How insurance market affects healthcare demand ?

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Abstract

This paper contributes to the current debate on health system reform by assessing the impact of insurance market organization on the price of healthcare. In contrast to the classic model à la Rothschild/Stiglitz (1976), a difference exists between the monetary evaluation of the discomfort caused by the illness and the price of healthcare. We focus on both the adverse effects on access to healthcare and the structure of the health insurance system: compulsory versus voluntary, and private versus public. Our model reveals clearly distortions of price on the healthcare market induced by the presence of an insurance market. Indeed, while the healthcare is always consumed when its price is inferior or equal to the discomfort, only the presence of an insurance market allows its consumption at a higher price. Moreover, three surprising results appear to depend on our distinction between discomfort and price of healthcare. First, adverse selection may lead to the healthcare to be sold at a price lower than under perfect information. Second, a potential non-participation of one type arises despite competition, depending the level of information. Third, in a public voluntary regime, one-type may prefer to be uninsured and consumed the healthcare. Moreover, under both perfect and imperfect information, the compulsory scheme Pareto-dominates the voluntary scheme in the private regime whereas this no longer holds in the public regime.

Keywords: Health insurance, Adverse selection, Health Care, Public/Private, Compulsory/Voluntary insurance

JEL Classification: D82; H52; I18

1 Introduction

This paper presents a general framework for modeling the impact of insurance scheme on the healthcare demand that overcomes some of the results of the two-type model of Rothschild and Stiglitz (1976), but also includes the latter as a special case. Rothschild and Stiglitz' approach assumes that the price of damage and the discomfort caused by the disease are confounded. The relaxation of this assumption turns out to be relevant to study the non-participation to insurance and the non-participation to the healthcare market. Thereby, the demand for insurance and the demand for healthcare are simultaneously modelised, under symmetric and asymmetric information. The presence of adverse selection affects both demands.

The discomfort concerns here the monetary evaluation of the individual suffering, and the price is the individual gross expenditure to be treated. The severity in terms of discomfort may not imply a costly treatment and *vice versa*. Indeed, an individual who suffers a disease with serious consequences may find that the health discomfort costs a lot relative to the medical good needed to treat for. Inversely, some harmless health problems require nevertheless very high levels of medical expenditure, in which case an

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individual may prefer to suffer the discomfort. This distinction makes clear the existence of two trade-offs: *i)* to choose an insurance contract or not, and *ii)* in the event of disease, to treat or not the disease whatever the choice made on the insurance market. As a direct consequence, the probability of consuming the medical care may differ from the probability of suffering an illness, even in a competitive insurance market. Our model highlights the relation between demand for healthcare and demand for insurance, which has not been analysed before to our knowledge.

Different forms of health insurance are observed across OECD countries. In the Netherlands and Switzerland, insurance contract is based on competition between private insurers. Nevertheless, basic swiss insurance is compulsory and insurers, which decide the premium, cannot discriminate between their members. In France, health insurance is provided by a public monopoly for the compulsory part. The premium is proportional to income. In the United States, individuals under 65 may subscribe to a voluntary insurance contract with a private insurer. A considerable [1] fraction of the population is uninsured. A certain part of the population is also insured *via* their firm.[2] In this context individuals do not really have the choice of a private insurer: were they to refuse health insurance *via* the company, the premium required by any other private insurer company would be higher. This situation can be linked with that of a monopoly private insurer. Thereby, we study different schemes of insurance market. By private system, we mean competing insurers with the possibility of discriminating between types. We call public system, a monopoly where discrimination is impossible. A voluntary regime is also compared to a compulsory one. In our paper, we show that the insurance scheme has a significant impact on the healthcare demand.

In order to assess the impact of insurance scheme on the healthcare demand, we propose new definitions of three concepts. Without insurance, the *perceived price* corresponds to the actual healthcare price. The insurance affects the perceived price leading to a distortion of the price. The perception of price coincides with the out-of-pocket price under the compulsory scheme. However, it may differ from the universal notion of out-of-pocket, as here it takes into account the probability that the individual participates **to** the insurance market. The *distortion* of healthcare price is the difference between *i)* the actual healthcare price, which is exogenous and *ii)* the individual perceived price which depends on the insurance system. The *willingness to pay* is the maximum amount of money which an individual is prepared to spend on the healthcare. The maximal level of distortion is reached when the healthcare is sold at a price corresponding to the individual's willingness to pay. Therefore, the individual perceived price varies as a function of the insurance scheme, and so do the distortion and the willingness to pay.

Our model clearly reveals price distortions on the healthcare market, induced by the presence of an insurance market. Indeed, without insurance, the healthcare is sold until the actual price is equal to the discomfort. Only the presence of insurance market allows healthcare price to be sold at a price higher than the discomfort. The highest actual price for which there exists a demand depends on the insurance scheme. Moreover, a counter-intuitive result appears with imperfect information. Adverse selection may have a decreasing effect on the willingness to pay. The healthcare may be sold at a lower price under imperfect information.

We find that the distinction between the monetary evaluation of discomfort and healthcare price induces possible non-participation in spite of the competitive insurance market. A similar result was previously shown by Dahlby (1981) and Hansen and Keiding (2002), who compared well-being between compulsory and voluntary insurance markets in the presence of adverse selection. Nevertheless, Dahlby's model

[1] "Approximately 15.6 percent of the American population were without health insurance coverage in 2003, and the number of the uninsured is rising". Source: http://www.nchc.org/facts/coverage.shtml.

[2] "A third of firms in the U.S. did not offer coverage in 2003. Two-thirds of uninsured workers in 2001 worked for employers who did not offer health benefits. Even if employees are offered coverage on the job, they cannot always afford their portion of the premium. Employee spending for health insurance coverage (employee's share of family coverage and deductibles) has increased 126 percent between 2000 and 2004. Losing a job, or quitting voluntarily, can mean losing affordable coverage - not only for the worker but also for their entire family)". Source: http://www.nchc.org/facts/coverage.shtml.

considers the level of insurance as fixed and exogenous, so that insurers choose only the amount of the premium. Hansen and Keiding (2002) assume the existence of a pooling contract in a private insurance market (Danzon, 2002). Our model has the advantage of not making these restrictive assumptions. First, we assume the premium and the coverage as endogenous. Second, this result of non-participation arises not only with pooling contract but also with separated contracts. In addition, we show that both high risks and low risks or even only one risk may be excluded from the insurance market either with information perfect or with imperfect one. However, the individual may participate to the healthcare market even though excluded from the insurance market. This result arises for the low-risk in a public voluntary insurance scheme.

Without modeling the insurance market, Santerre and Vernon (2005) considered the relationship between healthcare demand and individual out-of-pocket price. We overcome their approach by distinguishing between individual perceived price and out-of-pocket price. As them, we find that agents' demand for healthcare is inversely correlated with the individual perceived price, but we show also that the individual perceived price is higher under voluntary insurance than under compulsory insurance.

Moreover, we obtain that a voluntary scheme Pareto-dominates a compulsory scheme in private regime, whereas this is no longer the case in a public regime.

Our paper proceeds as follows. Section 2 defines the details of our two-type model relative to the classic model and discusses a first consequence: the probability of healthcare consumption may differ from the probability of illness. In Section 3, we set up our notions of perception of healthcare price, distortion of price and willingness to pay. In the two following sections, we analyse the model according to the way in which the insurance system is organized (compulsory versus voluntary). Section 4 deals with private insurance and Section 5 with public insurance. In these two sections, we also analyse the effect of optimal insurance contracts (derived in the Appendices). Section 6 summarizes and reinterprets our findings in terms of the relative power in healthcare price negotiation of insurers and healthcare suppliers.

2 Approach and notations

2.1 Distinction between damage and repairs

In a standard model, the wealth of an uninsured agent who chooses to repair a damage is exactly the same as the wealth when he suffers his discomfort due to the damage. In other words, the monetary evaluation of the discomfort due to the damage is exactly the price fixed to repair this damage. Our approach distinguishes between this monetary evaluation of the damage called D and the price fixed to repair this damage P, while in a standard model, both concepts are confounded, and noted P. The difference between the monetary evaluation of the discomfort due to the damage and the amount of repairs may be positive or negative in our model, while it is zero in a standard model. In both approaches, P and D are assumed exogenous. Without loss of generality, we assume that the repairs allow for the agent to totally recover his damage D.

Table 1 displays wealths in loss state according to our model and to the standard model. Denoting by w_0 the initial wealth of each individual, an insured agent pays a premium α and is covered at the rate x. So, he receives a compensation in case of repairs after the damage, corresponding to xP in both approaches.

Wealth in loss state	Standard model	Our approach
With insurance	$\begin{cases} w_0 - \alpha - P + xP \text{ if repairs} \\ w_0 - \alpha - P \text{ if no repair} \end{cases}$	$\begin{cases} w_0 - \alpha - P + xP \text{ if repairs} \\ w_0 - \alpha - D \text{ if no repair} \end{cases}$
Without insurance	$w_0 - P$	$\begin{cases} w_0 - P \text{ if repairs} \\ w_0 - D \text{ if no repair} \end{cases}$

(Table 1)

In our approach, the wealth of an uninsured agent depends on the discomfort and the repairs. The individual wealth in state loss is $(w_0 - D)$ without repair[3] and $(w_0 - D - P + D) = (w_0 - P)$ with repair, while in a classical approach his wealth is $(w_0 - P)$ in both cases.

Obviously, these differences in reservation utilities with standard model have an important effect on the demand of repairs. The relation between insurance market organization and demand of repairs is studied in details in Sections 4 and 5.

This model could remind of insurance models on fraud where a gap exists between the *actual* amount of repairs and the *claimed* amount of repairs. However in these models, the discomfort is confounded to repairs.

To illustrate our model and make interpretation easier, we propose to consider the context of health insurance. However, our results go way beyond the field of health economic. This model could be applied to a large number of economic fields as automobile insurance, housing insurance, life insurance or ever unemployment insurance on labour market and so on.

2.2 Probability of illness and probability of consumption

The monetary evaluation of the damage D can be here interpreted as the level of discomfort caused by an illness. The price of repairs P is the price of the healthcare. Thus in the absence of insurance, the treatment of illness costs P to an agent. For the sake of simplicity, without loss of generality, we assume that the healthcare enables agents to recover their initial health: treated agents suffer no monetary loss except P.[4]

We consider two types of agent. High risks denoted H have a higher probability p_H to have the illness than the low risks denoted L. The probability of illness of the $L-type$ is p_L.

We define by $\overline{p}$ the probability of consuming in the entire population (insured or not). Its value depends on the value of $\overline{p}_i$ (for $i = H, L$) with $\overline{p}_i$ the probability of consuming for a type i. Thus we have $\overline{p}_L \in \{0, p_L\}$ and $\overline{p}_H \in \{0, p_H\}$, depending on the participation of each type to the insurance system.

$$\overline{p} = \frac{N_H}{N}\overline{p}_H + \frac{N_L}{N}\overline{p}_L$$

with N_i the number of type i in the population $\left(\sum_{i=H,L} N_i = N\right)$ and $\frac{N_i}{N}$ the proportion of type i in the population $(i \in \{H, L\})$.

The distinction between probability of consuming and probability of illness (damage), specific to our model, is crucial in the further analysis of the comparison between voluntary or compulsory schemes and private or public systems of health insurance.

2.3 Individual preferences and isoprofit curves

In the absence of insurance, the reserve expected utility of a type i is:

$$V_i(E) = p_i U(w_0 - \min\{D, P\}) + (1 - p_i) U(w_0)$$

with $E = (w_0, w_0 - \min\{P, D\})$ the point of initial endowment. E is also called the point of no-insurance. In what follows, it is necessary to distinguish $E_D = (w_0, w_0 - D)$ the point of no-insurance without treatment from $E_P = (w_0, w_0 - P)$ the point of no-insurance with healthcare. By introducing $\max\{U(w_0 - P); U(w_0 - D)\}$ in the expected utility of reservation, we take into account the possibility for any agent to still purchase

[3] In this case, the agent suffers the discomfort.

[4] Note that a positive monetary loss relative to illness could be introduced in our model without loss of generality.

the care (at the price P) in case of illness, even if he is not insured. As usual, U is a *vNM* utility function, increasing and concave in wealth.

Moreover, any individual may subscribe a contract $C = (\alpha, x)$, which specifies the premium α paid to the insurer and the gross indemnification xP received by the insured in case of illness (with $x \in [0, 1]$ the level of coverage). The expected utility for an agent i insured by a contract (α_i, x_i) is written as:

$$V_i(\alpha_i, x_i) = p_i \max\{U(w_0 - \alpha_i - P + x_iP); U(w_0 - \alpha_i - \min\{D, P\})\} + (1 - p_i)U(w_0 - \alpha_i).$$

In a voluntary system, an individual i will choose to subscribe a contract (α_i, x_i) rather than no-insurance if $V_i(\alpha_i, x_i) \geq V_i(E)$.[5] It is obvious that no rational agent would choose to subscribe a contract whose coverage would not be used in loss state.

Finally the expected profit earned by an insurer on a type i $(i = H, L)$ is

$$\pi_i(\alpha_i, x_i) = N_i(\alpha_i - \overline{p}_i x_i P)$$

Note that the profit depends on the $\overline{p}_i$ the probability of consuming, which may differ from p_i the probability of illness.

3 Perception of the healthcare price and critical price

The presence of an insurance system plays a considerable role on the healthcare market. Indeed, the participation of an agent to the insurance market would "distort" his perception of the healthcare price. The notion of perception of price is set up after the premium is paid (of course, for an uninsured agent, the premium is null). This individual perception does depend on the participation of the $i - type$. For a given price P, the perception of price is noted Pe_i.

Definition of the agent's perception:

An individual i gets some level of expected utility when he consumes the healthcare at the price P by being covered by an insurance contract. The perceived price $Pe_i(P)$ is the fictive healthcare price spent by the agent i if he would not be covered, that allows for him to get the same level of expected utility. The perceived price is a relative notion that incorporates (through the expression in the left member of the equality (1)) the distinction between voluntary and compulsory regimes: a compulsory regime implies the constraint for the agent to pay the premium, meaning that the initial wealth of the agent is $w_0 - \alpha_i$, whatever happens, while it is w_0 in a voluntary scheme.

Algebrically,

$$p_i U(\textit{initial wealth } - Pe_i(P)) + (1 - p_i)\, U(\textit{initial wealth}) = EU_i \textit{ of an insured and consuming agent } i \quad (1)$$

with, $\textit{initial wealth} = \begin{cases} w_0 \text{ in voluntary scheme} \\ w_0 - \alpha_i \text{ in compulsory scheme} \end{cases} \quad \forall i = H, L$

The expected utility of an insured and consuming agent i is defined for any value of (x_i, α_i).

[5] Note that $V_i(E)$ is nothing else that $V_i(0, 0)$.

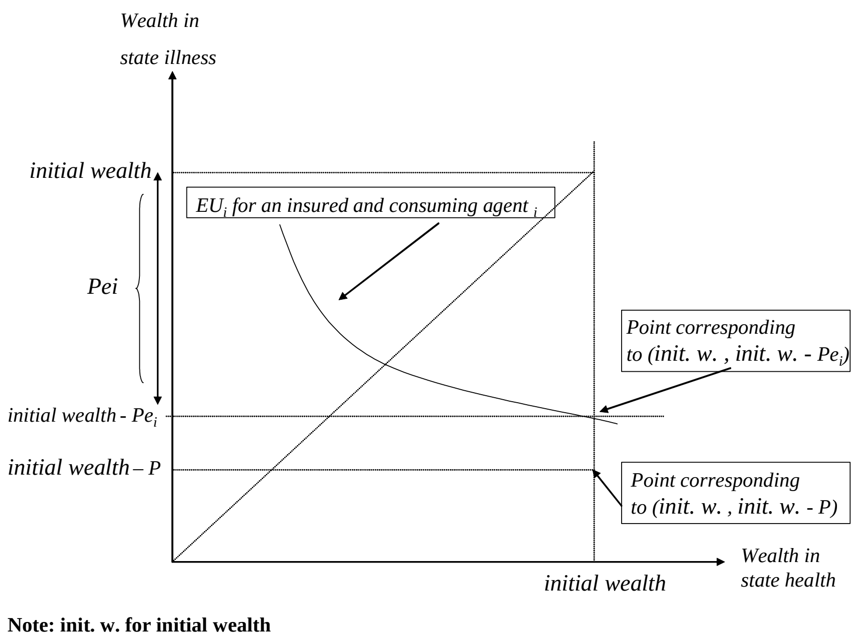

Figure 1: Definition of the agent's perception

To a wealth in state health is associated the corresponding level of wealth in state of illness. The perception is the difference between the initial wealth and the ordonate of the intersection of *i)* EU_i for an insured and consuming agent and *ii)* the vertical line intersecting with the initial wealth (Fig. 1).

This notion is defined more formally for each insurance regime.

Individual distortion

A difference between the actual price and the individual perception leads to an individual distortion of the healthcare price. So, the individual distortion due to the insurance market depends on the participation of the $i - type$. This distortion d_i can be measured by the difference between the price and the perception i.e.

$$d_i = P - Pe_i(P) \;\; \text{with} \;\; Pe_i(P) \in \{Pe_L, Pe_H\}$$

De facto, for an uninsured agent, the perception of the price corresponds to the price P,

$$Pe_i(P) = P \;\; \text{for } i = H, L \tag{2}$$

Therefore, his distortion is trivially zero.

Critical price

We denote by P^{C_i} with $i = H, L$ the critical price, also called the willingness to pay of the agent i. P^{C_i} is defined as the maximal price that an agent accepts to spend for the healthcare *i.e.* the price beyond which the agent refuses to consume. The agent accepts to consume until his perception of the price is equal to the monetary evaluation of his discomfort. Therefore, his willingness to pay P^{c_i} is defined by

$$Pe_i(P^{C_i}) = D \;\; \text{for } i = H, L \tag{3}$$

Trivially, the willingness to pay for an uninsured agent i comes from Eqs (2) and (3), we have

$$P^{C_i} = D$$

Notice that without requiring to the perception's notion, it is trivial to obtain this result. Indeed, the uninsured agent accepts to spend for the healthcare whenever his utility in case of treatment is higher than his utility in the absence of treatment in state loss[6] *i.e.* whenever,

$$\underbrace{U(w_0 - P)}_{\text{Utility if no insurance and treatment}} \geq \underbrace{U(w_0 - D)}_{\text{Utility if no insurance and no treatment}}$$

Therefore, we also find that the uninsured agent consumes while $P \leq D$.

Thus, there is a healthcare demand for any value of P such that $P \leq D$. That does not depend on the insurance market. On the contrary, when $P > D$ healthcare demand comes only from insured agents and the healthcare demand depends on the insurance system. Any consumption will be due to the presence of insurance market that will create an imperfection on the market by allowing the sell of healthcare to a level of price higher than D.

Graphically (Figures 2 to 8), w_{Fi} represents ordinates of the intersection between the indifference curve of an insured agent i and the vertical line intersecting with E_P and E_D in voluntary case and with E'_{Pi} and E'_{D_i} in compulsory case (E'_{Pi} and E'_{D_i} being individual points of initial endowment net of the compulsory premium). These ordinates correspond to,

$$w_{Fi} = \begin{cases} w_0 - Pe_i \text{ in voluntary scheme} \\ w_0 - \alpha_i - Pe_i \text{ in compulsory scheme} \end{cases} \quad \forall i = H, L$$

So, graphically, the possible distortion due to the insurance market is measured by the difference between w_{Fi} and $(w_0 - P)$ in voluntary scheme or $(w_0 - \alpha_i - P)$ in compulsory scheme.

The demand is depending on the probability to consume healthcare of each type H and L. Since these probabilities are themselves depending on whether the insurance is compulsory or voluntary and the market is public or private, we study the demand of healthcare associated to the four regimes. The demand is also depending on the level of information. With an environment of asymmetric information, all the individuals initially possess private information about their probability of suffering a discomfort but the individual type is not publicly observable. The analytic resolution of each program is presented in Appendices.

4 Private insurance

In case of a private insurance, we consider a competitive insurance market. Given the absence of regulation, insurers discriminate between high risks and low risks by offering separate contracts with different premia α_i and levels of coverage x_i. We compare the case of compulsory insurance with the one of voluntary insurance, first in full information and second in imperfect information. For each case, we present individual perceptions of the healthcare price and study impacts of the insurance market on these perceptions.

4.1 Compulsory scheme

In the case of compulsory insurance system, agents have to participate to the insurance market. All agents pay the premium α_i even if they choose not to consume the healthcare. If one of the two separate contracts is a null contract, the other contract is a null one too.[7] Different examples can be found in the insurance world, as the French compulsory clause for the automobile insurance or the housing insurance.

[6] We assume that, conditionally to the state illness, if a type i is indifferent between treatment and no treatment, he consumes the health care.

[7] The compulsory scheme means implicitly that if we constrain a type to participate to the insurance system, we constrain both types to participate.

4.1.1 Benchmark case: perfect information

In symmetric information, the insurer distinguishes the low risk from the high risk. If P is inferior to P^{C_i} the critical price of each type, the insurer is able to propose a contract with full-reimbursement against an actuarial premium for each type, since in this context high risks are not able to pretend to be low risks.

In other words, given that each type i always pays the premium α_i, competitive contracts in full information are derived from Program Ia,

$$\max_{\alpha_i, x_i} p_i \max\{U(w_0 - \alpha_i - P + x_i P); U(w_0 - \alpha_i - \min\{D, P\})\} + (1 - p_i)U(w_0 - \alpha_i) \qquad \text{(Program Ia)}$$

$$\text{subject to } N_i(\alpha_i - \overline{p}_i x_i P) \geq 0$$

for each type $i \in \{H, L\}$. Thus, insurers trivially maximize the expected welfare of each type subject to the no-negative expected profit constraint.

With $P \leq P^{C_i}$ $\forall i = \{H, L\}$, we have $\overline{p}_i = p_i$ *i.e.* each type consumes the healthcare and the optimal necessary conditions of Program Ia trivially lead to an actuarial premium $\alpha_i^{PI} = p_i P$ against the promise to receive the indemnity P in case of illness. In a world of full information, each type i would thus receive C_i^{PI}, his full insurance contract: $x_i^{PI} = 1$ (Figure 2a).

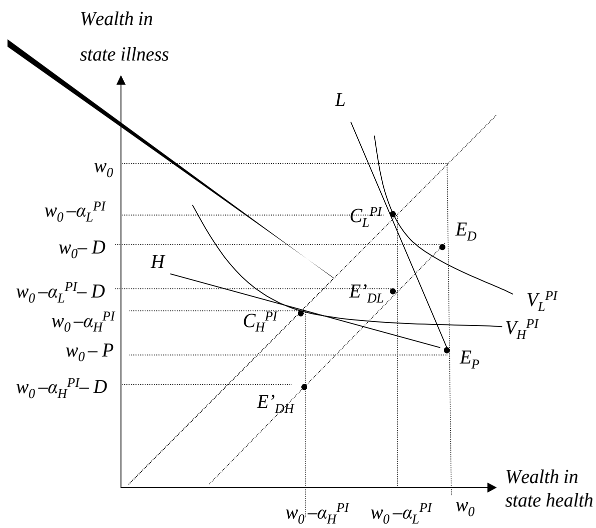

Figure 2a: Compulsory and private insurance with perfect information: C_i^{PI} always preferred to E'_{Di} by any type i

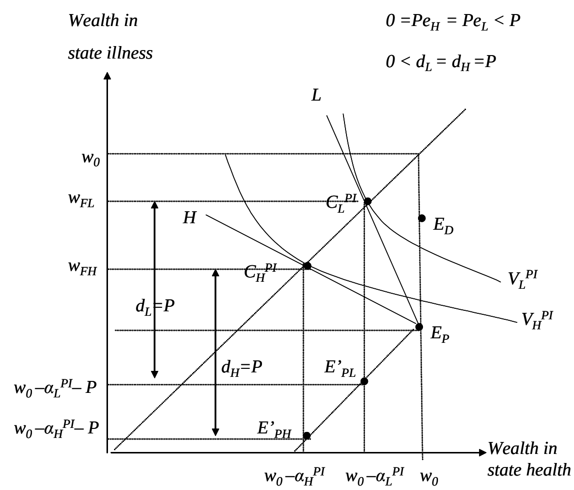

Figure 2b: Compulsory and private insurance with perfect information : Perception Pe_i and distortion d_i of the drug price

Whatever the decision about the consumption, each type has to pay the *compulsory* premium α_i^{PI}. Therefore, the initial wealth is $w_0 - \alpha_i^{PI}$. On one hand, a fully insured agent choosing to consume gets a final wealth corresponding to $\left(w_0 - \alpha_i^{PI}\right)$ in both states. On the other hand, an insured agent who chooses not to consume gets the final wealth in state illness $\left(w_0 - \alpha_i^{PI} - D\right)$ that is inferior to $\left(w_0 - \alpha_i^{PI}\right)$, whatever the level of the discomfort D.

Graphically (Figure 2a), whatever D, C_i^{PI} is always preferred to E'_{D_i} by any type i, E'_{D_i} being the allocation reached without consumption under a compulsory insurance regime.[8]

From optimal contracts, individual perceptions and distortions are characterized by Lemma 1.

Lemma 1*: When information is perfect, compulsory private insurance induces a unique distortion of the price equal to P and leads to a unique willingness to pay only limited by* $\frac{w_0}{\overline{p}_i}$.

[8] See points E'_{D_i} compared to C_i^{PI} on Figure 2a.

Proof. In a compulsory scheme, the individual i's perception of the price is defined by Pe_i such that:

$$p_i U(w_0 - \alpha_i^{PI} - P + x_i^{PI} P) + (1-p_i) U(w_0 - \alpha_i^{PI}) = p_i U(\underbrace{w_0 - Pe_i - \alpha_i^{PI}}_{w_{F_i}}) + (1-p_i) U(w_0 - \alpha_i^{PI})$$

$$\Leftrightarrow Pe_i = (1 - x_i^{PI})P \Leftrightarrow Pe_i = 0, \forall i$$

It directly follows that the distortion d_i is maximal, equal to P. In Figure 2b, the individual distortion is measured by

$$d_i = w_{F_i} - (w_0 - \alpha_i^{PI} - P)$$

with w_{F_i}, the ordinate of the intersection between the insured i's indifference curve and the vertical line crossing E'_{P_i}.

The individual critical price, noted P^{C_i} and defined by $Pe_i(P^{C_i}) = D$, is

$$P^{C_i} = \frac{D}{1 - x_i^{PI}}$$

Even though the critical price P^{C_i} seems to tend to infinite whatever i in a compulsory scheme, P^{C_i} is actually bounded by the wealth of the agent under the **no-loan** assumption: $w_0 - \alpha_i^{PI}(P) = 0$. Thus the price is limited by $\frac{w_0}{\overline{p}_i}$.■

4.1.2 Imperfect information

Under a private regime, introducing adverse selection in the model has some significant effects on perception and distortion. When insurers do not observe the risk linked to the agent, high risks are now able to pretend to be low risks. The menu of actuarial contracts with full insurance holds no longer when the risk-type is not observable by insurers. So, we introduce incentive constraints in Program Ib to derive competitive contracts in this regime. Thus, insurers maximize the expected welfare of low risks subject to the incentive constraints and the no-negative profit[9] constraints, so that optimal contracts in imperfect information are derived from Program Ib:

$$\max_{\alpha_i, x_i} p_L \max\{U(w_0 - \alpha_L - P + x_L P); U(w_0 - \alpha_L - \min\{D, P\})\} + (1-p_L) U(w_0 - \alpha_L)$$

subject to

$$p_i \max\{U(w_0 - \alpha_i - P + x_i P); U(w_0 - \alpha_i - \min\{D, P\})\} + (1-p_i) U(w_0 - \alpha_i) \geq$$
$$p_i \max\{U(w_0 - \alpha_k - P + x_k P); U(w_0 - \alpha_k - \min\{D, P\})\} + (1-p_i) U(w_0 - \alpha_k) \quad i, k \in \{H, L\}, i \neq k$$
$$N_i(\alpha_i - \overline{p}_i x_i P) \geq 0 \qquad \text{(Program Ib)}$$

The form of the objective function is due to imperfect information. We maximize the expected welfare of the low risks because they are the ones who support the negative externalities from high risks.

From Appendix A, we find that for $P \leq P^{C_i}$ (with P^{C_i} the critical price of an agent $i \in \{H, L\}$), the separate contract offered to each type is the Rothschild and Stiglitz contract (Fig. 3),

$$\begin{cases} x_H^* = 1 \text{ and } \alpha_H^* = p_H P \\ x_L^* < 1 \text{ and } \alpha_L^* = x_L^* p_L P \end{cases}$$

For $P > P^{C_i}$, none is insured nor consumes the healthcare.

[9] As usual, competition à la Rothschild/Stiglitz (1977) requires no negative profits on each contract for an equilibrium to exist. Moreover, no pooling contract is compatible with equilibrium because any situation in which some risks (here low risks) subsidize some others (high risks) would imply a possibility for a rival company to earn positive profits by attracting only low risks with a contract with a cheaper premium against the promise of a smaller coverage.

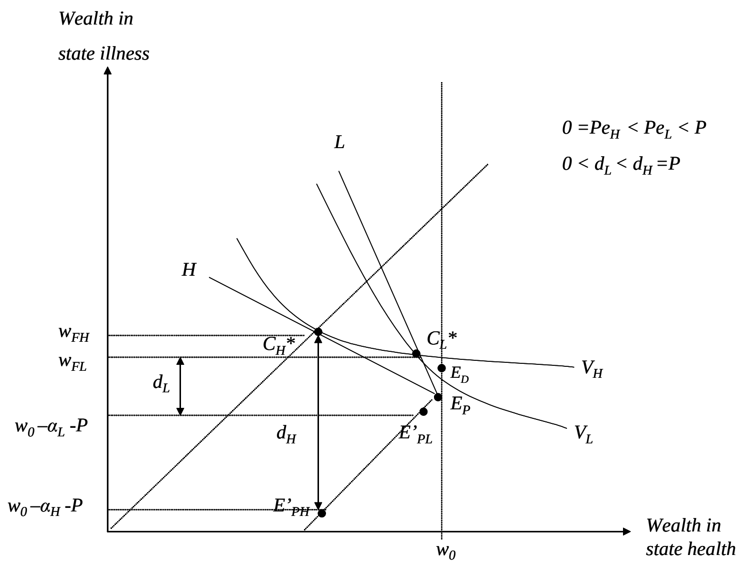

Figure 3: Compulsory and private insurance with imperfect information

Even though separate contracts lead to two different perceptions of price, the following Lemma shows that under compulsory private insurance, critical prices are identical.

Lemma 2: *Compulsory private insurance induces a distortion of the price higher for high risks ($d_H = P$) than for low risks ($d_L = x_L P$) when information is imperfect, but leads to a unique bounded willingness to pay* $P^{C_i} = P^{C_L} = \frac{D}{(1-x_L)}$.

Proof.

- As explained before, the perception is defined as the value for which the expected utility of an insured agent is equal to the expected utility if the agent is not insured but consumes. Here, "not insured" means that the agent does not receive any reimbursement in case of illness but, because the insurance regime is compulsory, the agent i has to pay the premium α_i. Thus, Pe_i is defined by,

$$p_i U(w_0 - \alpha_i - P + x_i P) + (1 - p_i) U(w_0 - \alpha_i) = p_i U(w_0 - \alpha_i - Pe_i) + (1 - p_i) U(w_0 - \alpha_i)$$
$$\Leftrightarrow U(w_0 - \alpha_i - P + x_i P) = U(w_0 - \alpha_i - Pe_i)$$
$$\text{and so } Pe_i(P) = P(1 - x_i)$$

So, $Pe_H = 0$ and $Pe_L(P) = P(1 - x_L) < P$. Individual distortion is equal to P as in perfect information for high risks while it is equal to $x_L P$ for low risks (Fig. 3).

- The critical price is defined such that the perception of the price corresponds to the discomfort. So for low risks, P^{C_L} is defined as:

$$Pe_L\left(P^{C_L}\right) = D \Leftrightarrow P^{C_L} = \frac{D}{(1 - x_L)}$$

For high risks, the definition of P^{C_H} is *a priori* more complex. As for the low risks, the $H - type$ agents choose between either to consume or to undergo the discomfort. In addition, they may be interested by the contract intended to low risks. That implies that the incentive constraint of the $H - type$ has to be taken into account in the definition of the critical price of $H - type$ in order to make him indifferent between his contract and the $L - type$'s contract.

High risks do not consume whenever,

$$p_H U(w_0 - \alpha_H - P + x_H P) + (1 - p_H) U(w_0 - \alpha_H) < p_H U(w_0 - \alpha_L - D) + (1 - p_H) U(w_0 - \alpha_L) \quad (4)$$

In the right member of (4), the compulsory premium paid by $H-type$ is α_L instead of α_H because each type chooses to pay the lowest premium α_L when suffering the discomfort is preferred to consuming the healthcare.

Given that the H' incentive constraint is binding, Inequation (4) is equivalent to

$$\begin{aligned} p_H U(w_0 - \alpha_L - P(1 - x_L)) + (1 - p_H) U(w_0 - \alpha_L) &< p_H U(w_0 - \alpha_L - D) + (1 - p_H) U(w_0 - \alpha_L) \\ &\Leftrightarrow \quad P > \frac{D}{(1 - x_L)} \Rightarrow P^{C_H} = \frac{D}{(1 - x_L)} = P^{C_L} \end{aligned}$$

Thus, the critical price does depend only on the coverage of $L - type$. ■

Remark that the perception of price[10] appears to coincide with the universal notion of *out-of-pocket price* under the compulsory scheme. The condition $P \leq P^{C_i}$ means that the *out-of-pocket price* is inferior to the monetary evaluation of the discomfort, D. Indeed, $P \leq \frac{D}{(1-x_L)} \Leftrightarrow P(1 - x_L) \leq D$. In contrast, this holds no more longer under the voluntary scheme, in which perception may differ from out-of-pocket.

4.2 Voluntary scheme

In this system, agents are not submitted to compulsory insurance. Individuals subscribe a contract from an insurer or remain not insured. As under compulsory scheme, an agent who participates to insurance, necessarily consumes. Moreover, we show here that if he would consume without contract, an insurer could always offer one contract that increases his expected utility.[11] In other words, consumption implies participation and reciprocally.

4.2.1 Benchmark case: perfect information

Voluntary insurance does not guarrantee that the two types do participate to insurance market. So, we take into account the exit option of the agent. In Program IIa, the choice of each type i to participate to the insurance market is captured by $\max\{V_i(0,0); V_i(\alpha_i, x_i)\}$. Any consumer i is thus led to choose between the best contract offered by competitive insurers and the best "option of exit". For each agent $i \in \{H, L\}$, the insurer proposes the contract that solves,

$$\underset{\alpha_i, x_i}{Max} \; \{max\{V_i(0,0); V_i(\alpha_i, x_i)\}\} \qquad \text{(Program IIa)}$$
$$\text{subject to } N_i(\alpha_i - \overline{p}_i x_i P) \geq 0$$

Because the contracts are separate and the insurance scheme is voluntary, three situations occur:

$$\begin{cases} \text{When both types are insured, } x_i^* = 1 \text{ and } \alpha_i^* = p_i P, \forall i \quad (\text{Fig. 4, } E_{D1}) \\ \text{When only the low risks are insured but not the high risks, } \begin{cases} x_L^* = 1 \text{ and } \alpha_L^* = p_L P \\ x_H^* = 0 \text{ and } \alpha_H^* = 0 \end{cases} \quad (E_{D2}) \\ \text{When no type is insured, } x_i^* = 0 \text{ and } \alpha_i^* = 0, \forall i \quad (E_{D3}) \end{cases}$$

[10] Fig. 3 displays $Pe_L = P(1 - x_L)$.

[11] Note that this implication does hold no more longer under a public voluntary regime.

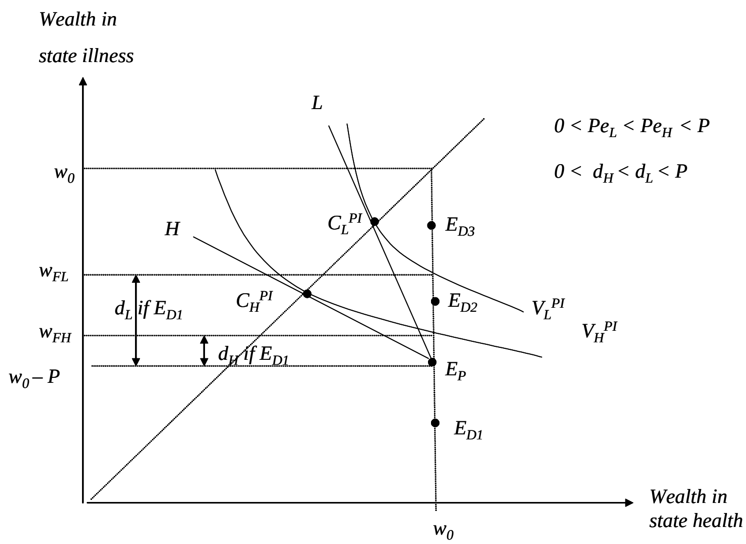

Figure 4: Voluntary and private insurance with perfect information

The individual i's perception of the price is defined by Pe_i such that:

$$p_i U(w_0 - \alpha_i^{PI} - P + x_i^{PI} P) + (1 - p_i) U(w_0 - \alpha_i^{PI}) = p_i U(\underbrace{w_0 - Pe_i}_{w_{F_i}}) + (1 - p_i) U(w_0) \tag{5}$$

and implies the following intermediary result,

Lemma 3: *Under perfect information, voluntary private insurance system induces a distortion of the price higher for $L - type$ than for $H - type$, and low risks are willing to pay more than high risks for consuming the healthcare.*

Proof. When both types are insured, Eq. (5) is equivalent to,

$$U(w_0 - p_i P) = p_i U(w_0 - Pe_i) + (1 - p_i) U(w_0)$$
$$\Leftrightarrow U(w_0 - p_i P) - U(w_0) = p_i [U(w_0 - Pe_i) - U(w_0)]$$

Moreover, $p_H > p_L$ implies $U(w_0 - p_H P) - U(w_0) < U(w_0 - p_L P) - U(w_0)$ and thus, we obtain

$$p_H [U(w_0 - Pe_H) - U(w_0)] < p_L [U(w_0 - Pe_L) - U(w_0)] \Rightarrow Pe_H > Pe_L$$

Thus, the distortion is higher for $L - type$ than for $H - type$. The case with only one type insured is for $L - type$. Therefore, his perception remains Pe_L while the perception of $H - type$ becomes P, so that $d_L > d_H = 0$. With no type insured, $Pe_i = P$ and $d_i = 0, \forall i$.

As a direct consequence, the critical price of $L - type$ is superior to the $H - type's$ one, meaning that the high risk would be the first type to leave the insurance market in case of attractive option of exit.■

4.2.2 Imperfect information

Competitive contracts are derived from the maximization of the $L - type$'s welfare subject to incentive constraints and no-negative profit constraints:

$$\underset{\alpha_i, x_i}{Max} \{max\{V_L(0,0); V_L(\alpha_L, x_L)\}\}$$
$$s.t. \; max\{V_i(0,0); V_i(\alpha_i, x_i)\} \geq max\{V_i(0,0); V_i(\alpha_k, x_k)\} \;\; i, k \in \{H, L\}, i \neq k$$
$$N_i(\alpha_i - \overline{p}_i x_i P) \geq 0 \;\; i \in \{H, L\}$$

Because the contracts are separated and the insurance scheme is *voluntary*, the participation to the insurance market of one type does not depend on the participation of the other type (as opposite to the compulsory case). So, four subcases are analyzed in Appendix B on the participation of each type i. From Appendix B, we obtain

$$\begin{cases} \text{When both types are insured} \begin{cases} x_H^* = 1 \text{ and } \alpha_H^* = p_H P \\ x_L^* < 1 \text{ and } \alpha_L^* = x_L^* p_L P \end{cases} \\ \\ \text{When only the high risks are insured but not the low risks,} \begin{cases} x_H^* = 1 \text{ and } \alpha_H^* = p_H P \\ x_L^* = 0 \text{ and } \alpha_L^* = 0 \end{cases} \\ \\ \text{When no type is insured, } x_i^* = 0 \text{ and } \alpha_i^* = 0, \forall i \end{cases}$$

From optimal contracts, it follows:

Lemma 4: *Under voluntary private insurance and imperfect information, distortions and willingnesses to pay depend on the type. The distortion induced by the insurance market is higher for $H-type$ than for $L-type$, and the $H-type$ is willing to pay more than the $L-type$ for consuming the healthcare.*

Proof: The perception of the healthcare price Pe_i for an agent i is such that:

$$p_i U(w_0 - \alpha_i - P + x_i P) + (1-p_i)U(w_0 - \alpha_i) = p_i U(w_0 - Pe_i) + (1-p_i)U(w_0) \text{ with } \alpha_i = x_i p_i P$$

and the critical price P^{c_i} for an agent i depends only on whether he does participate to insurance and is defined by $Pe_i(P^{c_i}) = D$ *i.e.* by

$$p_i U(w_0 - \alpha_i - P^{c_i} + x_i P^{c_i}) + (1-p_i)U(w_0 - \alpha_i) = p_i U(w_0 - D) + (1-p_i)U(w_0) \text{ with } \alpha_i = x_i p_i P^{c_i}$$

The perception of price and so the critical price for each type are defined for the reimbursement level obtained from the program so, at the Rothschild and Stiglitz equilibrium. At the equilibrium, the two types have not the same level of reimbursement, $H-type$ is fully reimbursed but the $L-type$ is partially reimbursed. Therefore, the critical price for the $L-type$ is much lower than one of the $H-type$.

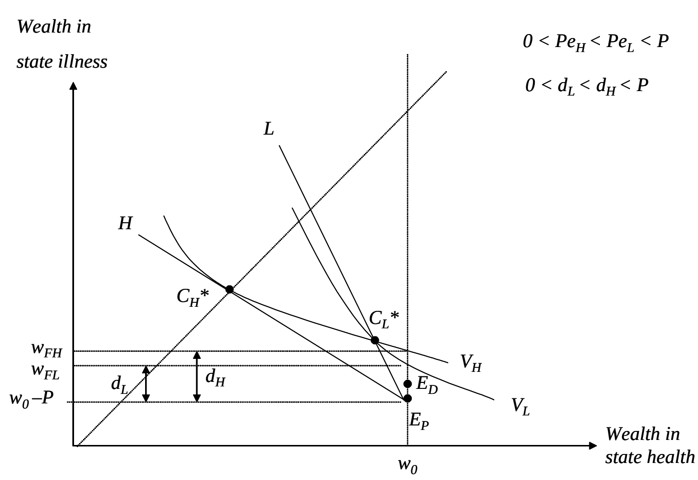

Figure 5: Imperfect information : Voluntary and private insurance when both types are insured

In Figure 5, the healthcare price is such that the expected utility of uninsured agents that undergo the discomfort is lower than that of the insured agents. So, both types prefer to be insured and consume the healthcare. However, other situations can be discussed. Let us consider the price is such that the level of wealth after undergoing the discomfort is between w_{FL} and w_{FH} (Fig. 6). The $L - type$ prefers not to be insured and to undergo the discomfort whereas the $H - type$ has a better expected utility by choosing to be insured. Thus, there exists an interval of price for which only the $H - type$ is insured. In this case, for $L - type$, the perception becomes P, the distortion is null and the critical price becomes D. At last, for a certain level of discomfort, both types may have a higher expected utility by choosing to be not insured (whenever $V_H(E_D) > V_H(\alpha_H^*, x_H^*)$). In this case, perceptions are equal to P, distortions are trivially zero and critical prices are D, whatever the type.■

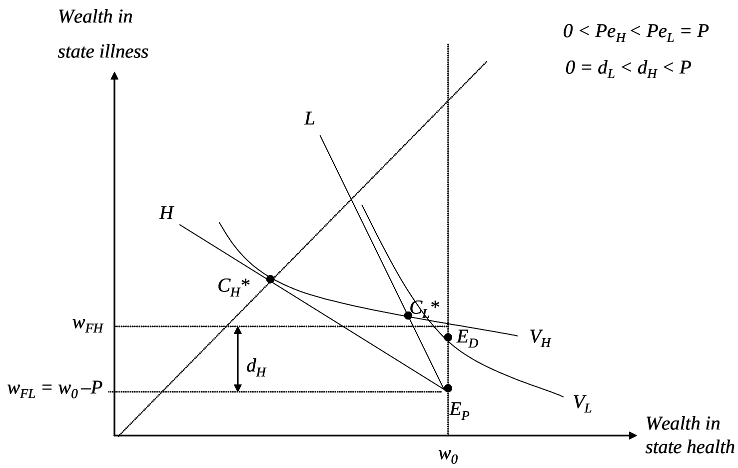

Figure 6: Imperfect information: voluntary and private insurance when only high risks are insured

Imperfect information is now compared with the perfect information situation. When probabilities of illness become unobservable for insurers, high risks can masquerade for low risks and choose their contract. So, incentive constraints lead the $L - type$ to be only partially insured, whereas the $H - type$ remains insured with his full information contract. As a consequence of Lemmata 1 and 3, it comes that,

Proposition 1: *Imperfect information leads to a change of the ranking of individual willingnesses to pay, via a reversal of individual perceptions and distortions. Moreover, the presence of adverse selection may drive the healthcare to be sold at a lower price.*

In other words, in perfect information, the $H - type$ leaves the insurance market before the $L - type$ and inversely in situation of imperfect information.

Concerning the second part of Proposition 1, the intuition is the following. With a partial coverage, the incentive to quit the insurance market is greater than the one with a full coverage.[12] With perfect information, both types are fully covered. The presence of adverse selection drives the $L - type$ to have a partial coverage, so a lower willingness to pay. Therefore, the healthcare may be sold at a lower price with imperfect information.

Note that under a compulsory system, agents do not have the choice to subscribe the insurance contract. They are under the contract that the insurer offers to them. So, whatever the decision about consumption, the $L - type$ has to pay the premium α_L^* and he consumes as long as $P \leq \frac{D}{(1-x_L)}$. Under a voluntary system, the agent's participation to the insurance market depends on his expected utility. So, there exist cases where under voluntary insurance, the $L - type$ chooses to be uninsured while under compulsory insurance, he has to be insured. Figure 3 displays such a configuration. These cases may appear for the $H - type$ too. This remark holds in the public system.

[12] Indeed, the difference between the expected utility to be insured and to be uninsured is greater with perfect information than imperfect information.

5 Public insurance

By public system, we mean both, a monopolistic insurer regime and no discrimination practiced. A unique premium α is paid by each individual to a public organism. As example, the "basic" French health insurance can be viewed as administrated by a unique public agency[13]. However, a discrimination based on the income can be done. In this paper, we assume that agents have the same income. The level of coverage x is thus the same for any individual.

For a given price P, the terms (α, x) of the optimal contract are derived from a program in which the public insurer maximizes the social welfare $N_H V_H(\alpha, x) + N_L V_L(\alpha, x)$[14] under an aggregate no-negative profits constraint $\sum_i N_i(\alpha - \overline{p}_i xP) \geq 0$.

In the public regime because discrimination is forbidden, incentive constraints are not consistent. Therefore, there is no difference between the program of perfect information and the program of imperfect information. We study voluntary system and compulsory one. The contract proposed to the agent is the pooling contract noted PC in Figures 7 and 8.

5.1 Compulsory scheme

Optimal public contracts are derived from Program III,

$$\max_{\alpha,x} N[\overline{p}\max\{U(w_0 - \alpha - \min\{D, P\}); U(w_0 - \alpha - P + xP)\} + (1-\overline{p})U(w_0 - \alpha)] \qquad \text{(Program III)}$$

$$s.t. \sum_i N_i(\alpha - \overline{p}_i xP) \geq 0$$

From Appendix C, we obtain a full-insurance pooling i.e. $x^* = 1$ and $\alpha^* = \overline{p}P = \left(\frac{N_H}{N}p_H + \frac{N_L}{N}p_L\right)P$ (see PC in Fig. 7). Not only do individuals have to subscribe a contract but also, a unique premium α^* is paid by each individual.

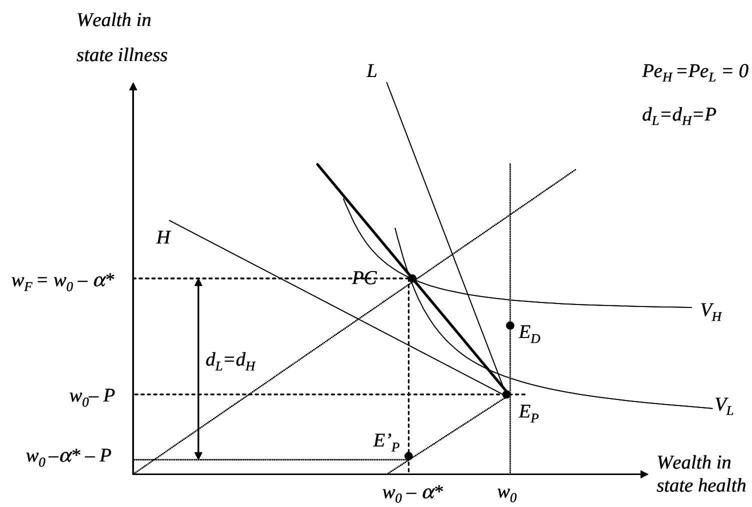

Figure 7: Compulsory and public insurance with full coverage
PC: Pooling contract

[13] In fact, the reality is a little more complex. To sum up, the biggest pourcentage of the population (subpopulation of workers) pays a compulsory premium (contingent to the income), to a unique public agency.

[14] We assume that the insurer adopts a utilitarist behavior, so that the respective weights of H and L in the social welfare function coincide with the proportions of H and L in the population.

From the characteristics of the pooling contract, we derive the following results:

Lemma 5 : *Under compulsory public insurance, the healthcare demand does not depend on P, the healthcare price. Both types perceive the price as being null, whatever the value of P. Insurance market induces the same distortion whatever the type, equal to P, and a unique willingness to pay, unbounded but by $\frac{w_0}{\overline{p}}$.*

Proof. Each type of agent has to pay the premium α^* and, in case of illness, each type is fully reimbursed. Henceforth, in state health, the level of wealth of each type is $w_0 - \alpha^*$ and in state illness, each type has to choose between either to consume the healthcare and to be completely reimbursed (the level of wealth is $w_0 - \alpha^*$) or not to consume the healthcare and suffer the discomfort D (the level of wealth is $w_0 - \alpha^* - D$). We obtain that whatever the level of P, each type prefers to consume the healthcare in case of illness ($w_0 - \alpha^* > w_0 - \alpha^* - D$, $\forall P$). *De facto*, the case where only one type i prefers consuming the healthcare is not possible.

Moreover, the perception of the price Pe_i does not depend on the type. Indeed, Pe_i is defined by,

$$\overline{p}U(w_0 - \alpha - P + xP) + (1 - \overline{p})U(w_0 - \alpha) = \overline{p}U(w_0 - \alpha - Pe_i) + (1 - \overline{p})U(w_0 - \alpha)$$
$$\text{and so } Pe_i\left(P\right) = P\left(1 - x\right) \Rightarrow Pe_i\left(P\right) = 0 \text{ and } d_i = 0, \forall i$$

and the critical price P^{C_i} is unique, defined by

$$Pe_i\left(P^{c_i}\right) = D \Leftrightarrow P^{c_i} = \frac{D}{1 - x}$$

and tends to infinite for $x = 1$. Only the individual wealth limits the willingness to pay.■

In a situation without insurance, the healthcare price P is bounded by D. Here, the presence of a compulsory public insurance enables the price to be unbounded.[15] Indeed, whatever the price the insured agent has the perception that the price is null.

5.2 Voluntary scheme

Contrary to the private system, when a type i chooses not to participate to insurance, he may choose to consume the healthcare.

Even if no discrimination is practiced in the public regime, the agent has the choice to participate to the insurance market. However, contrarily to competitive system with voluntary insurance, only one contract (α, x) is proposed in the market, whatever the agent type. Program IV may thus be written as,

$$\max_{\alpha,x} \sum_i N_i\{max\{V_i(0,0); V_i(\alpha, x)\}\} \qquad \text{(Program IV)}$$
$$s.t. \sum_i N_i(\alpha - \overline{p}_i xP) \geq 0$$

Depending on which type(s) i do(es) participate to insurance, four subcases appear. From Appendix D, we find that,

$$\begin{cases} \text{When both types are insured } x^* \leqq 1 \text{ and } \alpha^* = x^*\left(\frac{N_H}{N}p_H + \frac{N_L}{N}p_L\right)P \\ \text{When only the high risks are insured but not the low risks, } x^* = 1 \text{ and } \alpha^* = p_H P \\ \text{When no type is insured, } x^* = 0 \text{ and } \alpha^* = 0 \end{cases}$$

[15] Remark that an infinite price does not mean that the types are unsensitive to the price of prescription drug. Indeed, their expected utility is always decreasing in P, whatever the level of x.

Both types participate and definition of the $L-type$ critical price It is important to remark that in a standard insurance model where $P = D$, the solution of the program would lead to a full insurance for both types. Given P can be different from D, we get that both types either are fully insured (PC in Fig. 8) or partially insured (PC' in Fig. 8).

We explain below the mechanism that leads the insurer to propose $x^* < 1$. Starting from one case where $x^* = 1$ in which $L-type$ does not participate to the insurance market (Figure 8). Because we are in the case where $P > D$, he prefers not to consume the healthcare. Then, the pooling contract would concern only the $H-type$. Arrow 1 in Fig. 8 shows the variation of $H-type$'s optimal contract depending on the participation of the $L-type$. Some situations exist where the insurer is able to improve the expected utility of both types by proposing a level of reimbursement $x^* < 1$ (Arrows 2 and 3 in Fig. 8).

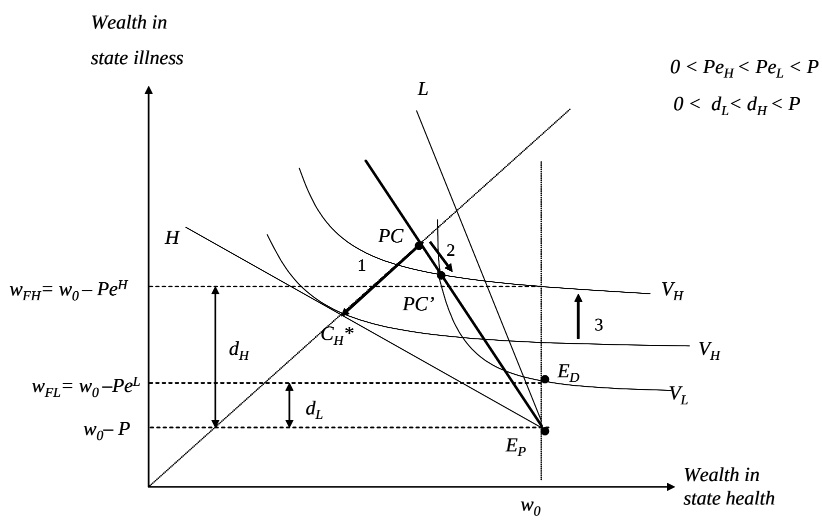

Figure 8: Voluntary and public insurance with full (PC) or partial (PC') coverage
PC: Pooling contract

To a pooling contract is associated two individual perceptions of the healthcare price, Pe_i, defined by,

$$p_i U(w_0 - \alpha - P + xP) + (1 - p_i)U(w_0 - \alpha) = p_i U(w_0 - Pe_i) + (1 - p_i)U(w_0)$$

$$\text{with } \alpha = x\left(\frac{N_H}{N}p_H + \frac{N_L}{N}p_L\right)P \text{ and } x \leqq 1$$

As in private insurance, the definition of critical price depends on which type(s) participate(s) to insurance market, under a voluntary scheme. A pooling contract is proposed when both types participate to the insurance market. The individual critical price is defined by,

$$Pe_i\left(P^{c_i}\right) = D \Rightarrow P^{c_L} < P^{c_H}$$

Therefore, if $L-type$ agents *consume the healthcare*, $H-type$ agents necessarily do. In addition, if $L-type$ agents *participate*, $H-type$ agents necessarily do *i.e* the existence of the pooling contract requires the $L-type'$ participation. Thus, the pooling contract exists only for values for P such that $P \leq P^{c_L}$. For P such that $P > P^{c_L}$, $L-type$ does not participate to the insurance market and does not consume.

Notice that even with $P < P^{c_L}$, the participation to the insurance market is not guaranted (for more details, see later Proposition 3).

One type participates and definition of the $H-type$ critical price The situation where only $H-type$ is insured is possible. In this situation, $L-type$ obtains a better expected utility being uninsured (and undergoing the discomfort in case of illness) than being insured. So, the $L-type$ does not participate to the insurance market. *De facto* the contract intended to the $H-type$ agents corresponds to their full insurance separate contract C_H^*.

As in private system, for the $L-type$, the perception of the price is P when he leaves the insurance market, and the distortion is null. For the $H-type$, from the definition of the perception we get,

$$U(w_0-\alpha_H)=p_H U(w_0-Pe_H)+(1-p_H)U(w_0) \text{ with } \alpha_H=p_H P$$

As a result, under a voluntary scheme, the perception of the healthcare price, the distortion and the critical price do not depend on the public or private regime when only $H-type$ is insured and they are the same as the ones found in the private regime. Perceptions and distortions are displayed in Figure 6.

None participates An extreme situation exists where the pooling contract will not be chosen by any type. Whatever the level of reimbursement $x \leqq 1$, $L-type$ does not participate to the insurance market. In addition, the expected utility of the $H-type$ insured in C_H^* is lower than the expected utility of the uninsured $H-type$ who undergoes the discomfort D in case of illness. So, both types would decide to suffer the discomfort in case of illness by remaining uninsured. In this case, the perception of both types is the price P and the distortion is trivially zero.

From these three configurations, it comes that,

Lemma 6: *Under voluntary public insurance, the distortion induced by the insurance market is higher for the $H-type$ than the $L-type$. The willingness to pay for the $L-type$ is lower than the one of the $H-type$ (regardless information).*

From Lemmata 5 and 6, we obtain this following proposition,

Proposition 2: *Under a public regime, the perception of the price is zero in a compulsory scheme whereas the perception is always strictly positive in a voluntary scheme, even for an individual fully insured. Moreover, the perception of the price on the insurance market is higher for $L-type$ than for $H-type$.*

Moreover, our model modelled simultaneously the demand of health care and the demand of insurance. The advantage of this modelisation is that we may obtain an empirical fact: the case where the agent consumes the health care without being insured.

Proposition 3: *Under a voluntary public regime, the $L-type$ may still consume even though being not insured.*

This configuration arises in this following case: First, the optimal pooling contract (in terms of social welfare) is Pareto-dominated by the configuration where $H-type$ is insured with a Rothschild and Stiglitz contract (C_H^*) and $L-type$ is not insured. Second, the monetary evaluation of the discomfort D is superior to the health care price P. So, the expected utility of any uninsured agent is higher consuming the health care than suffering the discomfort.[16] Therefore, under a voluntary public regime, consumption does not imply participation.

6 Insurance scheme and consequences

Distortion, willingness-to-pay and perception

Recall that the distortion is defined as the difference between the actual price and the perceived price. The individual perception corresponding to the discomfort defines the maximal level of price also called, the willingness to pay. This maximal level of price that determines the demand of healthcare is completely depending on both the presence of insurance and the insurance market organisation. Thus, for

[16] For instance, such a configuration arises with the following values of parameter : $p_H=0.5, p_L=0.2, w_0=20, P=5, D<5, \lambda_H=0.16$ and $U(w)=\ln(w)$. More details available on request.

a given price, the demands of healthcare and insurance appear strongly to depend on the form of insurance scheme. We compare results obtained in the previous sections in *Table 1.*

Insurance system	Level of price	Individual distortion		Demand of health care	Demand of insurance
		$H-type$	$L-type$		
Private compulsory	$P \leq \frac{D}{1-x_i} \to \infty$ in FI $P \leq \frac{D}{1-x_L}$ in AI	P	P in FI $< P$ in AI	$p_H N_H + p_L N_L$	N
Private voluntary	$P \leq P^{C_H}$ in FI $P \leq P^{C_L}_{AI}$ in AI	$d_H < P$	$d_L^{FI} > d_H$ in FI $d_L^{AI} < d_H$ in AI	$p_H N_H + p_L N_L$	N
	$P^{C_H} < P \leq P^{C_L}_{FI}$ in FI	0	$d_L^{FI} < P$	$p_L N_L$	N_L
	$P^{C_L} < P \leq P^{C_H}$ in AI	$d_H < P$	0	$p_H N_H$	N_H
	$P > P^{C_L}_{FI}$ in FI $P > P^{C_H}$ in AI	0	0	0	0
Public compulsory	$P \leq \frac{D}{1-x_i} \to \infty$	P	P	$p_H N_H + p_L N_L$	N
Public voluntary	$P \leq D (< P^{C_L}_{pooling})$	$\begin{cases} d_H^{pool.} < P \text{ (Pool.)} \\ d_H < P \text{ (R\&S)} \end{cases}$	$\begin{cases} d_L^{pool.} < d_H^{pool.} \text{ (Pool.)} \\ 0 \text{ (R\&S)} \end{cases}$	$p_H N_H + p_L N_L$	$\begin{cases} N \text{ (Pool.)} \\ N_H \text{ (R\&S)} \end{cases}$
	$D < P \leq P^{C_L}_{pooling}$	$d_H^{pool.} < P$	$d_L^{pool.} < d_H^{pool.}$	$p_H N_H + p_L N_L$	N
	$P^{C_L}_{pooling} < P \leq P^{C_H}$	$d_H < P$	0	$p_H N_H$	N_H
	$P > P^{C_H}$	0	0	0	0

FI for full information and AI for asymmetric information.

P^{C_H}: WTP and d_H: distortion defined for a R&S contract

$P^{C_L}_{AI}$: WTP and d_L^{AI}: distortion defined for a R&S contract and AI

$P^{C_L}_{FI}$: WTP and d_L^{FI}: distortion defined for a R&S contract and FI

$P^{C_L}_{pool.}$: WTP and $d_L^{pool.}$ and $d_H^{pool.}$: distortions defined for a pooling contract

From Table 1, we deduce the following propositions,

Proposition 4: *Whatever the level of information, the individual distortion is higher under a compulsory scheme than under a voluntary scheme. In addition, whatever the insurance system, with imperfect information, the distortion is higher for the $H-type$ than for the $L-type$.*

Indeed under a *private* regime with imperfect information, the distortion is higher for the $L-type$ than for the $H-type$.

Proposition 5: *Under a voluntary scheme, the willingness to pay for the $H-type$ does not depend on the regime (private or public). Moreover, the individual willingness to pay is always higher in a compulsory system than in a voluntary one but for a private regime and imperfect information. For the latter case, this assertion is true only with the restriction* $\frac{p_H}{1-x_L} > 1$.

Proof. For the second part, see Appendix E.

Intuitively, we expect that for a given demand of healthcare, a compulsory insurance allows for a set of price to be higher than a voluntary one. Actually, Proposition 5 shows that for $\frac{p_H}{1-x_L} \leq 1$, a compulsory insurance may allow for a set of price to be lower than a voluntary one.

Proposition 6: *For all prices such that $P \leq D$, the healthcare is always consumed in case of illness and the consumption does not depend on the agent type. For $P > D$, the healthcare is not consumed by uninsured agents but can be consumed by insured agents.*

For an uninsured agent, the perception is the price of healthcare. Because the consumption of healthcare depends on both the insurance market organisation and the subscription to an insurance contract, the insurance system distorts the individual perception of price. Moreover, the distinction between the price and the discomfort leads to unusual situations : *under a voluntary insurance, only one type or even no type may actually consume the healthcare, even in competition.*

The price is exogenous but the demand of healthcare is depending on its level. Under a compulsory insurance[17], the healthcare demand is always maximal whatever the level of healthcare price while this does not hold under a voluntary insurance.

Intuitively, we expect that for a given level of price, a public insurance leads to a demand of healthcare higher than a private one. Actually, it is not always true and the ranking is not possible. For instance, on one hand (for $P > P^{C_L}_{pooling}$), a pooling contract leads to a demand lower than the one of a separate contract. On the other hand (for $P > \frac{D}{1-x_L}$), the demand is null for a compulsory private insurance and the demand is maximal for a compulsory public one (See Table 1).

Demand and supply

In this paper, we modelled simultaneously the demand of health and the demand of insurance, and their implications. To have the equilibrium healthcare price, we could imagine to model the healthcare supply. However, such a modelisation raises different issues. The supply function of health care depends on *i)* the degree of competition between the suppliers (for instance, pharmaceutical laboratories), *ii)* the policy regulation. The latter concerns not only the policy on healthcare organisation (for instance, a unique public insurer or private insurance competition) but also, both the regulation on the healthcare price (the governement imposes rules on the healthcare price) and reimbursement policy on healthcare (prevention care, drugs, visit on physicians, and so on). Thus, the power of negotiate of suppliers is as much low as the healthcare market is regulated and competitive. On one hand, more regulated is the healthcare market, more high are the public part of insurance and the compulsory part of coverage. On the other hand, more competitive is the healthcare supply market, more the power to negotiate the healthcare price is high for insurers. Their power to negotiate is also more important when their number is small. Therefore, a competitive healthcare market offers the highest power to negotiate to a unique insurer.

Therefore, to include the supply market implies a complex modelisation of three markets. However, to consider a monopolistic healthcare supply without regulation allows to study a three-market model according to insurance system. Indeed, a monopolistic healthcare supplier has the highest power to negotiate on a competitive insurance market. Such a supplier is able to impose the healthcare price. So, the healthcare price is at the level of the maximal price that an agent accepts to spend, *i.e.* at the willingness to pay of the agent. Empirically, some physicians or specialists may be considered as monopolist suppliers because of their reputation, the density of suppliers on their area and so on. Moreover, they can be not regulated as in France.[18] Another example is medications protected by a patent that allow pharamaceutical firms to get a temporary monopoly. However, the willingness to pay may be multiple. With two willingnesses to pay, only one is the equilibrium price. The supplier has a trade-off (in terms of profit) between attracting all the demand by fixing the price at the lowest willingness to pay and attracting only a subpopulation by fixing the price at the highest willingness to pay. We showed that in a voluntary scheme, this trade-off occurs. Remark that if the trade-off leading to exclude the $L-type$ of the healthcare market, the healthcare price market which prevails is independent of the private or public regime, equal to the willingness-to-pay of the $H-type$ (See Proposition 5).

[17] Here we focus on the situation in which compulsory insurance is implementable.

[18] In France, there are two groups of physicians: ones, regulated (Secteur I) and others not regulated (Secteur II).

The level of equilibrium price can be discussed following the insurance scheme. From Proposition 5, the equilibrium price is higher in a compulsory system than in a voluntary one but for a private regime with imperfect information. From Table 1, a public system may not lead to a higher equilibrium price than a private one. At least, from Proposition 1, the equilibrium price is higher under perfect information than imperfect one. Therefore, the adverse selection may lead to decrease the price market.

Insurance scheme and welfare

Insurance scheme has an impact not only on the healthcare perceived price but also on the individual welfare.

Proposition 7: *Under perfect and imperfect information, a voluntary scheme Pareto-dominates a compulsory scheme in private regime whereas this holds no more longer in a public regime.*

Proof.

Indeed, we have three situations in the private regime:

- both types are indifferent between the two schemes,

- one type[19] prefers a voluntary system because he has the possibility to leave the insurance market, and the other is indifferent

- both types prefer a voluntary system because they have the possibility to leave the insurance market.

In contrast, in the public regime, some situations exist where high risks are better off under a compulsory scheme ($x^* = 1$) than a voluntary one ($x^* < 1$) and low risks are better off under a voluntary scheme than a compulsory one (see Fig. 7).■

7 Conclusion

One objective of this paper has been to explore the relation between the demand of insurance and the demand of healthcare. In contrast with a classic model à la Rothschild and Stiglitz (1976), a difference has been introduced between the monetary evaluation of the discomfort caused by illness and the medical care price. We focused on the adverse effects on access to healthcare and the form of health insurance system: compulsory versus voluntary, and private versus public. Our results have been illustrated in the context of health economics, however there are a variety of fields for which these results hold.

Without insurance, the perceived price corresponds to the actual price, so the healthcare is always consumed until the price equal to the discomfort. Only the presence of an insurance market allows its consumption at a higher price. The insurance affects the perceived price of healthcare making a distortion of the price. The perception of price coincides with the *out-of-pocket price* under the compulsory scheme. However, it may differ from the universal notion of *out-of-pocket*, as here it takes into account the probability that the individual participates in the insurance market. The perceived price is lower under a compulsory scheme than under a voluntary scheme. Therefore, the distortion is higher under a compulsory scheme. In terms of welfare, a compulsory scheme Pareto-dominates a voluntary scheme in the private regime, whereas this no longer holds in the public regime.

In our model, for a healthcare to be sold, its price has to be less than or equal to the willingness to pay. Under the private regime, perfect information leads the willingness to pay of low risk individuals to be higher than that of high risk individuals. The exit option is thus chosen at a higher price by the low risk than the high risk. This situation reflects what is observed in various insurance markets. For instance, bad drivers have difficulties in finding private insurance contracts except at high premia because their characteristics are at least partially observable. This is reversed under asymmetric information: high

[19] High risk under perfect information and low risk under imperfect information.

risk individuals participate in the insurance market at a higher level of healthcare price than do low risk individuals.

Surprisingly, adverse selection has a decreasing effect on the willingness to pay in certain configurations. Thus, the healthcare may be sold at a higher price under perfect information than under imperfect one.

Considering a monopolistic healthcare supply without regulation, the willingness to pay is the equilibrium price. So, we have that *i)* the equilibrium price may be lower in a compulsory system than in a voluntary one for a private regime under imperfect information and, *ii)* contrary to the intuition, the adverse selection may lead to decrease the price market.

The distinction between price and discomfort may lead to a situation where only one type consumes the healthcare even under competition, *i.e.* the price for this type is superior to his/her willingness to pay. This situation never exists in the classical competitive model of Rothschild and Stiglitz, because price is at the level where all agents are willing to pay. The exclusion of one group raises a public health issue.

In addition, under a voluntary public insurance, one type may prefer to be uninsured and consume the healthcare. That result models the empirical context observed in US (or European countries for the supplementary insurance coverage) where some individuals do not subscribe insurance contract but participate to the healthcare market.

These results provide some theoretical foundations, which to our knowledge has not been developed in insurance models to date, for the empirical evidence for two phenomena : the non-participation to insurance of some groups of risks and/or the exclusion of healthcare market.

By sake of simplicity, we assume two types of risk. Most of our results may be extended to a generalization to N types of risk. Moreover, we consider separately different insurance schemes. As in Hoel and Iversen (2002), we could imagine a system where the insured agents can choose, complementary coverage in addition to their compulsory insurance.

These results shed some light on the current debate over the reform of health systems world-wide, and particularly in OECD countries. These results may provide a framework in which to think about the issue of healthcare prices and their relation to the insurance system. However, health status is a subjective notion, and the perception of health status can be manipulated by the pharmaceutical industry, as explained by Moynihan *et alii* (2002), doctors and/or the regulator. Further research in this context could consider the impact of these actors on the demand for healthcare in the context where the discomfort can be different from the price.

8 Appendix

8.1 Appendix A: Private system with compulsory insurance

In order to characterize the optimal contracts under compulsory insurance, it is necessary to derive first order conditions.

The Lagrangean of Program Ib is :

$$\begin{aligned} L = \; & p_L \max\{U(w_0 - \alpha_L - P + x_L P); U(w_0 - \alpha_L - \min\{P; D\})\} + (1 - p_L)U(w_0 - \alpha_L) \\ & + \Sigma_{i=H,L}\delta_i[p_i \max\{U(w_0 - \alpha_i - P + x_i P); U(w_0 - \alpha_i - \min\{P; D\})\} + (1 - p_i)U(w_0 - \alpha_i) \\ & - p_i \max\{U(w_0 - \alpha_k - P + x_k P); U(w_0 - \alpha_k - \min\{P; D\})\} + (1 - p_i)U(w_0 - \alpha_k)] \\ & + \Sigma_{i=H,L}\mu_i N_i(\alpha_i - \overline{p}_i x_i P) \end{aligned}$$

with δ_i and μ_i the multipliers associated to the incentive and profit constraints respectively. It is trivial to show that any competitive regime implies that the no-negative profit constraints are binding. Thus $\mu_i > 0$ for each type i.

Insurance being compulsory, $P \leq P^{C_i}$ $\forall i \in \{H, L\}$ i.e. both types consume $\overline{p}_i = p_i$ $\forall i \in \{H, L\}$. The first order conditions relative to α_i and x_i are Equations (1) to (4):

$$[-p_L + \delta_H p_H - \delta_L p_L]U'(w_0 - \alpha_L - P + x_L P) + [\delta_H(1-p_H) - (\delta_L + 1)(1-p_L)]U'(w_0 - \alpha_L) + \mu_L N_L = 0 \tag{1}$$

$$[-\delta_H p_H + \delta_L p_L]U'(w_0 - \alpha_H - P + x_H P) + [-\delta_H(1-p_H) + \delta_L(1-p_L)]U'(w_0 - \alpha_H) + \mu_H N_H = 0 \tag{2}$$

$$[p_L - \delta_H p_H + \delta_L p_L]U'(w_0 - \alpha_L - P + x_L P) = \mu_L N_L p_L \tag{3}$$

$$[\delta_H p_H - \delta_L p_L]U'(w_0 - \alpha_H - P + x_H P) = \mu_H N_H p_H \tag{4}$$

Four subcases are possible depending on which incentive constraint(s) do(es) hold. It is easy to show that only high risks' incentive constraint is binding $\delta_H > 0$ and $\delta_L = 0$ so that the optimal contracts are the Rothschild and Stiglitz contracts. (For a formal demonstration, see Fombaron and Milcent (2005)). (2) and (4) imply $\boxed{x_H^* = 1}$ and from the no-negative profit constraint $\boxed{\alpha_H^* = p_H P}$. Moreover, $\delta_L = 0$ in Equations (4) and (2) leads to

$$\frac{U'(w_0 - \alpha_L - P + x_L P)}{U'(w_0 - \alpha_L)} = \frac{p_L(1-p_L) - \delta_H p_L(1-p_H)}{p_L(1-p_L) - \delta_H p_H(1-p_L)} > 1$$

implying that $\boxed{x_L^* < 1}$ and $\boxed{\alpha_L^* = x_L^* p_L P}$ since $p_L < p_H$.

Recall that the compulsory character implicitely requires that a premium strictly positive ($\alpha_i > 0$ $\forall i$) is demanded against the promise of a positive coverage ($x_i > 0$ $\forall i$). Therefore, $P > P^{C_i}$ for at least one $i \in \{H, L\}$ implies that the **healthcare** is not consumed for both types anymore. A regime of no-insurance prevails.

8.2 Appendix B: Private system with voluntary insurance

Program IIb can be rewritten as below

$$\underset{\alpha_i, x_i}{Max}\ max\{p_L U(w_0 - \min\{D; P\}) + (1-p_L)U(w_0); p_L U(w_0 - \alpha_L - P + x_L P) + (1-p_L)U(w_0 - \alpha_L)\}$$

$$\text{subject to}$$

$$max\{p_i U(w_0 - \min\{D; P\}) + (1-p_i)U(w_0); p_i U(w_0 - \alpha_i - P + x_i P) + (1-p_i)U(w_0 - \alpha_i)\} \geq$$
$$max\{p_i U(w_0 - \min\{D; P\}) + (1-p_i)U(w_0); p_i U(w_0 - \alpha_k - P + x_k P) + (1-p_i)U(w_0 - \alpha_k)\}$$
$$i, k \in \{H, L\}, i \neq k$$
$$N_i(\alpha_i - \overline{p}_i x_i P) \geq 0 \quad i \in \{H, L\}$$

$$\begin{aligned} L = {} & max\{p_L U(w_0 - \min\{D; P\}) + (1-p_L)U(w_0); p_L U(w_0 - \alpha_L - P + x_L P) + (1-p_L)U(w_0 - \alpha_L)\} \\ & + \Sigma_{i=H,L}\delta_i[max\{p_i U(w_0 - \min\{D; P\}) + (1-p_i)U(w_0); p_i U(w_0 - \alpha_i - P + x_i P) + (1-p_i)U(w_0 - \alpha_i)\} \\ & - max\{p_i U(w_0 - \min\{D; P\}) + (1-p_i)U(w_0); p_i U(w_0 - \alpha_k - P + x_k P) + (1-p_i)U(w_0 - \alpha_k)\}] \\ & + \Sigma_{i=H,L}\mu_i N_i(\alpha_i - \overline{p}_i x_i P) \end{aligned}$$

Four subcases must be analyzed depending on the consumption of each type i.

Since in this regime, participation implies consumption and reciprocally, we have formally

$$V_i(\alpha_i, x_i) \geq V_i(0,0) \Leftrightarrow max\{V_i(0,0); V_i(\alpha_i, x_i)\} = V_i(\alpha_i, x_i) \text{ and}$$
$$V_i(\alpha_i, x_i) < V_i(0,0) \Leftrightarrow max\{V_i(0,0); V_i(\alpha_i, x_i)\} = V_i(E_D)$$

so that any uninsured agent is located in E_D.

• **1.** $P \leq P^{C_i}$ $\forall i \in \{H, L\}$ *i.e.* both types consume the healthcare $\overline{p}_i = p_i$.

Each type consumes the healthcare when he participates to insurance market. This situation occurs when $max\{V_i(0,0); V_i(\alpha_i, x_i)\} = V_i(\alpha_i, x_i)$ for $i \in \{H, L\}$. Even if Program IIb differs from Program Ib, first order conditions after few manipulations are similar to the ones found in Appendix A and optimal contracts under voluntary insurance correspond with Rothschild/Stiglitz' contracts:

$$\boxed{x_H^* = 1,\ \alpha_H^* = p_H P,\ x_L^* < 1 \text{ and } \alpha_L^* = x_L^* p_L P.}$$

• **2.** $P > P^{C_i}$ $\forall i \in \{H, L\}$ i.e. none consumes the healthcare $\overline{p}_i = 0$

This case occurs when no type is insured : $max\{V_i(0,0); V_i(\alpha_i, x_i)\} = V_i(0,0)$ for $i \in \{H, L\}$. In terms of price, this case can only occur when $P > P^{C_i}$ $\forall i \in \{H, L\}$. That means no type consumes in case of illness. Optimal contracts are trivially, $\boxed{x_i^* = 0 \text{ and } \alpha_i^* = 0\ \forall i \in \{H, L\}}$.

• **3.** $P^{v_H} < P \leq P^{v_L}$ i.e. only low risks consume: $\overline{p}_H = 0$ and $\overline{p}_L = p_L$.

Formally, $max\{V_L(0,0); V_L(\alpha_L, x_L)\} = V_L(\alpha_L, x_L)$ and $max\{V_H(0,0); V_H(\alpha_H, x_H)\} = V_H(0,0)$. We show that this case where only low risks participate to insurance market can never arise. Indeed, if there exists a contract (α_L, x_L) which is preferred to no-insurance by low risks, this contract will be necessarily preferred to no-insurance by high risks. More formally, we prove that

$$V_L(\alpha_L, x_L) \geq V_L(0,0) \text{ implies } V_H(\alpha_L, x_L) \geq V_H(0,0).$$

Indeed, the first inequality is equivalent to

$$p_L\left[U(w_0 - \alpha_L - P + x_L P) - \max\{U(w_0 - P); U(w_0 - D)\}\right] + (1 - p_L)\left[U(w_0 - \alpha_L) - U(w_0)\right] \geq 0.$$

Moreover, $U(w_0 - \alpha_L) - U(w_0) < 0$ implies that $U(w_0 - \alpha_L - P + x_L P) - \max\{U(w_0 - P); U(w_0 - D)\} > 0$ given that low risks subscribe an insurance contract.

Furthermore, since $p_H > p_L$, the following inequality

$$p_H\underbrace{\left[U(w_0 - \alpha_L - P + x_L P) - \max\{U(w_0 - P); U(w_0 - D)\}\right]}_{>0} + (1 - p_H)\underbrace{\left[U(w_0 - \alpha_L) - U(w_0)\right]}_{<0} > 0$$

is ever satisfied. Thus,

$$V_H(\alpha_L, x_L) \geq V_H(0,0)$$

such that there exists no contract which would be preferred to no-insurance by low-risks and would not be subscribed by high risks.

4. $P^{C_L} < P \leq P^{C_H}$ i.e. only high risks consume: $\overline{p}_H = p_H$ and $\overline{p}_L = 0$

It occurs when $max\{V_H(0,0); V_H(\alpha_H, x_H)\} = V_H(\alpha_H, x_H)$ and $max\{V_L(0,0); V_L(\alpha_L, x_L)\} = V_L(0,0)$. Then first order conditions (2) and (4) relative to α_H and x_H implying after few manipulations:

$$\left[\frac{(1 - p_H)(p_H\delta_H - p_L\delta_L)}{p_H}\right]U'(w_0 - \alpha_H - P + x_H P) + [\delta_H + \delta_L - p_H\delta_H - p_L\delta_L]U'(w_0 - \alpha_H) = 0$$

$$\Leftrightarrow \quad \frac{U'(w_0 - \alpha_H - P + x_H P)}{U'(w_0 - \alpha_H)} = \frac{(p_H\delta_H - p_H\delta_L - p_H^2\delta_H + p_H p_L\delta_L)}{(p_H\delta_H - p_L\delta_L - p_H^2\delta_H + p_H p_L\delta_L)}$$

Moreover, if $\delta_L > 0$ or in other words if the incentive constraint of low risks is binding, the two types would be offered the same contract. Clearly, a pooling contract would be incompatible with the individual profit constraints. Thus the L's incentive constraint does hold with a strict inequality, implying $\delta_L = 0$ and consequently $\frac{U'(w_0 - \alpha_H - P + x_H P)}{U'(w_0 - \alpha_H)} = 1$. In terms of premium and indemnity, we obtain $\boxed{\alpha_H^* = p_H P,\ x_H^* = 1,\ \alpha_L^* = 0 \text{ and } x_L^* = 0}$ that means *L-types* leave the insurance market and the healthcare market, while *H-types* consume and are fully reimbursed.

8.3 Appendix C: Public system with compulsory insurance

For a given price P, the terms (α, x) of the optimal contract are derived from Program III in which the monopolistic insurer maximizes the social welfare under an aggregate no-negative profits constraint:

$$\max_{\alpha,x} N[\overline{p}\max\{U(w_0-\alpha-P+xP);U(w_0-\alpha-\min\{D;P\})\}+(1-\overline{p})U(w_0-\alpha)]$$
$$s.t.\ \sum_i N_i(\alpha-\overline{p}_i xP)\geq 0$$

$$L=N[\overline{p}\max\{U(w_0-\alpha-P+xP);U(w_0-\alpha-\min\{D;P\})\}+(1-\overline{p})U(w_0-\alpha)]+\mu\sum_i N_i(\alpha-\overline{p}_i xP)$$

Insurance being compulsory when $P\leq P^{C_i}\ \ \forall i\in\{H,L\}$, both types consume the healthcare *i.e.* $\overline{p}_i=p_i\ \forall i\in\{H,L\}$. Formally,

$$\max\{U(w_0-\alpha-P+xP);U(w_0-\alpha-\min\{P;D\})\}=U(w_0-\alpha-P+xP)$$

and the first order conditions relative to α and x are

$$-(N_Hp_H+N_Lp_L)U'(w_0-\alpha-P+xP)-(N-N_Hp_H-N_Lp_L)U'(w_0-\alpha)+\mu N=0 \quad (5)$$
$$(N_Hp_H+N_Lp_L)PU'(w_0-\alpha-P+xP)=\mu(N_Hp_H+N_Lp_L)P \quad (6)$$

that leads to
$$\frac{U'(w_0-\alpha-P+xP)}{U'(w_0-\alpha)}=1 \text{ i.e. } \boxed{x^*=1} \text{ and } \boxed{\alpha^*=(\tfrac{N_H}{N}p_H+\tfrac{N_L}{N}p_L)P}$$

For the same reason as in Appendix A, $P>P^{C_i}$ for at least one $i\in\{H,L\}$ is not compatible with a compulsory character of insurance. A no-insurance regime prevails.

8.4 Appendix D: Public system with voluntary insurance

Optimal contracts are derived from Program IV

$$\underset{\alpha_i,x_i}{Max}\sum_i N_i max\{V_i(0,0);V_i(\alpha,x)\}$$
$$s.t.\ \sum_i N_i(\alpha-\overline{p}_i xP)\geq 0$$

that may be developped as follows

$$\underset{\alpha_i,x_i}{Max}\sum_i N_i max\{p_iU(w_0-\min\{D;P\})+(1-p_i)U(w_0);p_iU(w_0-\alpha-P+xP)+(1-p_i)U(w_0-\alpha)\}$$
$$s.t.\ \sum_i N_i(\alpha-\overline{p}_i xP)\geq 0$$

with μ the multiplicator associated to the aggregate profit constraint. Four subcases must be analyzed depending on which type(s) do(es) consume the healthcare. Note that under the assumption of voluntary insurance it is not excluded that an uninsured agent consumes ever the healthcare. Participation to insurance market thus implies the consumption of the healthcare in case of illness, but the reciprocal assertion does not hold.

- **1.** $P\leq P^{C_i}\ \ \forall i\in\{H,L\}$: both types consume the healthcare $\overline{p}_i=p_i$

a) *Both types are insured*

In order to maximize the collective welfare, the public regulator can use the participation constraint to incentive the low-risk to prefer the pooling contract to the no-insurance. To take into account this situation, we add the L's participation constraint in the program, $V_L(\alpha, x) \geq V_L(0,0)$. Therefore, the Lagrangean is

$$L = \sum_i N_i max\{p_i U(w_0 - \min\{D; P\}) + (1-p_i)U(w_0); p_i U(w_0 - \alpha - P + xP) + (1-p_i)U(w_0 - \alpha)\}$$
$$+ \mu \sum_i N_i(\alpha - \overline{p}_i xP)$$
$$+ \delta[p_L U(w_0 - \alpha - P + xP) + (1-p_L)U(w_0 - \alpha) - p_L U(w_0 - \min\{D; P\}) - (1-p_L)U(w_0)]$$

with $\delta \geq 0$, the multiplicator associated to the participation constraint.

The first order conditions are,

$$\begin{array}{c} -(N_H p_H + N_L p_L)U'(w_0 - \alpha - P + xP) - (N - N_H p_H - N_L p_L)U'(w_0 - \alpha) \\ +\mu N - \delta p_L U'(w_0 - \alpha - P + xP) - \delta(1-p_L)U'(w_0 - \alpha) = 0 \end{array} \quad (7)$$

$$(N_H p_H + N_L p_L)PU'(w_0 - \alpha - P + xP) - \mu(N_H p_H + N_L p_L)P + \delta p_L U'(w_0 - \alpha - P + xP)P = 0 \quad (8)$$

From (8),

$$\mu = \frac{((N_H p_H + N_L p_L) + \delta p_L)U'(w_0 - \alpha - P + xP)}{(N_H p_H + N_L p_L)}$$

and with (7),

$$\frac{U'(w_0 - \alpha)}{U'(w_0 - \alpha - P + xP)} = \frac{((N_H p_H + N_L p_L) + \delta p_L)(-1 + \frac{N}{(N_H p_H + N_L p_L)})}{(N - (N_H p_H + N_L p_L) + \delta(1 - p_L))}$$

$$\iff \quad \frac{U'(w_0 - \alpha)}{U'(w_0 - \alpha - P + xP)} =$$
$$\frac{-(N_H p_H + N_L p_L)^2 + N(N_H p_H + N_L p_L) - \delta p_L(N_H p_H + N_L p_L) + \delta p_L N}{-(N_H p_H + N_L p_L)^2 + N(N_H p_H + N_L p_L) - \delta p_L(N_H p_H + N_L p_L) + \delta(N_H p_H + N_L p_L)}$$

→ When $\delta = 0$ the right member is equal to 1 so that $\boxed{x^* = 1}$ and $\boxed{\alpha^* = (\frac{N_H}{N} p_H + \frac{N_L}{N} p_L)P}$.
→ when $\delta > 0$, being that $\delta p_L N < \delta(N_H p_H + N_L p_L)$,
if $(N - N_H p_H - N_L p_L - \delta p_L + \delta) > 0$, the right member is inferior to 1 so that $\boxed{x^* < 1}$ and $\boxed{\alpha^* = x(\frac{N_H}{N} p_H + \frac{N_L}{N} p_L)P}$

b) *None is insured :* The case where both types consume and are not insured is not possible because this situation is always dominated by the Rothschild and stiglitz contract offered to the H type.

c) *One type is insured : de facto,* if both consume, only the type who can be insured is the H type. Indeed, we can show that no contract exists which would be preferred to no-insurance by low risks and would not be subscribed by high risks, i.e. that

$$\max\{V_L(0,0), V_L(\alpha, x)\} = V_L(\alpha, x) \Longrightarrow \max\{V_H(0,0), V_H(\alpha, x)\} = V_H(\alpha, x)$$

Only high risks are insured implies $\max\{V_H(0,0), V_H(\alpha, x)\} = V_H(\alpha, x)$ and $\max\{V_L(0,0), V_L(\alpha, x)\} = V_L(0,0)$. Thus we have necessarily $\overline{p}_H = p_H$. Moreover $\overline{p}_L = p_L$ occurs when $P < D$, so that $V_L(0,0) = V_L(E_P)$, and the Lagrangean is

$$L = N_H[p_H U(w_0 - \alpha - P + xP) + (1-p_H)U(w_0 - \alpha)]$$
$$+ N_L[p_L U(w_0 - P) + (1-p_L)U(w_0)] + \mu N_H(\alpha - (p_H x)P) \quad \text{avec } x = x_H \text{ and } x_L = 0$$

So, we obtain also $x^* = 1$ and $\alpha^* = p_H P$, but here (that is when the healthcare would be too purchased by each type in a world without insurance) the type excluded of insurance market chooses ever to treat his illness rather than to suffer the discomfort.

• 2. $P > P^{C_i}$ $\forall i \in \{H, L\}$ i.e. none consumes the healthcare $\overline{p}_i = 0$. This case implies that both types are not insured so, $\alpha^* = x^* = 0$.

• **3.** $p^{C_H} < P \leq P^{C_L}$ i.e. only low risks consume: $\overline{p}_H = 0$ and $\overline{p}_L = p_L$.

L type insured implies $\max\{V_H(0,0), V_H(\alpha,x)\} = V_H(0,0)$ and $\max\{V_L(0,0), V_L(\alpha,x)\} = V_L(\alpha,x)$. This configuration would imply $\overline{p}_L = p_L$ and $\overline{p}_H = 0$. By a similar argument as before, no contract exists which would be preferred to no-insurance by low risks and would not be subscribed by high risks.

L type uninsured. This case implies that both types are not insured. Thus, the decision of consumption does not depend of the type. Therefore, we cannot have one type who consumes and not the other.

4. $P^{C_L} < P \leq P^{C_H}$ i.e. only high risks consume: $\overline{p}_H = p_H$ and $\overline{p}_L = 0$

H type insured. The Lagrangean is

$$L = N_H[p_H U(w_0 - \alpha - P + xP) + (1 - p_H)U(w_0 - \alpha)] + N_L[p_L U(w_0 - D) + (1 - p_L)U(w_0)] + \mu N_H(\alpha - p_H x P)$$

and the first order conditions are:

$$-N_H p_H U'(w_0 - \alpha - P + xP) - N_H(1 - p_H)U'(w_0 - \alpha) + \mu N_H = 0 \quad (9)$$

$$N_H p_H P U'(w_0 - \alpha - P + xP) - \mu N_H p_H P = 0 \quad (10)$$

that imply that $x^* = 1$ and $\alpha^* = p_H P$.

H type uninsured. This case implies that both types are not insured. The decision of consumption does not depend of the type. Therefore, we cannot have one type who consumes and not the other.

8.5 Appendix E: Proof of Proposition 5

We distinguish $P_v^{c_i}$ the critical price under a voluntary scheme from $P_c^{c_i}$ the critical price under a compulsory scheme.

- For both types in a public regime regardless the level of information :

In a compulsory system, the price is bounded by the initial endowment of the agent. In the public voluntary one, it is bounded to $P_v^{c_L}$ for the $L - type$ and it is bounded to $P_v^{c_H}$ for the $H - type$. Therefore, the critical price is always higher in a compulsory system than in a voluntary one.

- For both types in a private regime under perfect information : the same argument as for the public regime is true here.

- For both types in a private regime under imperfect information:

The situation is more complicated. (a) For the $L - type$, the price is bounded to $\frac{D}{1-x_L}$ in a compulsory system and it is bounded to $P_v^{c_L} < \frac{D}{1-x_L}$ in the voluntary one. (b) For the $H - type$, there is no clear-cut result. We show a sufficient condition for the critical price to be higher in a compulsory system than in a voluntary one.

$P_v^{c_i}$ is defined by

$$p_iU(w_0-\alpha_i-P_v^{c_i}+x_iP_v^{c_i})+(1-p_i)U(w_0-\alpha_i)=p_iU(w_0-D)+(1-p_i)U(w_0) \text{ with } \alpha_i=x_ip_iP_v^{c_i} \text{ (A)}$$

Because $P_c^{c_L}=\frac{D}{1-x_L}$,

$$w_0-\alpha_i-P_c^{c_L}+x_iP_c^{c_L}=w_0-\alpha_i-\left(\frac{1-x_i}{1-x_L}\right)D$$
$$w_0-(x_ip_iP_c^{c_L})-P_c^{c_L}+x_iP_c^{c_L}=w_0-(x_ip_iP_c^{c_L})-\left(\frac{1-x_i}{1-x_L}\right)D \quad \text{(B)}$$

(a) If $x_i=x_L$ then $\left(\frac{1-x_i}{1-x_L}\right)=1$

$p_LU(w_0-\alpha_L-D)<p_LU(w_0-D)$ implies
$p_LU(w_0-\alpha_L-D)+(1-p_L)U(w_0)<p_LU(w_0-D)+(1-p_L)U(w_0)$
from (A), $p_LU(w_0-\alpha_L-D)+(1-p_L)U(w_0)<p_LU(w_0-\alpha_L-P_v^{c_L}+x_LP_v^{c_L})+(1-p_L)U(w_0-\alpha_L)$
from (B),
$p_LU(w_0-\alpha_L-P_c^{c_L}+x_LP_c^{c_L})+(1-p_L)U(w_0)<p_LU(w_0-\alpha_L-P_v^{c_L}+x_LP_v^{c_L})+(1-p_L)U(w_0-\alpha_L)$
$\Leftrightarrow p_LU(w_0-\alpha_L-(1-x_L)P_c^{c_L})+(1-p_L)U(w_0)<p_LU(w_0-\alpha_L-(1-x_L)P_v^{c_L})+(1-p_L)U(w_0-\alpha_L)$
implying $P_c^{c_L}>P_v^{c_L}$

(b) If $x_i=x_H$ and $x_H^*=1$, from (B)

$$w_0-(x_H^*p_HP_c^{c_L})-P_c^{c_L}+x_H^*P_c^{c_L}=w_0-p_HP_c^{c_L}$$

Since $P_c^{c_L}=P_c^{c_H}$ in a compulsory private system and $P_c^{c_L}=\frac{D}{1-x_L}$, we obtain

$$w_0-(x_H^*p_HP_c^{c_L})-P_c^{c_L}+x_H^*P_c^{c_L}=w_0-\frac{p_H}{1-x_L}D$$

Then,

$$p_HU(w_0-(x_H^*p_HP_c^{c_L})-P_c^{c_L}+x_H^*P_c^{c_L})+(1-p_H)U(w_0)=p_HU(w_0-\frac{p_H}{1-x_L}D)+(1-p_H)U(w_0)$$

And, if $\frac{p_H}{1-x_L}>1$,

$p_HU(w_0-\frac{p_H}{1-x_L}D)+(1-p_H)U(w_0)<p_HU(w_0-D)+(1-p_H)U(w_0)$
$\Leftrightarrow p_HU(w_0-(x_H^*p_HP_c^{c_L})-P_c^{c_L}+x_H^*P_c^{c_L})+(1-p_H)U(w_0)<p_HU(w_0-D)+(1-p_H)U(w_0)$
from(A), $p_HU(w_0-\alpha_H^*-(1-x_H^*)P_v^{c_H})+(1-p_H)U(w_0-\alpha_H^*)=p_HU(w_0-D)+(1-p_H)U(w_0)$
$\Rightarrow \begin{array}{l} p_HU(w_0-(x_H^*p_HP_c^{c_L})-P_c^{c_L}+x_H^*P_c^{c_L})+(1-p_H)U(w_0) \\ <p_HU(w_0-\alpha_H^*-(1-x_H^*)P_v^{c_H})+(1-p_H)U(w_0-\alpha_H^*) \end{array}$
$\Rightarrow \begin{array}{l} p_HU(w_0-(x_H^*p_HP_c^{c_L})-(1-x_H^*)P_c^{c_L})+(1-p_H)U(w_0) \\ <p_HU(w_0-\alpha_H^*-(1-x_H^*)P_v^{c_H})+(1-p_H)U(w_0) \end{array}$
Because $\alpha_H^*=x_H^*p_HP_c^{c_H}$, we must have $P_c^{c_H}>P_v^{c_H}$ if $\frac{p_H}{1-x_L}>1$. ■

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