w-L) \end{aligned} \tag{1}$$

Hence, the consumer's utility gain from buying insurance, $\triangle E(u) \equiv E_I(u) - E_{UI}(u)$, is

$$\begin{aligned} \triangle E(u) &= (1-\rho)\,[\underbrace{u(w-p)-\pi u(B)-(1-\pi)\,u(w)}_{\triangle E \text{ with no BGR}}]- \\ & \quad -\rho[\underbrace{u(w-p)-u(w-L-p)+(1-\pi)[u(w)-u(w-L)]}_{\text{positive and increasing with } \rho \text{ and } L}] \end{aligned} \tag{1a}$$

Equation (1a) implies that in the presence of a bankrupting insurable risk, the introduction of a non-bankrupting wealth deteriorating background risk decreases gains from insurance purchase. That is for $B+L<w<B+M$, $\frac{\partial\triangle E(u)}{\partial L}, \frac{\partial\triangle E(u)}{\partial\rho}<0$. To see that, notice that the sum of the first three addends in (1a) is the gain from having medical insurance when there is no background risk. The concavity of $u(\bullet)$ and fair insurance pricing imply that the expression in the brackets in (1a) is positive and increasing with L ($\forall L>0$). Hence, the gains from insurance take up are decreasing in both the likelihood of a wealth deteriorating risk ρ, and its magnitude L.

Case 2: LBGR and LMR, $w<L+B, M+B$.

Consumer's expected utility with and without insurance are given by

$$E_I(u) = \rho u(B)+(1-\rho)\,u(w-p) \tag{2}$$

$$E_{UI}(u) = [\pi+\rho\,(1-\pi)]\,u(B)+(1-\pi)\,(1-\rho)\,u(w)$$

Therefore, the gain from buying insurance in this case can be written as

$$\triangle E(u) = (1-\rho)\left[\underbrace{u(w-p)-\pi u(B)-(1-\pi)\,u(w)}_{\triangle E \text{ with LMR and no BGR}}\right] \tag{2a}$$

Inspection of (2a) reveals that the expression in the brackets is the utility gain from insurance when there is no background risk at all. Hence, in the presence of a bankrupting insurable risk, the introduction of a bankrupting BGR decreases (increases) gains from insurance for the initially insured (uninsured). That is, for $\triangle E(u)>0$ ($\triangle E(u)<0$): $\frac{\partial\triangle E(u)}{\partial\rho}<0$ ($\frac{\partial\triangle E(u)}{\partial\rho}>0$).

Case 3: SMR and LBGR ($M < w - B < L$)

Here, the consumer's expected utilities with and without medical insurance are given by

$$\begin{aligned} E_I(u) &= \rho u(B) + (1-\rho)\, u(w-p) \\ E_{UI}(u) &= (1-\rho)\left[\pi\,(w-M) + (1-\pi)\, u(w)\right] + \rho u(B) \end{aligned} \tag{3}$$

and the gain from buying insurance is given by

$$\triangle E(u) = (1-\rho)\left[\underbrace{u(w-p) - \pi\,(w-M) - (1-\pi)\, u(w)}_{\triangle E \text{ with SMR and no BGR } \Longrightarrow \triangle E>0}\right] \tag{3a}$$

Inspection of equation (3a) reveals that in the presence of a non-bankrupting insurable risk, the introduction of a bankrupting wealth deteriorating background risk decreases gains from insurance. That is, for $M < w-B < L$: $\frac{\partial \triangle E(u)}{\partial \rho} < 0$. This result corresponds with the one reported by Hoffman et al. (2018) for the case of uncorrelated risks.

Case 4: JBGR ($M, L < w - B < L + M$)

Recall that this is the case where only the realization of both risks is bankrupting. For this case the expected utilities with and without medical insurance are

$$\begin{aligned} E_I(u) &= \rho u(w-p-L) + (1-\rho)\, u(w-p) \\ E_{UI}(u) &= \pi\,(1-\rho)\,(w-M) + \pi\rho\,(B) + (1-\pi)\,(1-\rho)\, u(w) + (1-\pi)\,\rho u(w-L) \end{aligned} \tag{4}$$

and the consumer's utility gain from buying insurance is

$$\begin{aligned} \triangle E(u) &= (1-\rho)\underbrace{\left[u(w-p) - \pi u\,(w-M) - (1-\pi)\, u(w)\right]}_{\triangle E \text{ with SMR and no BGR}} + \\ &\quad +\rho\underbrace{\left[u(w-p-L) - \pi u\,(B) - (1-\pi)\, u(w-L)\right]}_{\triangle E \text{ with LMR and no BGR for for wealth } (w-L)} \end{aligned} \tag{4a}$$

Equation (4a) shows that the utility gain from insurance purchase under a JBGR is the weighted average of the terms in the two brackets. The term in the first bracket is the gain from insurance under SMR and no BGR, and therefore it is positive. The term in the second bracket is the gain from insurance under LMR and no BGR for the income level $\widehat{w} \equiv w - L > B$, and by Lemma 1 it is decreasing with L, that is $\frac{\partial \triangle E(u)}{\partial L} < 0$, and it can be either positive or negative depending on the whether $\widehat{w}$ is great or smaller than $\widetilde{w}_0$. For $L < M - \widetilde{w}_0$ the sign of the term in the second bracket of (4a) is guaranteed to be positive as $\widehat{w} > \widetilde{w}_0$ for entire relevant wealth range $w \in (M+B, M+L+B)$. Then, however, Lemma 1 and Lemma 2 imply that for the lower (upper) end of the relevant wealth range the consumer's gain from insurance is decreasing (increasing) with the probability of the BGR, that is $\frac{\partial \triangle E(u)}{\partial \rho} < 0$ ($\frac{\partial \triangle E(u)}{\partial \rho} > 0$). However, for $M - \widetilde{w}_0 < L < M$ there is a range on the lower end of the relevant wealth interval, for which the sign of the term in the second bracket of (4a) turns negative, whereas for wealth levels from the upper end of this interval its sign is positive. This is also the case if $L > M$. Given that the term in the second bracket of (4a) is negative, for a sufficiently high ρ the consumer gain from insurance under JBGR is also negative. Hence, for sufficiently small L and ρ the consumer's gain from insurance purchase is positive under JBGR. However, for sufficiently large values of L and ρ the consumer's gain from insurance under JBGR is negative (positive) for low (high) wealth levels within the range $M, L < w - B < L + M$.

Case 5: SMR and SBGR **(**$B + M + L < w$**)**

This is the case where bankruptcy is not possible. The consumer's expected utilities with and without medical insurance are

$$
\begin{aligned}
E_I(u) &= \rho u(w-p-L) + (1-\rho)\, u(w-p) &(5)\\
E_{UI}(u) &= (1-\rho)\,\pi\,(w-M) + \pi\rho\,(w-M-L) + (1-\pi)\,(1-\rho)\, u(w) + \rho\,(1-\pi)\, u(w-L)
\end{aligned}
$$

and the utility gain from insurance purchase is

$$
\begin{aligned}
\triangle E(u) &= (1-\rho)\underbrace{\left[u(w-p) - \pi u\,(w-M) - (1-\pi)\, u(w)\right]}_{\triangle E>0 \text{ with SMR and no BGR}} + &(5a)\\
&\quad +\rho\left[\underbrace{u(w-p-L) - \pi u\,(w-M-L) - (1-\pi)\, u(w-L)}_{\triangle E\,>0 \text{ with SMR and no BGR for wealth level } w-L}\right]
\end{aligned}
$$

Equation (5a) shows that the gain from purchasing insurance under SMR and SBGR is the weighted sum of the positive gains from insurance with SMR with no BGR under two income levels: w and $\widehat{w} \equiv w - L > B$. By Lemma 2, the gains from insurance for prudent consumers are decreasing with income level. Hence, they are increasing with the magnitude and the likelihood of the BGR, ρ. Therefore, in the presence of a non-bankrupting insurable risk, the introduction of a non-bankrupting BGR increases utility gain from insurance purchase for prudent consumers. That is, for $B + L + M < w$: $\frac{\partial \triangle E(u)}{\partial L}, \frac{\partial \triangle E(u)}{\partial \rho} > 0$.

The following table summerizes the results presented in equations (1a)-(5a).

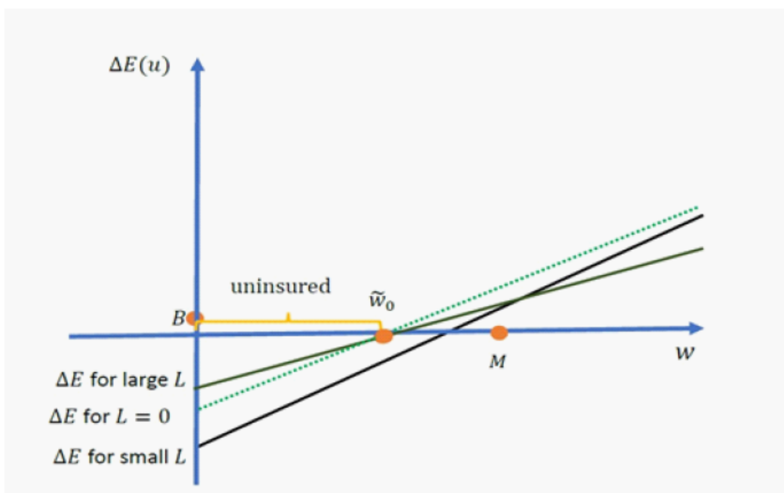
Table 1: The effect of wealth deteriorating BGR on gains from insurance purchase

	LMR	SMR
$LBGR$	depends on w	$(-)$
$SBGR$	$(-)$	$(-)$
$JBGR$	NA	depends on w and L

Thus far, we have considered "small" and "large" BGR separately. However, any specific BGR $L < M$, is "large" to consumers in the wealth range $w < B+L$ (i.e., it would lead to bankruptcy by itself), and is "small" or "jointly bankrupting" to all other consumers. However, as the magnitude of the BGR increases more consumers consider it "large". We will explore now the implications of the results summarized in Table 1, for the relation between the size of the BGR risk L and the demand for medical insurance, and the rate of uninsured consumers.

In what follows, we present a diagrammatic analysis the effect of an increasing BGR-magnitude on insurance take-up and the population of uninsured consumers, based on the effect of the BGR on the consumer's gain from insurance and characterized in equations (1a)-(5a). We start with the case where, under a JBGR, consumers have a positive gain from buying insurance. In this case the uninsured population is confined to consumers who are subject to LMR and either SBGR or LBGR; hence, we can confine our diagrammatic presentation and analysis to the corresponding equations, (1a)-(2a).

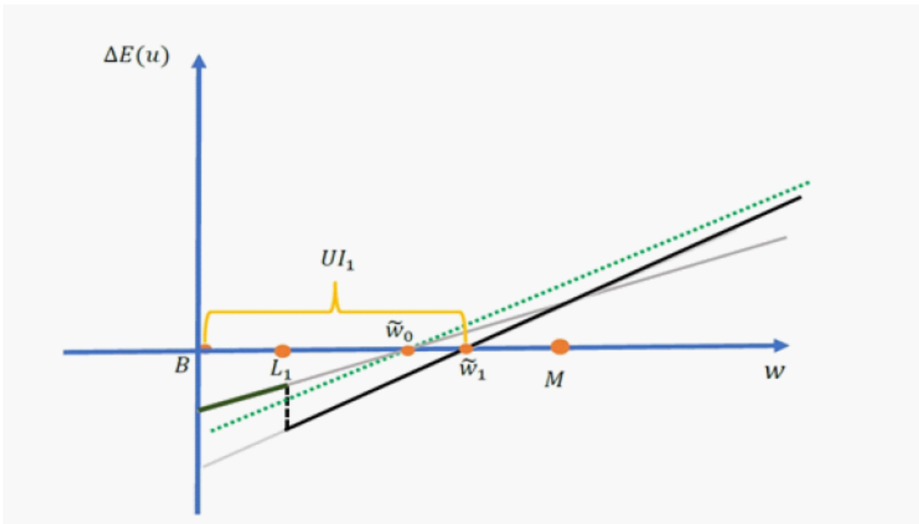
Figure 3: The gains from insurance purchase under small and large BGR



The dashed line shows the gains from insurance purchases, for consumers of different wealth levels, when there is no BGR (i.e. $L = 0$, as presented in Figure 1) - hereafter the "NBGR line". The steeper, dark, line shows the gains from insurance purchase under a given small BGR - hereafter the "SBGR line" : in accordance with Proposition 1 the SBGR line shows the decrease in the gain from insurance when facing a SBGR. The flattest line shows the gains from insurance purchase under a given LBGR: in accordance with equation (2a) and Proposition 2, the LBGR line is a rotation of the NBGR line around the income level of the marginal insured $\widetilde{w}_0$.

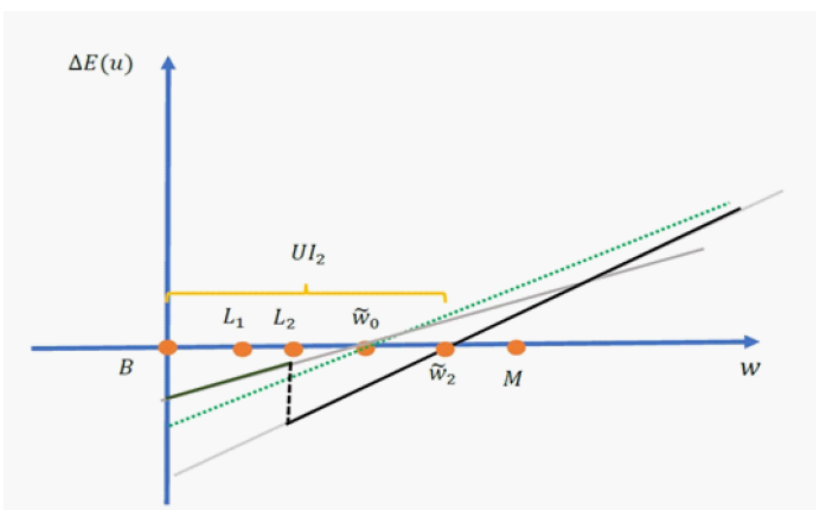
Next, we illustrate the non-monotonic effect of the magnitude of the BGR L on the proportion of uninsured consumers. For an arbitrary small BGR, an arbitrarily large share of consumers uses the SBGR line in making their insurance purchase choices. As the magnitude of the BGR, L, increases, the uninsured population increases. However, as L keeps increasing, for a non-neglible (and increasing) fraction of consumers from the lower end of the wealth distribution, the LGBR line becomes relevant for insurance take-up choice. Figure 4 shows insurance take up choice for BGR $L_1 < \widetilde{w}_0$, and the resulting uninsured population, $\widetilde{w}_1$.

Figure 4: Insurance take-up for $L_1 < \widetilde{w}_0$



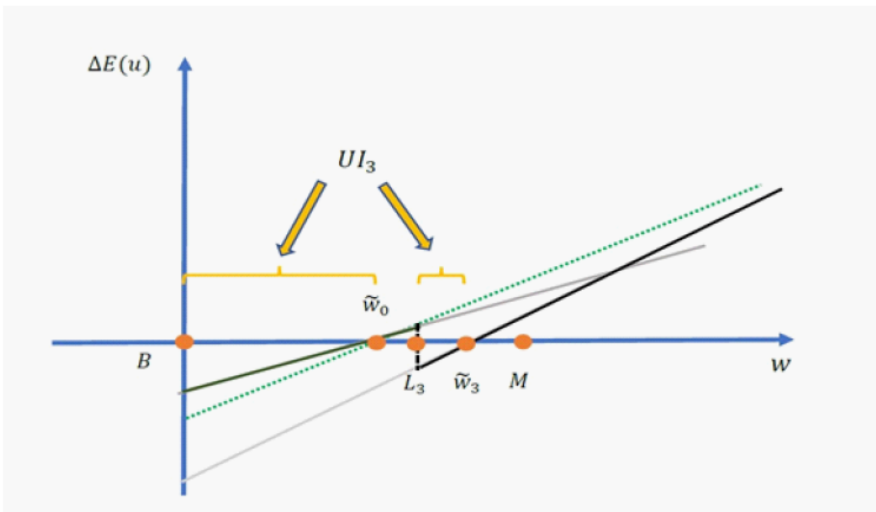
For all consumers with $w < L_1$ ($w > L_1$), the BGR L_1 is "large" ("small"), and therefore, their insurance take-up choice is made according to the relevant segment of the LBGR (SNGR) line. As the BGR increases to $L_2 > L_1$, the SBGR line shifts further downward and the LBGR line flattens out, rotating around the $\widetilde{w}_0$ point. Consequently, for any $\widetilde{w}_0 > L_2 > L_1$ insurance take-up is decreasing with the magnitude of the BGR, i.e. $\widetilde{w}_2 > \widetilde{w}_1$. Figure 5 illustrates this negative effect of BGR on insurance take-up for this case.

Figure 5: Insurance take-up for $L_1 < L_2 < \widetilde{w}_0$



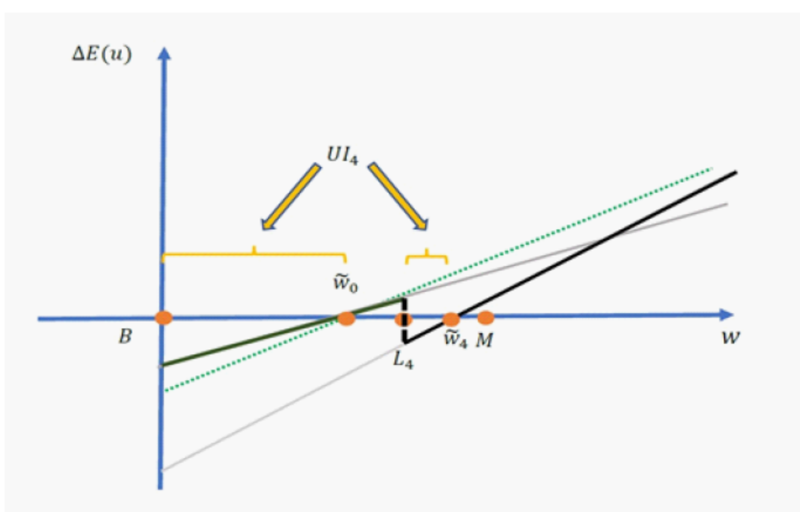
Consider now a further increase in the magnitude of the BGR, so that $M > L_3 > \widetilde{w}_0$, the population of uninsured consumers is split between two disjoint wealth intervals, and it starts decreasing from below with L. This case is illustrated in Figure 5.

Figure 5: Insurance take-up for $M > L_3 > \widetilde{w}_0$



As L further increases toward M, the population of the uninsured will eventually start decreasing toward its initial level. Such an overall decrease in the uninsured population is illustrated in Figure 6, which should be compared with Figure 5.

Figure 6: Insurance take-up for $M > L_4 > L_3$



As the magnitude of the BGR keeps increasing and a large fraction of the consumer population is subject to the LBGR line, the rate of uninsured consumers keeps falling and converging to its initial level, $\widetilde{w}_0$ - for $L \geqslant M$ it is guarenteed that the convergence is complete.

The effect of increasing the likelihood of the BGR, ρ, on insurance take-up and the uninsured population depends on the risk's magnitude: for SBGR, an increase in ρ shifts the $\triangle E(u)$-line downward thereby decreasing insurance take-up. For LBGR, an increase in ρ only tilts the $\triangle E(u)$-line around the initial intersection point, $\widetilde{w}_0$, without affecting insurance take-up and the rate of uninsured consumers.

The results from the latter analysis are summarized in the following three propositions.

Proposition 1 *For sufficiently small BGR the likelihood of the BGR, ρ, has negative effect on insurance take-up. For sufficiently large BGR-magnitude, the likelihood of the BGR has no effect on insurance take-up.*

Proposition 2 *For intermediate values of BGR magnitude, L, the uninsured population comprises the bottom end of the wealth distribution and some middle income consumers, as illustrated in Figures 5-6.*

Proposition 3 *The magnitude of the wealth deteriorating BGR, L, has a non-monotonic effect on insurance take-up: insurance take-up first decreases with the magnitude of the BGR, but then it starts decreasing and eventually converges to its zero BGR level.*

Proposition 3 highlights a fundamental feature of the effects of an uninsurable first-order deterioration in the wealth distribution on consumer purchases of insurance: the effects of "small" BGRs differ fundamentally from the effects of "large" BGRs. Of course "small" and "large" are relative to the consumer's income. As the risk becomes larger, it becomes "large" to more consumers. In the limit, when the risk is very large, it is large to everyone and merely represents an independent source of bankruptcy risk, thus having no effect on the tendency to purchase insurance against the insurable risk.

Finally, consider now the case where either ρ or L (or both) are sufficiently large so that the JBGR generates negative gain from insurance. This will generate an additional disconnected range of the uninsured population at the lower part of the wealth range $w \in (M+B, M+L+B)$. Under the assumed prudence the number of uninsured within this range increases with L and with ρ, whereas the dynamics of the uninsured population from the lower part of the wealth distribution remain as described above.

3.3 Mean preserving background risk

Not all surprises are bad: sometimes consumers enjoy windfalls. Thus, next we consider a symmetric, mean preserving, BGR that increases or decreases income by L with (equal) probability $\frac{\rho}{2}$. We present, again, the consumer's gain from insurance under different combinations of MR and

BGR magnitudes. Below are the expressions for the consumer's utility gain from insurance under the five different cases presented in the corresponding analysis of wealth deteriorating risk, i.e., in equations (1a)-(5a).

Case 1: SBGR and LMR, $L < w - B < M$,

$$\begin{aligned} E_I(u) &= \frac{\rho}{2}u(w-p-L) + (1-\rho)\,u(w-p) + \frac{\rho}{2}u(w-p+L) \\ E_{UI}(u) &= \pi u(B) + (1-\pi)\left[(1-\rho)\,u(w) + \frac{\rho}{2}u(w+L) + \frac{\rho}{2}u(w-L)\right] \end{aligned} \tag{6}$$

so the consumer's gain from insurance can be presented as

$$\begin{aligned} \triangle E(u) = {} & (1-\rho)\left[\underbrace{u(w-p) - (1-\pi)\,u(w) - \pi u(B)}_{\triangle E(u) \text{ with no BGR}}\right] + \\ & +\frac{\rho}{2}\left[\underbrace{u(w-p-L) - (1-\pi)\,u(w-L) - \pi u(B)}_{\triangle E(u) \text{ for } w-L}\right] + \\ & +\frac{\rho}{2}\left[\underbrace{u(w-p+L) - (1-\pi)\,u(w+L) - \pi u(B)}_{\triangle E(u) \text{ for } w+L}\right] \end{aligned} \tag{6a}$$

Case 2: LMR and LBGR ($w < L + B, M + B$, $w + L - M > B$)

In this case the mean-preserving risk's negative realization causes bankruptcy by itself, but its positive realization can prevent medical bankruptcy, so a consumer's expected utility with and without insurance is given by

$$\begin{aligned} E_I(u) &= \frac{\rho}{2}u(B) + (1-\rho)\,u(w-p) + \frac{\rho}{2}u(w-p+L) \\ E_{UI}(u) &= \pi\left[\left(1-\frac{\rho}{2}\right)u(B) + \frac{\rho}{2}u\left(w+L-M\right)\right] + \\ & \quad + (1-\pi)\left[(1-\rho)\,u(w) + \frac{\rho}{2}u(w+L) + \frac{\rho}{2}u(B)\right] \end{aligned} \tag{7}$$

and the consumer's gain from buying insurance is

$$\begin{aligned}\triangle E\,(u) &= (1-\rho)\left[\underbrace{u(w-p)-(1-\pi)\,u(w)-\pi u(B)}_{\triangle E(u)\text{ with no BGR}}\right]+ \\ &+\frac{\rho}{2}\left[\underbrace{u(w+L-p)-\pi u\,(w+L-M)-(1-\pi)\,u(w+L)}_{\triangle E(u)\text{ for } w+L}\right]\end{aligned} \tag{7a}$$

Case 3 SMR and LBGR ($M < w - B < L$)
In this case, where a negative BGR is bankrupting and the MR is not, we have

$$\begin{aligned}E_I\,(u) &= \frac{\rho}{2}u(B)+(1-\rho)\,u(w-p)+\frac{\rho}{2}u(w-p+L) \\ E_{UI}\,(u) &= \pi\left[(1-\rho)\,u(w-M)+\frac{\rho}{2}u(w+L-M)+\frac{\rho}{2}u(B)\right]+ \\ &+(1-\pi)\left[(1-\rho)\,u(w)+\frac{\rho}{2}u(w+L)+\frac{\rho}{2}u(B)\right]\end{aligned} \tag{8}$$

$$\begin{aligned}\triangle E\,(u) &= (1-\rho)\underbrace{[u(w-p)-\pi u(w-M)-(1-\pi)\,u(w)]}_{\triangle E(u)\text{ with no BGR }>0}+ \\ &+\frac{\rho}{2}\left\{\underbrace{u(w-p+L)-\pi u(w+L-M)-(1-\pi)\,u(w+L)}_{\triangle E(u)\text{ with no bankruptcy and BGR for } w+L\implies >0}\right\}\end{aligned} \tag{8a}$$

Case 4: JBGR ($M, L < w - B < L + M$)

$$\begin{aligned}E_I\,(u) &= \frac{\rho}{2}u(w-p-L)+(1-\rho)\,u(w-p)+\frac{\rho}{2}u(w-p+L) \\ E_{UI}\,(u) &= \pi\left[(1-\rho)\,u(w-M)+\frac{\rho}{2}u(w+L-M)+\frac{\rho}{2}u(B)\right]+ \\ &+(1-\pi)\left[(1-\rho)\,u(w)+\frac{\rho}{2}u(w+L)+\frac{\rho}{2}u(w-L)\right]\end{aligned} \tag{9}$$

$$\begin{aligned}\triangle E\,(u) &= (1-\rho)\underbrace{[u(w-p)-\pi u(w-M)-(1-\pi)\,u(w)]}_{\triangle E(u)\text{ with no BGR}}+ \\ &+\frac{\rho}{2}\left\{\begin{array}{c}\underbrace{u(w-p-L)-\pi u(B)-(1-\pi)\,u(w-L)}_{\triangle E(u)\text{ with no BGR r } LMR\text{ and } w-L}+ \\ +\underbrace{u(w-p+L)-\pi u(w+L-M)-(1-\pi)\,u(w+L)}_{\triangle E(u)\text{ with no BGR for } SMR\text{ and } w+L\ >0}\end{array}\right\}\end{aligned} \tag{9a}$$

Case 5: SMR and SBGR

Finally, consider the case where neither the MR nor the BGR is bankrupting:

$$\begin{aligned} E_I(u) &= \frac{\rho}{2}u(w-p-L)+(1-\rho)\,u(w-p)+\frac{\rho}{2}u(w-p+L) \\ E_{UI}(u) &= \pi\left[(1-\rho)\,u(w-M)+\frac{\rho}{2}u(w+L-M)+\frac{\rho}{2}u(w-L-M)\right] \\ &\quad +(1-\pi)\left[(1-\rho)\,u(w)+\frac{\rho}{2}u(w+L)+\frac{\rho}{2}u(w-L)\right] \end{aligned} \tag{10}$$

$$\begin{aligned} \triangle E(u) &= (1-\rho)\Big[\underbrace{u(w-p)-\pi u(w-M)-(1-\pi)\,u(w)}_{\triangle E(u)\text{ with no BGR}}\Big]+ \\ &\quad +\frac{\rho}{2}\left\{\begin{array}{c} \underbrace{u(w-p-L)-\pi u(w-L-M)-(1-\pi)\,u(w-L)}_{>0}+ \\ \underbrace{u(w-p+L)-\pi u(w+L-M)-(1-\pi)\,u(w+L)}_{>0} \end{array}\right\} \end{aligned} \tag{10a}$$

Analyzing equations (6a)-(10a) based on the same reasoning presented in the analysis of the corresponding equations (1a)-(5a), reveals that the results presented in Table 1 for the case of wealth deteriorating risk apply also to the case of mean-preserving wealth risk presented here.

The reasoning behind Proposition 2 implies that, in order to re-validate the non-monotonic effect of the BGR on insurance take rate, we can confine our attention to the effects of large and small BGRs on consumers' gains from insurance, in the presence of large (bankrupting) medical risk. As presented in equations (5a), given that the medical risk is bankrupting (i.e. LMR) the effect of a SBGR on the consumer's gain from insurance is negative, so it works to decrease insurance take-up, i.e., increase the rate of the uninsured. However, as the magnitude of the BGR increases,equation (6a) becomes relevant in assessing the uninsured rate. Equation (6a) implies, for the consumer who is indifferent between buying and not buying insurance in the absence of BGR, that she has a strictly positive gain from buying insurance in the presence of LBGR. Hence, for sufficiently large BGR, the rate of uninsured consumers is decreasing. The opposing effects of SBGR and LBGR on the rate of uninsured imply that the magnitude of the mean-preserving BGR has a non-monotonic effect on insurance take-up and the rate of uninsured consumers.

Our analyses of the effects of background risk on insurance take-up in the presence of bankruptcy protection has produced a consistent pattern across first order deteriorating and mean-preserving pareads for risk-averse, prudential consumers. In both cases, when medical risks are "small" the introduction (or increase) in the size of the background risk reduces insurance take-up. In contrast, when medical risks are large, such a conclusion obtains only when the background risk, of whatever type, is "small". This is perheps the most policy relevant case, since medical risks play a larger part in consumer bankruptcy than any other risk (though not larger perheps than all other risks combined). In the other relevant cases, the outcome depends on wealth. This apparent consistency is mirrored in our finding of non-monotonic effects of risk magnitude on take-up rates.

4 Correlated risks

Suppose now that the risk may be correlated. We denote the sum of realized losses X, and we follow the Hoffman et al. (2018) specification of its probability distribution, denoted $P(X)$:

$$
\begin{aligned}
P(X &= M+L) = \pi\rho+\varepsilon \\
P(X &= M) = \pi(1-\rho)-\varepsilon \\
P(X &= L) = \rho(1-\pi)-\varepsilon \\
P(X &= 0) = (1-\pi)\,(1-\rho)+\varepsilon
\end{aligned}
$$

where $max(0,\pi+\rho-1)-\pi\rho<\varepsilon<min(\pi,\rho)-\pi\rho$, and the covariance of the realized losses is given by[9] $Cov(M,L)=M\cdot L\cdot\varepsilon$. Hence, the sign and magnitude of ε corresponds to the sign and magnitude of the risks' correlation. Next, we represent the consumer's utility gain from insurance purchase for the five cases defined in the previous section, for various risk magnitudes and income levels. The consumer's gain from insurance purchase is presented below in a tractable manner, so that for $\varepsilon=0$ the expressions in (6a)-(10a) below coincide with the corresponding expressions (1a)-(5a) in the previous section.

Case 1: SBGR and LMR ($L<w-B<M$).

$$
\begin{aligned}
E_I\,(u) &= \rho u(w-p-L)+(1-\rho)\,u(w-p) \\
E_{UI}\,(u) &= \pi u(B)+[(1-\pi)\,(1-\rho)+\varepsilon]\,u(w)+[\rho\,(1-\pi)-\varepsilon]\,u(w-L)
\end{aligned}
\tag{11}
$$

$$
\begin{aligned}
\triangle E\,(u) = {} & (1-\rho)\,[u(w-p)-(1-\pi)\,u(w)-\pi u(B)]+ \\
& +\rho[u(w-L-p)-(1-\pi)u(w-L)-\pi u(B)]-\varepsilon[\underbrace{u(w)-u(w-L)}_{\text{positive}}]
\end{aligned}
\tag{11a}
$$

Inspection of (11a) reveals that the presence of a bankrupting insurable risk and a non-bankrupting wealth deteriorating BGR, the gain from insurance purchase depends negatively on correlation between the risks. That is for $B+L<w<B+M$, $\frac{\partial\triangle E(u)}{\partial\varepsilon}<0$.

Case 2: LBGR and LMR ($w-B<L,M$).

[9] See Hoffman et al. (2018) page 10.

$$
\begin{aligned}
E_I(u) &= \rho u(B) + (1-\rho)\, u(w-p) \\
E_{UI}(u) &= [\pi + \rho(1-\pi) - \varepsilon]\, u(B) + [(1-\pi)(1-\rho) + \varepsilon]\, u(w)
\end{aligned}
\tag{12}
$$

$$
\triangle E(u) = (1-\rho)\,[u(w-p) - (1-\pi)\, u(w) - \pi u(B)] - \varepsilon \underbrace{[u(w) - u(B)]}_{\text{positive}}
\tag{12a}
$$

Case 3: SMR and LBGR ($M < w - B < L$).

$$
\begin{aligned}
E_I(u) &= \rho u(B) + (1-\rho)\, u(w-p) \\
E_{UI}(u) &= [(1-\rho)\pi - \varepsilon]\, u(w-M) + [(1-\pi)(1-\rho) + \varepsilon]\, u(w) + \rho u(B)
\end{aligned}
\tag{13}
$$

$$
\triangle E(u) = (1-\rho)\,[u(w-p) - \pi(w-M) - (1-\pi)\, u(w)] - \varepsilon \underbrace{[u(w) - u(w-M)]}_{\text{positive}}
\tag{13a}
$$

Inspection of equation (13a) reveals that in the presence of a non-bankrupting insurable risk and a bankrupting wealth deteriorating BGR, the consumer's gain from insurance purchase increases with the correlation between the risks. That is, for $M < w - B < L$: $\frac{\partial \triangle E(u)}{\partial \varepsilon} > 0$.

Case 4: JBGR ($M, L < w - B < L + M$)

$$
\begin{aligned}
E_I(u) &= \rho u(w-p-L) + (1-\rho)\, u(w-p) \\
E_{UI}(u) &= [(1-\rho)\pi - \varepsilon]\, u(w-M) + (\pi\rho + \varepsilon)\, u(B) + \\
&\quad + [(1-\pi)(1-\rho) + \varepsilon]\, u(w) + [\rho(1-\pi) - \varepsilon]\, u(w-L)
\end{aligned}
\tag{14}
$$

$$
\begin{aligned}
\triangle E(u) &= (1-\rho)\,[u(w-p) - \pi(w-M) - (1-\pi)\, u(w)] + \\
&\quad + \rho\,[u(w-p-L) - \pi(B) - (1-\pi)\, u(w-L)] - \\
&\quad - \varepsilon \underbrace{[u(w) + u(B) - u(w-L) - u(w-M)]}_{\text{indefinite sign}}
\end{aligned}
\tag{14a}
$$

Inspection of the expression in the latter brackets on the right hand side of equation (14a) reveals that its sign depends on the concavity of the utility function: it is definitely positive if the utility function is linear, but it can turn negative if the utility function is sufficiently concave. In the presence of a non-bankrupting insurable risk and a jointly bankrupting wealth deteriorating BGR the effect of the correlation between the risks on the gain from insurance purchase is ambiguous. That is for $L, M < w - B < M + L$, $\frac{\partial \triangle E(u)}{\partial \varepsilon} \underset{?}{\gtreqless} 0$.

Case 5: SMR and SBGR **(**$B + M + L < w$**)**

$$\begin{aligned} E_I(u) &= \rho u(w-p-L) + (1-\rho)\, u(w-p) \\ E_{UI}(u) &= [(1-\rho)\,\pi - \varepsilon]\, u\,(w-M) + (\pi\rho+\varepsilon)\, u\,(w-M-L) + \\ &\quad + [(1-\pi)\,(1-\rho)+\varepsilon]\, u(w) + [\rho\,(1-\pi)-\varepsilon]\, u(w-L) \end{aligned} \tag{15}$$

$$\begin{aligned} \triangle E(u) &= (1-\rho)\,[u(w-p) - \pi u\,(w-M) - (1-\pi)\, u(w)] + \\ &\quad +\rho\,[u(w-p-L) - \pi u\,(w-M-L) - (1-\pi)\, u(w-L)] + \\ &\quad +\varepsilon \underbrace{[u\,(w-M) - u\,(w-M-L) + u(w) - u(w-L)]}_{\text{positive}} \end{aligned} \tag{15a}$$

Inspection of equation (15a) revelas that in the presence of a non-bankrupting insurable risk and a non-bankrupting wealth deteriorating BGR, the gain from insurance purchase is increasing with the correlation between the risks. That is, for $B + L + M < w$: $\frac{\partial \triangle E(u)}{\partial \varepsilon} > 0$.

Table 2: The effect of (positive) risk correlation on the consumer's gain from insurance

	LMR	SMR
$LBGR$	$(-)$	$(-)$
$SBGR$	$(-)$	$(+)$
$JBGR$	NA	depends on w

To re-assess the validity of Proposition 3 in the presences of corralated risks, we focus on equations (11a) and (12a). Comparing between the two yields the difference between consumer utility from insurance under SBGR and LBGR, given that the medical risk is bankrupting (i.e. LMR):

$$\rho[u(w-L-p) - (1-\pi)u(w-L) - \pi u(B)] + \varepsilon\,[u(w-L) - u(B)]$$

Evaluated at $w = \widetilde{w}_0$ the term in brakets above is negative. Hence, for any $\varepsilon < 0$ the above expression is negative, revalidating the non-monotonic effect of L on the rate of uninsured consumers. Nonetheless, it can also be shown that, if the two risks are positively-correalted and the correlation is sufficiently high, the above expression turns positive: plugging in the maximal value of ε, for the case where $\rho < \pi$ yields[10]

[10] Recall that $\varepsilon < min(\pi, \rho) - \pi\rho$.

$$\rho[u(w-L-p)-(1-\pi)u(w-L)-\pi u(B)]+\rho\,(1-\pi)\,[u(w-L)-u(B)]=$$

$$=\rho[u(w-L-p)-u(B)]>0$$

5 Conclusion

Consumers must make insurance purchase decisions in an environment of uninsurable risks. Such "background risks" have been of continuing interest in risk and insurance theory, and a number of conclusions about the effects of these phenomena are available in the literature. As a generality, most analysts expect the introduction of these additional risks to motivate agents to behave more cautiously towards risks that can be hedged, although the technical requirements for this result are relatively severe.

The advent of the Affordable Care Act in the United States, and the spirited debates over its future, has stimulated interest in the insurance take-up decision. At the same time, however, the potentially extraordinary costs of medical catastrophes have highlighted a special form on "unintentional insurance" available to many households: the limited liability implications of individual bankruptcy filings provide unfortunate agents with a form of partial insurance against very high medical costs. Unsurprisingly, the potential recourse to bankruptcy itself reduces the demand for market insurance.

Missing from the literature to date has been the question of how the presence of bankruptcy affects agents' responses to background risks. We seek to remedy this by analyzing the insurance take-up decisions of consumers facing two sorts of simple changes in background risks: mean deteriorations and mean-preserving spreads. Because bankruptcy introduces a distortion in payoffs, we show that the consequences for both sorts of background risks depend on whether they are "small" or "large" for the agent in question. In particular, because agent wealth varies, any particular background risk is likely to be small for some consumers, but large for others, leading to disparate responses. We demonstrate that, rather than having any simple effect on market insurance demand, changes in both sorts of risks can lead to non-monotonic response in the rate of insurance take-up. This result occurs in perhaps the simplest agent space applicable to this problem, so it is improbable that models incorporating additional complications will exhibit simpler comparative statics.

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