The Influence of Premium Subsidies on Moral Hazard in Insurance Contracts

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Abstract

Legislation for the introduction of subsidies is usually passed to increase participation in an insurance market. It is often argued that the increased demand for insurance due to subsidies also increases moral hazard in the market. While this argument is intuitive, it ignores wealth effects of premium subsidies on moral hazard. We argue that such effects can in certain markets be dominating for the majority of the insured, particularly in insurance markets where most insured do not have a choice between different insurance policies and thus demand effects do not play a major role. Our theoretical model shows that wealth effects do influence the moral hazard in a given insurance market and that the influence depends on contract design. The results offer policy implications for premium subsidies in public insurance systems calling for a differential legislative treatment of premium subsidies in insurance systems with different premium schedules.

Keywords: Subsidization; Moral Hazard; Insurance Regulation

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1 Introduction

Insurance markets are often thought of as being competitively prized in a risk-based fashion. However, there are certain markets in which either the government or the insurance company itself subsidizes at least some of the policies such that they will be prized below actuarially fair value. Probably the most commonly cited example for this is the U.S. health insurance market. Through tax exemptions of employer sponsored health insurance and the corresponding insurance policies for the self-employed, it is estimated that the U.S. state and federal governments waived tax revenues of about $260 billion in 2009 alone (Gruber, 2011). Furthermore, subsidies exist in many other insurance markets.\(^1\) In this paper, we thus offer a theoretical analysis of premium subsidies and moral hazard in non-specific insurance markets and will make frequent references to examples which highlight the relevance of a given model to a particular market.

Legislation which entails premium subsidies is typically introduced to stimulate demand for a certain type of insurance. This is done, for instance, if it is judged to be socially desirable to have a large proportion of the population covered against a certain risk. Additionally, it has been argued that subsidies are a possible way to counter the effects of adverse selection (Glauber, 2004). However, when discussing subsidies for insurance schemes, moral hazard has seldom been considered. This is not due to a lack of attention for moral hazard, per se. Empirical studies of moral hazard exists for many insurance markets such as workers’ compensation insurance (Dionne and St-Michel, 1991), unemployment insurance (Christofides and McKenna, 1995) and crop insurance (Smith and Goodwin, 1996). However, as of yet, the influence of premium subsidies on moral hazard has only sparingly been analyzed.

Feldstein and Friedman (1977) were the first to consider the effect of premium subsidies on moral hazard using the specific setting of the U.S. health care market. They hold the wide-scale introduction of tax exemptions for employer covered health insurance responsible for the increase in health care spending in the United States by arguing that the subsidies lead to increased insurance coverage which, through moral hazard, increased the medical expenditures in the country. Empirical evidence exists that subsidies make some people increase their coverage (Finkelstein, 2002; Goda,\(^{1}\) One possible example for this is the U.S. crop insurance market. Starting with the Federal Crop Insurance Improvement Act of 1980 and continuing with the Crop Insurance Reform Act of 1994, U.S. federal crop insurance is one of the most subsidized public insurance systems in the world. Further legislation has changed the relative level of subsidization, but the payments remain at a high level until today.\(^{2}\)
2011) and that the increased coverage can lead to higher medical spending (Cutler and Zeckhauser, 2000; Finkelstein et al., 2012).

However, it is also apparent that many people do not change their demand due to subsidies. This can be the case because the choice of insurance coverage is discrete and the subsidy is not sufficient to make the insured choose the next higher level of coverage. Another explanation, particularly relevant in health insurance, is that the people are not actually able to choose their level of coverage (Finkelstein, 2002). In the case that insurance coverage does not change for the individual, premium subsidies will only influence the behavior of the insured through wealth effects. While Feldstein and Friedman (1977) explicitly exclude the consideration of such effects from their model, we focus our examination on them. We use a theoretical model to analyze the influence of premium subsidies on moral hazard if insurance coverage does not change. We thus amend the literature by considering the behavior of individuals that do not switch their coverage due to premium subsidies and by studying an additional aspect of subsidy induced behavior change for those who do.

In our first analysis, we use a simple one period model based on Shavell (1979). We model premium subsidies as a relative deduction of premium payment and look at their influence on the effort exercised by the insured to reduce the loss probability. This way, we show that premium subsidies increase the problematic effects of moral hazard. Since the analysis is based on Shavell (1979), it models moral hazard as a change in loss prevention. Common examples for loss prevention activities include careful driving to limit the probability of a car accident, locking doors and windows to prevent burglaries and providing good work in employment to prevent getting laid off. To reflect the specific conditions in the health insurance market, we also consider the influence of premium subsidies on ex-post loss reduction instead of loss prevention. The analysis shows that the effects are similar in both models.

When studying moral hazard, the design of the insurance contract is essential for the behavior of individuals. Prior studies have emphasized the importance of co-payments by the insured (Pauly, 1968; Einav et al., 2011). We, however, focus on the premium payment plan, that is the question under which circumstances the insured has to pay a premium. In models of insurance demand, premium payments are usually non-contingent in the sense that whether or not a loss occurs, the insured is always required to pay the insurance premium. While this is a common design feature in

Note that this is also the case in the popular model approach that uses net-indemnities. The difference between
health insurance or property and casualty insurance, not all insurance policies feature non-contingent premiums. Certain policies do not require a premium payment once a loss has occurred. Long term care insurance or disability insurance are two possible examples for insurance systems in which such contingent premiums are common. In a second part of the paper we extend our analysis to this kind of contracts. Additionally, since virtually all examples for contingent premiums concern intertemporal decision problems, we reflect this in the model and use a two period set-up. We show that in contingent premium contracts the effect of premium subsidies is reversed and subsidies actually encourage loss prevention. Thus, contract design is essential for analyzing the wealth effects of premium subsidies.

The rest of the paper is structured as follows. In the next section, we review the literature on premium subsidies and make some considerations regarding insurance contracts and moral hazard. Section three introduces our extension of the model by Shavell (1979) and shows our results regarding the wealth effects of premium subsidies on moral hazard for loss prevention and ex-post loss reduction. In section four we investigate the influence of premium subsidies on moral hazard in a two period setting with contingent premiums. Section five summarizes and discusses the findings and offers some implications for public policy. The last section concludes and considers some possible directions for further research.

2 Literature Review

Many public insurance systems include some kind of premium subsidy for at least parts of the insured population. In insurance markets such as the market for employer sponsored health insurance or the federal crop insurance system in the U.S., policies are deliberately subsidized by the government in order to increase participation. Subsidies are usually administered through one of two different channels: direct subsidization through pricing and tax exemptions. Public programs such as the Federal Crop Insurance Commission (FCIC) issue policies that are deliberately priced below the actuarially fair value and do not include additional loadings for administrative expenditures or capital costs. In the FCIC, the relative rate of subsidization is tied to the coverage level of the insured but not to the risk. The National Flood Insurance Program (NFIP) on the other hand

\[\text{those two model approaches is that the premium does not explicitly appear in the loss state. It is, however, still implicitly included in the model.}\]
does not subsidize all policies but only those for older houses which have a substantial risk of being
damaged by a flood. Since unsubsidized coverage for these houses could not be afforded by most
owners, the NFIP ties the relative subsidization rate to risk exposure instead of coverage level.

The second possible channel to administer subsidies is through tax exemptions of premium
payments to private insurance policies. This is, for example, done in the U.S. and Canada for health
insurance and in the U.S. long term care insurance market. Tax exemptions keep the relative rate of
subsidization constant in both coverage level and risk exposure, but tie it to the insured’s marginal
tax rate. Since most taxation systems have variable marginal tax rates in income, the relative rate
of subsidization will thus be dependent on the income of the insured.

Some subsidies are relatively small in size. Kunreuther and Michel-Kerjan (2009) estimate the
accumulated losses of the NFIP between 1968 and 2005 to be about $2.2 billion, which can be
considered an upper bound for the amount of subsidies provided in that timespan. However, other
insurance systems are subsidized with considerably larger amounts. The FCIC paid out total pre-
mium subsidies of $7.3 billion and incurred a loss of $11.3 billion in the fiscal year of 2011 alone
insurance dwarfs all other subsidies in the U.S. by comparison. The Joint Committee on Taxation
estimates that solely the exclusion of employer contributions for health care, health insurance pre-
miums, and long-term care insurance premiums from taxation will lead to tax expenditures just by
the federal government of $760 billion between 2013 and 2017 (Joint Committee on Taxation, 2013).
This poses the largest tax expenditure of the U.S. federal government (Gruber, 2011). Gruber and
Poterba (1996) estimate an average subsidy of employer sponsored health insurance of 31.8% of
the initial premium through tax deductions. While this is a rather large number, Gruber (2011)
also states that the actual amount of the subsidy varies by income of the insured. The increasing
marginal income tax of the United States leads to more highly subsidized premiums for high income
individuals than for those with lower income. Additionally, subsidies for the participation in health
care exchanges, as implemented by the Patient Protection and Affordable Care Act, will amount
to $308 Billion, while tax exemptions for small businesses, the self-employed and for contributions
to health savings accounts add another $52 Billion in the coming five years (Joint Committee on
Taxation, 2013).

Subsidies for some policyholders can even appear in public insurance systems which are self
financing in nature. In systems such as the U.S. unemployment insurance system (Anderson and Meyer, 1993) or the German health insurance system (Buchner and Wasem, 2003), the pricing of the insurance policies does not adequately reflect the risk of the individual policyholder. Thus, even if the entire system is self-financing, some of the insured can buy policies below the actuarially fair price. For those insured that can profit from such cross subsidies, the effect is essentially the same as that of subsidies administered to all insured.

Several studies have examined the effect of subsidies on insurance demand. Most of the studies have focused on health insurance. They usually take advantage of the fact that the subsidy towards the insurance policy depends on the marginal tax rate of the insured. Cutler and Zeckhauser (2000) survey the literature regarding the United States and find estimates of demand elasticities for employer provided health care between -0.14 and -1.5. More recent literature validates these estimates (Royalty, 2000; Gruber and Lettau, 2004). Finkelstein (2002) employs a difference-in-difference estimation and takes advantage of a change in Canadian tax legislation to show that the findings are robust in the international context. Often cited as most trusted for their accuracy are the estimates from the RAND Health Insurance Experiment (Manning et al., 1987; Newhouse and Rand Corporation Insurance Experiment Group, 1993) which deem the demand elasticity to be at -0.2.

Studies in other insurance markets have also found evidence for an increase in demand due to subsidies. Glauber (2004) states that the introduction of heavily subsidized crop insurance policies significantly increased the participation in the program. Goda (2011) shows that the introduction of tax subsidies for long term care insurance increases demand. However, some evidence to the contrary also exists. In his survey study, Kunreuther (1976) states that the demand for flood insurance in the U.S. is small even though the policies are (at the time of the study) heavily subsidized.

In this study, we are concerned with the influence of premium subsidies on moral hazard. Moral hazard is a broadly defined term. In our model and for the sake of the discussion, we define moral hazard as a change in behavior of the insured that is induced by an insurance contract in the presence of asymmetric information. Behavior is modeled similar to Shavell (1979) as costly effort taken by the insured to reduce the expected loss, so called loss prevention. Models with loss prevention analyze ex-ante moral hazard. While this is a common approach in modeling moral hazard, it is in contrast to much of the literature on moral hazard in health insurance (for example Arrow, 1963;
Coulson et al., 1995). We thus also model the specific case for ex-post loss reduction, which can be argued to be more relevant for the health insurance context.

Nevertheless, the relevance of loss prevention in many insurance markets cannot be doubted. Provisions such as sprinkler systems or lightning rods clearly decrease the likelihood of damages to a house in case of fire or storm. Similarly, good work effort will decrease the probability of unemployment. Even though, amongst others, Cutler and Zeckhauser (2000) state that ex-ante moral hazard is not necessarily applicable for health insurance, certain examples still come to mind. A healthy lifestyle generally leads to less health problems and thus ex-ante moral hazard is at least a possibility in health insurance (Dave and Kaestner, 2009). As an example, anecdotal evidence suggests that in countries such as Switzerland, in which few people have comprehensive dental insurance, most white collar workers brush their teeth after lunch at the office to avoid dental problems. Hence, both ex-ante and ex-post moral hazard have relevance for health insurance.

There is empirical evidence that moral hazard exists in insurance markets (Chiappori et al., 1998; Stabile, 2001) and it has been noted that the differentiation between ex-ante and ex-post moral hazard is important in this respect (Abbring et al., 2008). In health insurance, the existence of ex-post moral hazard is well documented. Finkelstein et al. (2012) find in a study similar to the RAND Experiment that individuals from the lower income sector increase their annual utilization of medical care by 25% or $778 if they obtain health insurance.3

In contrast to the influence of subsidies on demand, the influence of premium subsidies on moral hazard is not researched as well. Generally, subsidies can influence the market inefficiencies due to moral hazard in two ways: subsidies can increase the insurance coverage level which in turn can lead to an increase in moral hazard. We call this a demand effect. The second type of influence is a change in the composition of the insurance contract. Subsidies reduce the premium and thus increase the wealth of the insured for any given insurance coverage. We call this a wealth effect. Which of these effects dominates depends, among other factors, on the structure of the insurance market.

3 Based on considerations of price elasticities for medical care, multiple studies have estimated the welfare loss due to moral hazard in health insurance in the United States. Based on the calculations by Feldstein (1973), Feldman and Dowd (1991) estimate the welfare loss due to health insurance to be between $33.4 billion and $109.3 billion in 1984. Converted to 2012 dollars, this would correspond to a welfare loss between $74.4 billion and $243.4 billion (Calculations are based on an annual inflation rate of 2.9%). It is obvious that subsidized insurance will amplify this effect, because more people will be insured.
It could be argued that demand effects will be more significant economically than wealth effects. Feldstein and Friedman (1977) exclude wealth effects from their consideration entirely. However, while this is valid for some cases, in other cases wealth effects will be more important than demand effects. Some cases will not show any demand effects at all and thus only wealth effects will be at play. Three specific market settings come to mind:

1. If insured can only choose between a few different coverage levels and a subsidy is introduced to the market, it might not give the insured a sufficiently large incentive to switch to the next higher coverage level. In this case, the insured will remain at the existing coverage level and subsidies will only have consequences for the individuals’ wealth and not for their demand.

2. A similar argument applies in case only one level of coverage exists. In this situation, the insured can only decide to purchase insurance or not. Those who are already insured cannot increase their coverage due to the subsidy and only wealth effects will influence their behavior.

3. If insurance coverage is mandatory, a subsidy will not change the insurance demand at all and will only affect the wealth of the insured.

The first case is probably the most common setting for an insurance market. Almost no insurance provider offers a choice of coverage levels on a continuous scale. The fewer policies are offered to the insured, the less likely it will be for the subsidy to influence the demand of the insured and the more important wealth effects will be in comparison to demand effects. Case two is to some extent the extreme case of case one. It is relatively common in public insurance programs such as unemployment insurance. The relevance of wealth effects in comparison to demand effects in this case can further be demonstrated by the results of Gruber and Washington (2005) who find a very small price elasticity of insurance take-up if tax subsidies are introduced.

Insurance coverage can be factually mandatory as is the case for most European public insurance systems. Germany, for example, requires mandatory health care coverage, unemployment insurance, annuity coverage and automobile liability coverage of every citizen. If such a mandatory insurance scheme is combined with a single level of coverage, any subsidy applied to the contract will solely have an effect on the insured’s behavior through their wealth. Insurance coverage can also be circumstantially mandatory even if it is not directly required by law. In some areas of the U.S.
every household who takes up a mortgage from a federally backed or regulated lender is required to buy flood insurance coverage from the NFIP (Michel-Kerjan and Kousky, 2010). As Finkelstein (2002) mentions, many employees also do not have a choice whether to take up their employer’s health plan or not. Save from changing employment, this also poses a mandatory insurance scheme, particularly if the employees are not offered a choice between different health plans.

Despite these considerations, the prior literature on the influence of premium subsidies on moral hazard solely focused on demand effects. Feldstein and Friedman (1977) explore both the issue of increasing insurance demand and rising cost of third party services (see also Nell et al., 2009) in a simulation model of the health care market. They conclude that the impact is highly economically significant and might be responsible for some of the increased health care spending in the United States. An argument similar to that of Feldstein and Friedman (1977) is proposed in Pauly’s (1986) review of price elasticities for health insurance and medical care. He cites evidence that subsidized insurance premiums will increase insurance demand, lead to overinsurance and ultimately to overconsumption of medical care. Such an argument has been repeated by multiple authors since (Feldstein, 1995). Jack and Sheiner (1997) offer a closed form solution supporting this result and argue that under certain conditions subsidizing out-of-pocket medical spending can offset the effect of premium subsidies at least to a certain degree. This entire line of research has contributed significantly to the understanding of the economic effects of premium subsidies. However, the argumentation does not differentiate between ex-ante and ex-post moral hazard and assumes that insurance coverage only influences moral hazard through demand effects.

There are a variety of papers started by the discussion in Arnott and Stiglitz (1986) which deal with the subsidization of prevention goods or technologies. An empirical analysis on the fiscal effects of cigarettes and possible effects of taxation can be found in Viscusi (1999). A similar argument is made by Gaynor et al. (2000) who analyze prize changes in health care services and the implications for ex-post moral hazard. We differentiate our study in the sense that we do not model the subsidization of the preventive act. More specifically, we assume that the preventive act is non-monetary in nature and its prize can thus not be changed at all. In our model, the prize of insurance is varied through subsidization. We thus examine indirect effects of subsidization of insurance on non-monetary behavior. This is an aspect which has not been covered by the aforementioned literature.
Our study needs to be differentiated from the analysis performed by Ehrlich and Becker (1972). In their comprehensive study of market insurance, self-insurance and self-protection, they also explore the influence of insurance pricing on preventive behavior. However, when considering self-protection, they analyze a case in which behavior of the insured can be observed by the insurance company and thus the premium can be adjusted correspondingly. In the case of self-insurance, they simply assume that insurance is a lump-sum payment independent of the amount of loss incurred. This makes the premium independent of the amount of self-insurance and thus also no problem of asymmetric information exists. Since asymmetric information changes the interaction of insurance and loss protection, the results of the model by Ehrlich and Becker (1972) cannot be applied to analyze the problems considered in this study.

It can be seen that even though premium subsidies and moral hazard have been discussed in many respects, the discussion has been focused on demand effects. Thus, even though wealth effects of subsidies on ex-ante moral hazard under asymmetric information can be economically significant, they have not yet been investigated empirically or theoretically. We offer a theoretical foundation for such a discussion in the next sections.

3 Premium Subsidies and Moral Hazard with Non-Contingent Premiums

3.1 Basic Model and Ex-Ante Loss Prevention

For our analysis, we use a simple model with two states of the world. The insured is assumed to maximize the expected utility of his random wealth. He is expected to have a von Neumann/Morgenstern utility function \( U(\cdot) \) showing risk aversion such that \( U'(\cdot) > 0 \) and \( U''(\cdot) < 0 \). The wealth takes on the value \( x_L \) with probability \( p > 0 \) and the value \( x_H \) with probability \( (1 - p) \), whereas \( x_L < x_H \). The insured can exercise effort \( e \in [0, \infty] \) that will influence the probability. The effort has a diminishing marginal benefit in terms of loss probability reduction such that \( p'(e) < 0 \) and \( p''(e) > 0 \). Exercising effort causes costs \( c(e) \) for the insured which are increasing convexly such that \( c'(e) > 0 \) and \( c''(e) > 0 \). We assume the cost function to be measured in utility units such that the costs are separable from the insured’s utility function.

Making a change in wealth to be the only difference between the loss state and the no-loss state is to a certain degree a simplification. Research shows that living through a loss event causes emotional
damage in addition to monetary consequences (Siegrist and Gutscher, 2008). Similarly, a loss in a health insurance or long-term care insurance context does not only have monetary consequences in terms of treatment cost, but can also have permanent health effects. We abstract from such effects in the interest of brevity. Nevertheless, even if losses may have non monetary consequences in certain cases, they will have monetary consequences in all cases relevant for insurance markets since insurance policies can only reimburse monetary losses. This makes our model applicable to every market studied here despite the simplification.

Effort is measured in utility units to emphasize the fact that most effort in the situations under scrutiny here is non-monetary in nature. Consider, for example, health insurance. One substantial driver of health risk are unhealthy eating habits. Eating less is cheaper than eating more and would be the more healthy option for many people. Such dietary restrictions are a question of discipline, which is, by definition, non monetary effort. Another example would be the effort necessary to prevent unemployment through hard work. This requires concentration on the task at hand and less time being spend on coffee breaks or surfing social media websites. While such behavior has a cost associated with it, that cost is not monetary in nature.

Non-contingent premiums imply that the premium payment is independent of whether or not a loss occurs. As stated above, such contracts are common in health insurance and property and casualty contracts. They are also prevalent in most commercial insurance lines such as the crop insurance policies offered by the FCIC. The premium is typically paid at the beginning of the period or payments are spread out over it. In case of a loss within the time period, the insurer will make an indemnity payment which does not affect the payment plan for the premium. We investigate this type of contract using a model set-up in which the insured can take up insurance for a fixed indemnity of $I$ and a premium of $\pi$ to be paid regardless of the state of nature. The insurer offers only one possible insurance contract to the insured. We simplify to this in order to investigate the wealth effects of premium subsidies on moral hazard in an isolated fashion. As is common in most insurance markets, the insured will only be able to buy less than full coverage such that $x_H - \pi > x_L - \pi + I$ will always be fulfilled.

In the model, the insurer offers a fixed insurance level $I$ at premium $\pi$. The insured decides to take up the insurance or not and contingent on that choice determines his effort. Consecutively, the state of nature is determined and the insurance contract is executed.
To identify the first best solution of the problem under perfect information we assume that the
premium \( \pi \) charged by the insurer is dependent on the effort exercised by the insured and observed
by the insurer. The insurer charges actuarially fair premiums and thus the contract will be subject
to a budget constraint such that the expected value of the insurance contract is zero, that is that
the expected premium payment equals the expected indemnity:

\[
\pi(e) - p(e)I = 0
\]

We assume the insurer to incur zero profits. This could be due to multiple reasons. If the
insurance market is competitive, expected profit will be zero in equilibrium.\(^4\) However, it could
also be the case that the insurer is the government and that the government does not have a profit
motive when pricing insurance policies. In the case that subsidies are introduced to the market, the
insurance policies and thus the budget constraints will be modeled such that the expected profit
for each policy will be negative. This will of course not mean that the expected profit for the
insurance companies has to be negative. The model does not make specific assumptions on whether
the insurer is reimbursed for the subsidy by the government such that expected profits will again
be zero or the insurer in fact incurs a loss (if, for example, the insurer is the government).

This is a natural way to model most insurance markets which are subsidized. If, for example, US
crop insurance is considered, private insurance companies in a competitive market sell policies for
which the premium income does not cover the expected loss of the insurer. They get reimbursed for
the calculated loss from the FCIC. In the case of health insurance, the insurers that offer health care
plans actually do so in a competitive market and the tax exemption of premium payments make
the policies appear to the insured as if they were priced with a calculated loss for the insurance
company (which is again carried by the government through the tax expenditure). As such, the
model accurately describes the perception from the point of view of the insured, whose behavior is
what is of interest in this study.

Due to the price setting mechanism, the insured always takes up insurance\(^5\). He will anticipate
the price-setting mechanism and chose \( e \) as to maximize expected utility, where expected utility is

\(^4\)In any market structure with multiple insurers, we also assume that the insured cannot buy insurance from multiple insurers at the same time.

\(^5\)This, and that the second order condition is fulfilled is shown in A.
For ease of expression, we abbreviate $U(x_H - \pi(e))$ as $U_H$ and $U(x_L - \pi(e) + I)$ as $U_L$. The first order condition is given as:

$$p'(e) [U_L - U_H] - \pi'(e) [(1 - p(e))U_H' + p(e)U_L'] = c'(e)$$

(1)

It can be seen that the marginal benefit of carrying out effort is twofold. First, it decreases the probability of the loss state (first term on the LHS) and secondly it increases the wealth because the premium decreases with increased effort (second term on the LHS).

In case of asymmetric information, the insurer cannot observe the insured’s effort. The insurer will assume the insured to exercise effort such that her utility is maximized and offer an insurance contract with fixed premium and indemnity based on this assumption. This renders the following maximization problem:

$$\max_e EU = (1 - p(e))U(x_H - \pi(e)) + p(e)U(x_L - \pi(e) + I) - c(e)$$

which renders the first order condition to be:

$$p'(e) [U_L - U_H] = c'(e)$$

(2)

Comparing the solution from (2) to the first-best solution in (1) shows that the marginal benefit due to premium reduction is removed. With less marginal benefit but the same marginal cost function, there will be less effort exercised. At any given premium $\pi$, the insured will now exercise less effort and have a higher chance of the low wealth state than in the perfect information case. This is the effect of moral hazard.

Premium subsidies price the insurance contract at a rate such that it will have a negative expected value for the insurer. In order to model this, we use a loading factor $\lambda$ that implies

\footnote{Several technical points regarding this model and the following results are addressed on pp. 25f in A.}
subsidies if $\lambda > 1$. The budget constraint of the insurer now is:

$$\lambda \pi - p(e) I = 0$$  \hspace{1cm} (3)$$

Here, $\lambda$ is modeled as a relative subsidy. By increasing it to a value larger than one, only $\frac{1}{\lambda}$ of the expected indemnity need to be covered by the premium income. This way, we model subsidies as they appear most often in practice. All of the examples mentioned above are relative subsidies in nature. However, all our results also hold for an absolute subsidy. In that case the budget constraint would be $\lambda + \pi - p(e) I = 0$.\(^7\) In this model we assume the relative subsidy to be constant. In practice, the relative rate of subsidization is often tied to one or more parameters of the insurance contract, such as coverage level. The incentives set through such variable subsidization rates are outside the scope of this study, but offer a natural direction for future work.

Considering the effect of the premium subsidies on moral hazard in the case of asymmetric information, we use the first order condition rendered by (2) and apply the implicit function theorem to arrive at:

$$\frac{\partial e}{\partial \lambda} = -\frac{p'(e) \frac{\partial \pi}{\partial \lambda} [U'_{H} - U'_{L}]}{p''(e) [U_{L} - U_{H}] - c''(e)} < 0$$  \hspace{1cm} (4)$$

$\lambda$ has a negative effect on the effort exercised by the insured. Thus, with this contract design the wealth effects of premium subsidies will increase the market inefficiency due to moral hazard. Intuitively, this can be explained by the fact that premium subsidies influence the wealth independent of the state of nature. Due to the condition that $x_{H} - \pi > x_{L} - \pi + I$ and the decreasing marginal utility of $U(\cdot)$, the low wealth state will have higher marginal utility than the high wealth state. Thus, the increase in wealth increases the attractiveness of the low-wealth state more strongly than it increases the attractiveness of the high-wealth state. The insured now has relatively less incentive to be in the high-wealth state and will decrease the effort to reach it. Thus, with non-contingent premiums, wealth effects will amplify demand effects and increase the detrimental consequences of moral hazard in the insurance market.

\(^7\)The proof is available from the authors at request.
3.2 Ex-Post Moral Hazard and Premium Subsidies

As stated above, health insurance is one of the major examples for the relevance of premium subsidies. It has been argued by various authors (Arrow, 1963; Coulson et al., 1995; Cutler and Zeckhauser, 2000) that a lack of loss prevention is not the major problem of moral hazard in medical care markets. The way in which insured individuals deal with treatment costs once an illness has occurred is much more problematic. Thus, a lack of effort to reduce losses once they occurred is a major driver of moral hazard in health insurance. In this section we deal with this issue by looking at the wealth effects of premium subsidies on ex-post loss reduction in non-contingent contracts.

The model set-up has to be adjusted to fit the context. For simplicity, we define the low wealth state in terms of the high wealth state and a random loss: \( x_L = x_H - L \). The probability that a loss occurs is \( p \). If it occurs, the size of the loss is randomly determined according to a probability distribution \( f(L,e) \) with support \([L,L]\) such that \( L,L \in [0,\infty] \) \& \( L < L \). In case a loss occurs, the insured can exercise effort \( e \in [0,\infty] \) at convexly increasing costs \( c(e) \) to influence this probability distribution. Let \( f(L,e) \) be twice continuously differentiable, effort then influences the probability distribution such that \( \frac{\partial F(L,e)}{\partial e} > 0 \) and \( \frac{\partial^2 F(L,e)}{\partial e^2} < 0 \). Namely, for any two effort levels \( e_1 < e_2 \), \( F(L,e_1) \) first order stochastically dominates \( F(L,e_2) \), but the influence of \( e \) on the probability distribution is concave. It is assumed that for any effort level, the support of the probability distribution remains unchanged.

Instead of an absolute indemnity we model insurance as a coinsurance contract such that the indemnity now is a fraction of the loss determined by the coinsurance rate, \( \delta \). The insured bears a share of the loss equal to the coinsurance rate and the insurer indemnifies the rest.

In the interest of brevity, we focus on the asymmetric information case in this extension. The insurer cannot observe the insured’s effort. In anticipation of utility maximizing behavior by the insured, the insurer will offer an insurance contract \((\delta, \pi)\), such that his budget constraint \( \lambda \pi - p \int_L^T (1 - \delta) L f(L,e) dL = 0 \) and the no full insurance or overinsurance condition \( \delta > 0 \) is fulfilled. The insured will purchase the contract and in case of a loss he will determine his effort for loss reduction. After \( L \) has been determined, the contract is executed.

\(^8\)As before, the effort under symmetric information will be higher than under asymmetric information. Results are available from the authors at request.
This renders the following maximization problem for the optimal level of effort by the insured:

$$
\max_{e} \ EU = (1 - p)U(x_H - \pi) + p \left[ \int_{L}^{T} U(x_H - \pi - \delta L)f(L, e)dL - c(e) \right]
$$

we arrive at the first order condition in (5)\(^9\).

$$
\delta \int_{L}^{T} U'(x_H - \pi - \delta L) \frac{\partial F(L, e)}{\partial e} dL = c'(e)
$$

(5)

Using this and the implicit function theorem, we can derive the influence of premium subsidies on loss reduction with non-contingent premiums as:

$$
\frac{\partial e}{\partial \lambda} = \frac{\delta \int_{L}^{T} \frac{\partial \pi}{\partial \lambda} U''(x_H - \pi - \delta L) \frac{\partial F(L, e)}{\partial e} dL}{\delta \int_{L}^{T} U'(x_H - \pi - \delta L) \frac{\partial^2 F(L, e)}{\partial e^2} dL - c''(e)} < 0
$$

(6)

We can see from (4) and (6) that the result for the wealth effects of premium subsidies on moral hazard are the same whether loss prevention or loss reduction are analyzed. The intuitive explanation for both results is similar, as well. In the low-wealth state, premium subsidies increase the wealth of the insured by the same amount independent of how large the loss is. Due to $U''(\cdot) < 0$, this will lead to a larger increase in utility in states with higher values of $L$ than in states with lower values of $L$. Subsidies thus decrease the utility gained from reducing the loss amount once a loss has occurred. Since the cost of effort is non-monetary and thus unaffected by subsidies, subsidies will increase ex-post moral hazard.

That the result for non-contingent premiums is valid for ex-post loss reduction as well as for ex-ante loss prevention shows that premium subsidies will increase moral hazard no matter what behavioral pattern is more important in a given insurance market. For the medical care market, which in part motivated the inclusion of ex-post moral hazard in this study, this shows that wealth effects of premium subsidies will aggravate their already problematic demand effects.

\(^9\)A justification of the first order approach and other technical points regarding this model and the following results are addressed on pp. 27f in B.
4 Dependence on Contract Design - Loss Prevention and Contingent Premiums

The intuitive explanations for the influence of premium subsidies on moral hazard in the two models above show that the question in which state of nature the premiums and thus the subsidies are paid is crucial. Hence, the results given above might change if premiums are not paid in every state of the world. A good example for an insurance contract in which the premium is not paid independently of the loss is long-term care insurance. Here the insured buys a policy and only pays premiums as long as no claim is made. If the insured requires long-term care, he seizes to pay premiums and the insurance company starts paying the indemnity. Similar structures of insurance contracts can, for example, be seen in disability insurance or unemployment insurance.

When considering examples for insurance contracts with contingent premiums, it becomes apparent, that all of them are intertemporal decision problems. To model contingent premiums as simple as possible, we assume a model with two periods. In the first period, the insured has wealth $x_H$ with certainty. His wealth in the second period either takes on the value $x_L$ with probability $p > 0$ or the value $x_H$ with probability $(1-p)$, where $x_L < x_H$. The insured can exercise effort that will influence the probability distribution of his wealth in the second period at convexly increasing costs $c(e)$. To protect himself from the low wealth state in the second period, he is able to take up insurance with a contingent premium. In exchange for a premium $\pi$ to be paid in the first period and in the high wealth state of the second period he will gain a payment $I$ in case of the low wealth state in the second period. We assume the insurer to offer a fixed level of insurance $I$. All changes in the insurance contract, as could, for example, be induced by premium subsidies, will only influence $\pi$, while $I$ will stay constant. As above, the insured needs to be in a worse position when a loss occurs than when no loss occurs: $x_H - \pi > x_L + I$. This condition is slightly stronger than the no full insurance or overinsurance condition used above since the indemnity must be smaller than the loss minus the premium.

It is important to differentiate contingent premium contracts from the popular modelling approach in which an insurance contract is given by a premium and a net-indemnity. This net-indemnity is calculated by subtracting the premium from the indemnity. In a case like this, a subsidy would again influence both the good state of the world and the bad state of the world. This is not the case in contingent premiums. The difference becomes obvious when again considering
the example of long-term care insurance. In such a system, indemnity payments are paid on the basis of necessity; this means the insured receives whatever monetary reimbursement is necessary to cover the cost of receiving care. Since care receivers are incapable of generating further income, it is possible that they will not have any funds to pay insurance premiums. Hence such contracts are designed in a way that the expected premium payment in case of a good state of the world can fully cover the expected indemnity in case of a bad state of the world. As such, any change of the premium will only influence the good state of the world. Contrary to the net indemnity approach, $I$ is not influenced by changes in $\lambda$.

The second period is added to the model to emphasize the intertemporal nature of insurance situations with contingent contracts. This becomes clear when taking unemployment insurance as an example. The insured enters a job in the first period and earns $x_H$ as a wage and pays $\pi$ as a premium for unemployment insurance. In this period she exercises effort such as coming to work on time and working hard in order to stay employed in the second period. Once the uncertainty about the employment status is resolved, the insured enters the second period either still earning the wage $x_H$ and paying $\pi$ to protect herself against unemployment in the future or earning her reservation income $x_L$ (which could indeed be 0) and gaining unemployment benefits $I$. This example makes clear that the model could be stretched for more than two periods, but the essential features of the decision situation of the insured are captured in this simplified version. Additionally, the example shows why in this model as well, effort is measured in utility cost and not in monetary units, since the examples for effort are non-monetary in nature.

For simplification we assume insurer and insured not to have time preferences and no possibility of transferring wealth between the two periods. The insurer will offer an insurance contract, the insured will accept or decline it and contingent on that decision determine his effort. Based on the effort, the state of nature for the second period is determined and the insurance contract is executed.

In the perfect information, the insurer can again make the premium dependent on the effort of the insured. The insured anticipates the price-setting mechanism, takes up insurance and chooses $e$ as to maximize expected utility. The first best solution under perfect information thus implies the
following maximization problem of the insured\textsuperscript{10}:

\[
\max_e EU = U(x_H - \pi(e)) + (1 - p(e))U(x_H - \pi(e)) + p(e)U(x_L + I) - c(e)
\]

For convenience, we abbreviate \(U(x_H - \pi(e))\) as \(U_H\) and \(U(x_L + I)\) as \(U_L\). The budget constraint of the insurer reads:

\[
(2 - p(e))\pi(e) - p(e)I = 0
\]

Thus the first order condition is given as:

\[
p'(e) [U_L - U_H] - \frac{\partial \pi}{\partial e}(2 - p(e))U_H' = c'(e)
\] \hspace{1cm} (7)

As in (1), the case of non-contingent premiums, the marginal benefit of effort is twofold, the loss probability and the premium are decreased through effort.

The second best solution is again characterized by non-observability of effort and thus a fixed insurance contract \((\pi, I)\) independent of effort. The maximization problem is\textsuperscript{11}:

\[
\max_e EU = U(x_H - \pi) + (1 - p(e))U(x_H - \pi) + p(e)U(x_L + I) - c(e)
\]

It renders the first order condition:

\[
p'(e) [U_L - U_H] = c'(e)
\] \hspace{1cm} (8)

which compared to (7) shows no marginal benefit due to premium reduction. We use this situation in order to analyze the influence of premium subsidies on the effort exercised by the insured. We again introduce \(\lambda\) as a relative subsidy factor\textsuperscript{12}. This yields the following budget constraint:

\[
\lambda(2 - p(e))\pi - p(e)I = 0
\] \hspace{1cm} (9)

\textsuperscript{10}For technical issues, see C.
\textsuperscript{11}For technical points, especially with regard to the result given in (10), see pp. 29f in C.
\textsuperscript{12}Again, the results hold for absolute subsidies, as well.
As above, we use (8) and apply the implicit function theorem to arrive at:

$$\frac{\partial e}{\partial \lambda} = -\frac{p'(e) \frac{\partial \pi}{\partial \lambda} U'}{p''(e) [U_L - U_H] - c''(e)} > 0 \quad (10)$$

The result shows that higher subsidies increase the effort exercised by the insured and reduce the problematic effects of moral hazard in insurance contracts with contingent premiums. This can be intuitively explained by the fact that by subsidizing the premium to be paid at a constant coverage level the wealth in the high-wealth state increases. This now increases the incentive for the insured to be in the high-wealth state and thus he will increase the exercised effort in order to have a higher probability of achieving that state. In contrast to demand effects, wealth effects in contingent premium contracts thus decrease the inefficiency due to moral hazard.

5 Discussion and Policy Implications

Our results highlight two aspects of premium subsidies. Firstly, premium subsidies in insurance programs can change the behavior of individuals even if they do not change their insurance coverage. Secondly, the design of the insurance system and particularly the premium payment plan, will determine the influence premium subsidies will have on the insured’s behavior.

By focusing the discussion of premium subsidies and moral hazard on demand effects, it has implicitly been limited to those people that change their coverage due to the premium subsidies. The goal of virtually every policy measure which introduces or increases premium subsidies is to increase insurance take-up. A change in behavior is an obvious consequence of insurance coverage. Even though this change in behavior might be problematic, the increased insurance coverage was the initial goal of the subsidization. So any change in behavior must initially have been judged as an acceptable cost for the benefit of increased coverage. Nevertheless, subsidies do not only affect those people that will end up changing their coverage. Any person that is already insured will benefit from the subsidy even if they do not change their insurance coverage at all. This study focuses on the way which this benefit will change the behavior of the insured.

It is important to consider all market participants when considering premium subsidies and not only those who will change their insurance coverage or start to participate in the insurance program for the first time. Depending on the structure of the insurance program and the available
coverage levels, those individuals who do not change their coverage can be much more economically significant than those who do. This might change the outlook on some of the economic policies which are in consideration or already in force. The question of whether demand effects or wealth effects are more important is directly tied to the design of the insurance system. In a market with many different accessible coverage levels, demand effects will most probably have the stronger impact on the insured’s behavior. However, with a decreasing number of options to choose from and increasing transactions costs associated with the change of one’s coverage, wealth effects will gain importance.

The second design aspect shown to be important by this study, is the way premiums are paid by the insured. By subsidizing the premium, the wealth of the insured changes in all states of the world in which the insured pays a premium. Thus, if the premium payment is contingent, the benefit of the subsidy is only gained if no loss occurs. This way, the premium subsidy provides the insured with an additional incentive to prevent a loss. While this result is important for analyzing the effects of a subsidy on moral hazard, it also holds potential implications for redeveloping old insurance systems or designing new ones.

A possible criticism towards our results could be the fact that for the case of non-contingent contracts, they are solely derived from a change in the curvature of the utility function due to the subsidy. It could be argued that this change is rather small since the change in lifetime consumption implied by a subsidy is minor. There are several arguments against this. Firstly, insurance premiums are an annual payment and should thus be seen in relation a yearly consumption instead of lifetime consumptions. Secondly, they can be rather large, Since health insurance policies can easily exceed $10,000, a tax exemption as is currently in force in the United States implies a change in annual consumption by over $3,000. Thirdly, the change in the curvature of consumption utility need not only depend on risk aversion. When considering a model including consumption commitments as is done by Chetty and Szeidl (2007), even smaller changes in wealth can lead to significant changes in utility curvature. Lastly, even if the wealth effects of subsidies in non-contingent contracts are only marginal, they are still opposite in sign to those in contingent insurance contracts, which do not only stem from a change in utility curvature. Thus, our central result calling for a differential treatment of insurance contracts with different premium payment plans still stands.

Apart from the results regarding premium subsidies and moral hazard, our results also hold
for positive premium loadings. None of the results are bound to \( \lambda \geq 1 \). However, if the premium payments are loaded instead of subsidized (\( \lambda < 1 \)), the participation constraint of the insured might not hold. In a case where it does not hold anymore, the insured will not take up insurance and the moral hazard problem disappears. Nevertheless, for sufficiently risk averse decision makers or in the case the insurance coverage is mandatory, the results will hold and can be applied to premium loadings.

Our results have implications for public policy. It is apparent that when discussing subsidization for insurance, considerations are mostly focused on the trade-off between the cost of the subsidy and the potential positive effects of increased participation and decreased adverse selection (Glauber, 2004). Neglecting moral hazard as a possible consequence of subsidized insurance policies is a common, but possibly dangerous mistake. When implementing premium subsidies, the moral hazard problem should always be considered. Our analysis highlights, however, that the considerations must differ according to the design of the insurance scheme. It must be determined whether demand effects or wealth effects play the predominant role in the insurance system. Wealth effects are most likely to be significant if premiums are high and few possible coverage choices exist. In such systems, the effects of premium subsidies on moral hazard will then differ with the premium payment plan. In the following, we will use two current policy debates as examples of how policy implications can be derived.

In many countries, unemployment insurance is part of a mandatory benefits package for all employees, a policy that has been criticized on the grounds of moral hazard before (Christofides and McKenna, 1995). In Germany, for example, the premium for unemployment insurance amounts to the smaller of 3\% of the employees’ pre-tax income or €174 a month. In this system, coverage is mandatory and only one possible level of coverage exists. Wealth effects are thus extremely likely to play a role. Additionally, premium payments are contingent, that is they are only paid as long as the individual is in employment. Subsidizing unemployment insurance premiums, for example by means of a different financing system of unemployment protection, would thus increase the income of people in employment. This improved situation of people that do not claim on unemployment insurance raises the incentives for people to work. Thus, premium subsidies in this unemployment insurance system could deter moral hazard.

The health and long term care insurance system in the United States is one of the most discussed
economic issues to date (see, for example, Feldstein, 1973; Coulson et al., 1995; Danzon and Pauly, 2002; Gruber, 2011, for just a selection of the issues under discussion). Additionally, as was mentioned above, subsidies play a very significant role in this system, amounting to over $1.1 Trillion between 2013 and 2017 (Joint Committee on Taxation, 2013). Several differentiations need to be made. It is a sensible assumption that individuals have more coverage choice when participating in a health care exchange than when being covered with an employer sponsored health insurance plan. Thus wealth effects should play a bigger role in the latter market. Furthermore, the coverage for health care and long term care are often rightfully discussed as being very similar (Goda, 2011). This goes so far that in the report on tax exemptions by the Joint Committee on Taxation, the subsidies for the two coverages are listed as a single, combined item. However, when it comes to wealth effects of premium subsidies they differ in a key aspect: the premium payment plan. Hence, premium subsidies will have different wealth effects in both systems. For health insurance, premium subsidies will raise moral hazard, due to the non-contingent premium payments. For long term care insurance, moral hazard will be reduced by premium subsidies, since the premium payment is contingent on not claiming benefits. The policy discussion on subsidies for these two insurance programs should thus be carried out separately rather than jointly. The excise tax on high coverage level health insurance plans that is part of the Patient Protection and Affordable Care Act and will come into effect in 2018 can be seen as a step in the right direction in this regard. It only applies to health insurance plans and thus separates the two policy issues.

6 Conclusion

The results derived in this study show that the wealth effects of premium subsidies can influence the behavior of an insured. Depending on the premium payment plan, subsidies will either worsen or lessen the detrimental consequences of moral hazard in insurance markets. These results carry important implications for public policy, especially considering the large monetary expenditures on premium subsidies in certain insurance systems (Gruber, 2011).

Our study shows that the influence of premium subsidies on moral hazard is a multi-faceted

13 This is particularly true when looking at its long term effects. The tax of 40% applies to all health insurance plans with a premium higher than $10,200 for an individual or $27,500 for a family. These amounts are inflation adjusted, but only by overall inflation and not by the (assumed to be) considerably higher medical cost inflation. Thus, the tax will effectively phase out all health insurance subsidies in the United Stated over the coming decades.
problem. It thus seems necessary to promote more research in this area. One obvious extension to this study would be an econometric test of the results from the models derived above. A second one is to extend the models to include demand effects as well as wealth effects in the considerations. Even though the results of this study offer some insights into how the different effects should interact, it was the goal to investigate the behavior of individuals that do not change their coverage due to the premium subsidy. This way, it was possible to isolate wealth effects and provide a detailed look at it. Future work can use these results to study the case in which both wealth effects and demand effects are present. Finally, the results of this study show, that different insurance systems lead to different results. It could thus be beneficial to identify additional design aspects that could influence the wealth effects of premium subsidies on moral hazard.
A Non-Contingent Premiums and Ex-Ante Moral Hazard

**Perfect Information:** In order for the first order condition given by (1) to identify the correct and unique solution, two properties of the model must be fulfilled. The participation constraint of the insured must be non-binding and the second order condition must be fulfilled.

The participation constrain in the model is given by the following inequality.

\[
(1 - p(e))U(x_H - \pi(e)) + p(e)U(x_L - \pi(e) + I) \geq (1 - p(e))U(x_H) + p(e)U(x_L)
\]

To see that it is not binding, meaning that the inequality is strict, it has to be observed that fairly priced insurance in the way it is introduced in the model leads to a mean preserving contraction in the lottery that determines the wealth of the insured. Since we assume \( U(\cdot) \) to be strictly concave, the above inequality must thus be strict.

We also see the second order condition fulfilled. The no full insurance condition provides that \( x_H - \pi > x_L - \pi + I \). Also, as can be seen by: \( \frac{\partial \pi}{\partial e} = p'(e)I \) and \( \frac{\partial^2 \pi}{\partial e^2} = p''(e)I \), the premium is convexly decreasing in effort. Thus:

\[
\frac{\partial^2 EU}{\partial e^2} = p''(e) [U_L - U_H] + p'(e) \pi'(e) [U_H' - U_L'] - \pi''(e) \left[ (1 - p(e))U_H' + p(e)U_L' \right] \\
- \pi'(e) \left[ p'(e) (U_H' - U_L') - \pi'(e) \left( (1 - p(e))U_H'' + p(e)U_L'' \right) \right] < 0
\]

**Asymmetric Information:** We characterize the insured’s decision by the first order condition in (2). For this we need to show again that the participation constraint is non-binding and that the second order condition holds. Furthermore, there are some technical problems usually associated with moral hazard models. As demonstrated by Shavell (1979) and Gjesdal (1982), the solution could be random. However, due to our assumption that the cost function is measured in utility units, this cannot be the case in our model. Additionally, the expected profit curves of the insurer could be non-convex (Helpman and Laffont, 1975). We assume the insured to buy insurance from only a single insurer, which is a valid assumption for almost all insurance markets. In this case, expected profit curves will be convex.

We show the participation constraint to be holding by the same reasoning as employed by Shavell (1979). Given an actuarially fairly priced insurance contract and the effort of the insured to
be determined according to (2), we express the budget constraint of the insurer as \( \pi(I) = p(e(I))I \).

If the insured were to choose the insurance contract \((\pi(I), I)\) such that her utility is maximized, her maximization problem would read:

\[
\max_I EU = (1 - p(e(I)))U(x_H - \pi(I)) + p(e(I)))U(x_L - \pi(I) + I) - c(e(I))
\]

Maximizing the expected utility and substituting (2) then renders:

\[
\frac{\partial EU}{\partial I} = p(e(I))(1 - p(e(I))) [U'_L - U'_H] - p'(e) \frac{\partial e}{\partial I} I [(1 - p(e(I)))U'_H + p(e(I))U'_L]
\]

From this we can see that \( \frac{\partial EU}{\partial I} |_{I=0} > 0 \). Due to the concavity of the maximization problem in \( I \), we can thus infer that there will always be some insurance contract with positive indemnity which is better than no insurance.

This in itself is not sufficient to show that the participation constraint is not binding. However, consider the market structure assumed in this model. If the insurance market is perfectly competitive, that insurance contract which offers the most utility to the insured will be offered by all insurers. Since the above shows that there is an insurance contract with positive expected utility for the insured, the participation constraint will be non-binding. In the second possible market structure discussed above, a benevolent monopolist (such as the government) offers the insurance contracts. It is a sensible assumption that this monopolist will also offer that insurance contract which maximizes the expected utility of the insured. Since the insurance contract will only improve from the insured’s perspective if \( \lambda > 1 \), this result also holds for subsidized insurance policies.

From the assumptions on marginal cost and marginal benefit of effort, it is trivial to see that the second order condition holds:

\[
p''(e) [U_L - U_H] - c''(e) < 0
\]

Lastly, the effect of premium subsidies on the effort of the insured hinges on \( \frac{\partial \pi}{\partial \lambda} < 0 \). We can see that this is fulfilled from:

\[
\frac{\partial e}{\partial \pi} = - \frac{p'(e) [U'_H - U'_L]}{p''(e)[U_L - U_H] - c''(e)} > 0
\]

26
and thus:
\[
\frac{\partial \pi}{\partial \lambda} = -\frac{\pi}{\lambda - p'(e) \frac{\partial e}{\partial \pi}} I < 0
\]

B Non-Contingent Premiums and Ex-Post Moral Hazard

For this model the same considerations as for the asymmetric information model above apply. Thus the solution will be non-random and the expected profit curves will be convex. That the first order condition in (5) renders a unique and global maximum can be seen due to the fact that the term
\[
G = (1 - p)U(x_H - \pi) + p \int_{L}^{\overline{L}} U(x_H - \pi - \delta L) f(L, e) dL
\]
is concavely increasing in \( e \). Calculating the first derivative and using integration by parts renders:
\[
\frac{\partial G}{\partial e} = p \int_{L}^{\overline{L}} U(x_H - \pi - \delta L) \frac{\partial f(L, e)}{\partial e} dL
\]
\[= p \left[ U(x_H - \pi - \delta L) \frac{\partial F(L, e)}{\partial e} \right]_{L}^{\overline{L}} - p \int_{L}^{\overline{L}} (-\delta) U'(x_H - \pi - \delta L) \frac{\partial F(L, e)}{\partial e} dL \quad (B.1)
\]
By assumption, the support of \( f(L, e) \) does not change in \( e \). Thus, \( F(L, e) = 0 \forall e \) and \( F(\overline{L}, e) = 1 \forall e \) leading to \( \frac{\partial F(L, e)}{\partial e} = \frac{\partial F(\overline{L}, e)}{\partial e} = 0 \). This makes the first term on the right hand side of (B.1) equal zero and as such:
\[
\frac{\partial G}{\partial e} = p\delta \int_{L}^{\overline{L}} U'(x_H - \pi - \delta L) \frac{\partial F(L, e)}{\partial e} dL > 0
\]
and
\[
\frac{\partial^2 G}{\partial e^2} = p\delta \int_{L}^{\overline{L}} U'(x_H - \pi - \delta L) \frac{\partial^2 F(L, e)}{\partial e^2} dL < 0
\]
This in combination with the assumption on \( c(e) \) also implies a fulfilled second order condition. The same logic as above can be used to derive the first order condition in equation (5).

We can see that the participation constraint is non-binding by the same reasoning as employed above. We again maximize the expected utility of the insured with respect to the insurance coverage,
in this case $\delta$. The relevant budget constraint is $\pi(\delta) = p \int_{L}^{T} (1 - \delta) L f(L, e(\delta)) dL$. 

$$
\max_{\delta} EU = (1 - p) U(x_H - \pi(\delta)) + p \left[ \int_{L}^{T} U(x_H - \pi(\delta) - \delta L) f(L, e(\delta)) dL - c(e(\delta)) \right]
$$

Taking the derivative gives us:

$$
\frac{\partial EU}{\partial \delta} = p \left[ \int_{L}^{T} \left( -\frac{\partial \pi}{\partial \delta} - L \right) U'(x_H - \pi(\delta) - \delta L) f(L, e(\delta)) dL + \int_{L}^{T} U(x_H - \pi(\delta) - \delta L) \frac{\partial e}{\partial \delta} \frac{\partial f(L, e(\delta))}{\partial e} dL \right] 
- \frac{\partial \pi}{\partial \delta} (1 - p) U'(x_H - \pi(\delta)) - p c'(e) \frac{\partial e}{\partial \delta}
$$

We know from the derivation of the first order condition that $p \int_{L}^{T} U(x_H - \pi - \delta L) \frac{\partial f(L, e)}{\partial e} dL - p c'(e) = 0$. We can substitute this and rearrange slightly:

$$
\frac{\partial EU}{\partial \delta} = - \frac{\partial \pi}{\partial \delta} p \int_{L}^{T} U'(x_H - \pi(\delta) - \delta L) f(L, e(\delta)) dL - p \int_{L}^{T} U'(x_H - \pi(\delta) - \delta L) L f(L, e(\delta)) dL 
- \frac{\partial \pi}{\partial \delta} (1 - p) U'(x_H - \pi(\delta))
$$

We now consider the budget constraint. We can see that $\frac{\partial \pi}{\partial \delta} = -p \int_{L}^{T} L f(L, e(\delta)) dL + p(1 - \delta) \int_{L}^{T} \frac{\partial e}{\partial \delta} \frac{\partial f(L, e(\delta))}{\partial e} dL$. Through partial integration and the assumptions on the support of $f(L, e)$, this can be expressed as $\frac{\partial \pi}{\partial \delta} = -p \int_{L}^{T} L f(L, e(\delta)) dL - p(1 - \delta) \frac{\partial e}{\partial \delta} \int_{L}^{T} \frac{\partial f(L, e(\delta))}{\partial e} dL$. We can substitute this into the expression above to gain:

$$
\frac{\partial EU}{\partial \delta} = p(1 - \delta) \frac{\partial e}{\partial \delta} \int_{L}^{T} \frac{\partial F(L, e(\delta))}{\partial L} dL \left[ (1 - p) U'(x_H - \pi(\delta)) + p \int_{L}^{T} U'(x_H - \pi(\delta) - \delta L) f(L, e(\delta)) dL \right] 
+ p \int_{L}^{T} L f(L, e(\delta)) dL \left[ (1 - p) U'(x_H - \pi(\delta)) + p \int_{L}^{T} U'(x_H - \pi(\delta) - \delta L) f(L, e(\delta)) dL \right] 
- p \int_{L}^{T} U'(x_H - \pi(\delta) - \delta L) L f(L, e(\delta)) dL
$$

We can take advantage of the fact that $U'$ is increasing in $L$ which implies:

$$E \left[ U'(x_H - \pi(\delta) - \delta L) \cdot L \right] > E \left[ U'(x_H - \pi(\delta) - \delta L) \right] \cdot E \left[ L \right]$$
Thus, when evaluating $\frac{\partial EU}{\partial \delta} \bigg|_{\delta = 1}$, we get:

$$\frac{\partial EU}{\partial \delta} \bigg|_{\delta = 1} < \int_L^T L f(L, e(\delta))dL \left[ (1 - p)U'(x_H - \pi(\delta)) + p \int_L^T U'(x_H - \pi(\delta) - \delta L)f(L, e(\delta))dL \right]$$

$$\quad \quad \quad \quad \quad - \int_L^T L f(L, e(\delta))dL \int_L^T U'(x_H - \pi(\delta) - \delta L)f(L, e(\delta))dL < 0$$

Again, due to the concavity of the maximization problem in $\delta$, we can thus infer that there will always be some insurance contract with $\delta < 1$ which is better than no insurance at all. In combination with the assumed market structure, this shows that the participation constraint is not binding. Since the insurance contract will only improve from the insured’s perspective if $\lambda > 1$, this result also holds for subsidized insurance policies.

To determine the sign of the influence of premium subsidies on effort in (6), we again need to show that $\frac{\partial \pi}{\partial \lambda} < 0$. The implicit function theorem and (5) render:

$$\frac{\partial e}{\partial \pi} = \delta \int_L^T U''(x_H - \pi - \delta L) \frac{\partial F(L, e)}{\partial e} dL$$

$$\quad \quad \quad \quad \quad - \pi \int_L^T U'(x_H - \pi - \delta L) \frac{\partial F(L, e)}{\partial e} dL - c''(e) > 0$$

We now apply the implicit function theorem on the insurers budget constraint to identify the influence of the subsidy parameter on the premium:

$$\frac{\partial \pi}{\partial \lambda} = \frac{\pi}{\lambda - p \int_L^T (1 - \delta) L \frac{\partial F(L, e)}{\partial e} \frac{\partial F(L, e)}{\partial e} dL} > 0$$

Through integrating by parts and using the assumption that the support of $F(L, e)$ does not change in effort, we can thus see:

$$\frac{\partial \pi}{\partial \lambda} = \frac{\pi}{\lambda + p \int_L^T (1 - \delta) \frac{\partial F(L, e)}{\partial \pi} \frac{\partial F(L, e)}{\partial e} dL} < 0$$

C Contingent Premiums and Ex-Ante Moral Hazard

Perfect Information: The same reasoning as for the participation constraint in the perfect information case with non-contingent premiums also applies for contingent premiums. Fairly priced insurance is a mean preserving contraction in the distribution of the insured’s wealth and thus
insurance is preferred to no insurance.

Consider the second order condition:

\[
\frac{\partial^2 EU}{\partial e^2} = \left( \frac{\partial \pi}{\partial e} \right)^2 (2 - p(e))U_H'' - \frac{\partial^2 \pi}{\partial e^2} (2 - p(e))U_H' + p''(e) [U_L - U_H] + 2 \frac{\partial \pi}{\partial e} p'(e)U_H' - c''(e)
\]

To show that it is fulfilled, we need to see that \( \frac{\partial \pi}{\partial e} = \frac{2p'(e)}{(2 - p(e))^2} I \) and \( \frac{\partial^2 \pi}{\partial e^2} = \frac{2p''(e)(2 - p(e)) + 4(p'(e))^2}{(2 - p(e))^3} I \).

Substituting these and rearranging renders:

\[
\frac{\partial^2 EU}{\partial e^2} = \left( \frac{2p'(e)}{(2 - p(e))^2} I \right)^2 (2 - p(e))U_H'' - \frac{2p''(e)(2 - p(e)) + 4(p'(e))^2}{(2 - p(e))^2} IU_H' - c''(e) < 0
\]

**Asymmetric Information:** As in the asymmetric information models above. The possibility of random coverage or non-convex expected profit curves of the insurer do not play a role in our specific model set up.

We again use the approach by Shavell (1979) to see that the participation constraint is non-binding. We maximize the expected utility of the insured with respect to the insurance coverage, in this case \( I \). The relevant budget constraint is \((2 - p(e(\pi, I)))\pi - p(e(\pi, I))I = 0\).

\[
\max_I EU = U(x_H - \pi(I)) + (1 - p(e(I)))U(x_H - \pi(I)) + p(e(I))U(x_L + I) - c(e(I))
\]

Maximizing the expected utility and substituting (8) then renders:

\[
p(e(I)) [U_L' - U_H'] - 2I \frac{p'(e) \frac{\partial \pi}{\partial I}}{2 - p(e(I))} U_H' = 0
\]

So we can see that \( \frac{\partial EU}{\partial I} |_{I=0} > 0 \) and thus there will always be some insurance to maximize the expected utility of the insured. From this we can infer that there will be a contract \((\pi, I)\) for which the participation constraint of the insured and the budget constraint of the insurer are fulfilled. This and our assumptions on the market structure again make the participation constraint non-binding. Since the insurance contract will only improve from the insured’s perspective if \( \lambda > 1 \), this result
also holds for subsidized insurance policies.

The second order condition is fulfilled:

\[ p''(e) [U_L - U_H] - c''(e) \]

The effect of subsidies on the premium level is characterized by (10). In this equation the sign of \( \frac{\partial \pi}{\partial \lambda} \) is not obvious, since there are multiple \((\pi, e)\) pairs which fulfill both (8) and (9). One can, however, show graphically that the influence must be negative. The insured will choose his effort as to fulfill the first order condition in (8) and the insurer will set \( \pi \) such that the budget constraint in (9) is binding. The solution to both problems will thus be characterized by the intersection of the graphical representations of (8) and (9) in \((\pi, e)\)-space.\(^{14}\)

The graph of the budget constrain (9) can easily be shown to be convexly downward sloping since it renders:

\[
\frac{\partial e}{\partial \pi} = \frac{(2 - p(e)) \lambda}{p'(e) I + p'(e) \pi \lambda} < 0
\]

and

\[
\frac{\partial^2 e}{\partial \pi^2} = -\lambda p'(e) \frac{\partial}{\partial \pi} [p'(e)(\lambda \pi + I)] - \lambda(2 - p(e)) \frac{p''(e) \partial}{\partial \pi} (\lambda \pi + I) + p'(e) \lambda \frac{p'(e) I + p'(e) \pi \lambda}{(p'(e) I + p'(e) \pi \lambda)^2} > 0
\]

The graph of the first-order condition (8) is also downward sloping:

\[
\frac{\partial e}{\partial \pi} = \frac{-p'(e) U'_H}{p''(e) [U_L - U_H] - c''(e)} < 0
\]

However, the slope of this line in the \((\pi, e)\)-space cannot be shown to be uniquely concave or convex so there might be multiple intersections of the two graphs representing (8) and (9). Nevertheless, we can use three key observations:

1. Due to the fulfilled participation constraint there will always be at least one intersection of the two lines corresponding to (8) and (9).

2. The intersection with the highest \( e \) and the lowest \( \pi \) will always be the best solution.

- Imagine there are two intersections \((\pi_1, e^*(\pi_1))\) and \((\pi_2, e^*(\pi_2))\) with \( \pi_1 < \pi_2 \).
- Then \( EU(\pi_1, e^*(\pi_1)) \geq EU(\pi_1, e^*(\pi_2)) \geq EU(\pi_2, e^*(\pi_2)) \).

\(^{14}\)We thank Casey Rothschild for suggesting this solution.
3. On the first intersection, the line representing (8) will cross the line corresponding to (9) from left to right.

- According to (8) $e^*(\pi = 0)$ will be some finite value.
- Since by assumption $p(e) > 0 \ \forall \ e$, (9) can never be fulfilled for $\pi = 0$ and thus never crosses the y-axis.

An increase (decrease) in $\lambda$ will shift the graph representing (9) to the left (right) in the $(\pi, e)$-space and due to the second observation thus shift the optimal solution to a lower (higher) value of $\pi$ thus proving that $\frac{\partial \pi}{\partial \lambda} < 0$ leading to $\frac{\partial e}{\partial \lambda} > 0$ in (10). This is shown graphically in figure 1. Due to the negative effect of premium subsidies on the premium, it also follows that the participation constraint remains fulfilled for all $\lambda > 1$.

![Diagram showing graphical solution in the $(\pi, e)$-space.](image)

Figure 1: Graphical solution in the $(\pi, e)$-space.
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