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THE DISTORTIONARY EFFECT OF HEALTH INSURANCE ON HEALTHCARE DEMAND*

Nathalie Fombaron† and Carine Milcent ‡

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Abstract

This paper presents a general framework for modeling the impact of insurance on healthcare demand extending some of the results of the two-risk model of Rothschild and Stiglitz (1976), but including the latter as a special case. Rothschild and Stiglitz's approach assumes equivalence between the price of treatment and the discomfort caused by the disease. Relaxing this assumption turns out to be key in understanding participation in the insurance and healthcare markets. The demands for insurance and healthcare are modeled simultaneously, under symmetric and asymmetric information. Four main results arise from the relaxation of this assumption. First, only the presence of an insurance market can produce healthcare consumption at higher prices than the discomfort. Second, adverse selection may lead healthcare to be sold at a price lower than that under perfect information. Third, the potential non-participation of one type risk arises despite competition, depending on the degree of information. Last, in a public voluntary regime, one type risk may prefer to be uninsured and still consume healthcare.

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

JEL Classification: D82, H52, I18.

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1 Introduction

This paper contributes to the current debate over health system reform by assessing the impact of insurance on the demand for healthcare, using an insurance model with two types of individuals (high-risk and low-risk). In contrast to the classic model of Rothschild and Stiglitz (1976), we introduce a gap 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.

We define discomfort as the monetary evaluation of the individual's suffering, and price as the cost of treatment. The severity of discomfort may not imply costly treatment and *vice versa*. An individual who suffers from a disease with serious consequences may find that the health discomfort costs a great deal relative to the price of treatment. Conversely, some harmless health problems nevertheless require high levels of medical expenditure, in which case an individual may prefer to suffer the discomfort. This distinction makes clear that there are two trade-offs: *i)* choosing whether to be insured; and *ii)* in the event of disease, choosing to treat the disease or not, whatever the choice made on the insurance market. As a direct consequence, the probability of consuming medical care may differ from the probability of suffering from an illness, even with a competitive insurance market. Our model highlights the relation between the demand for healthcare and the demand for insurance. This has not previously been analyzed, to our knowledge.

In our examination of the effect of insurance type on healthcare demand, we focus on three concepts: *perceived price, distortion* and *willingness to pay*. Without insurance, the *perceived price* corresponds to the actual price of healthcare; insurance will then affect this perceived price, leading to *distortions* of the healthcare market. The perception of price coincides with the universal notion of out-of-pocket costs under the compulsory scheme. However, it may differ from out-of-pocket costs when insurance is voluntary. We find, as Santerre and Vernon (2005) do,[1] that the agent's healthcare demand falls with perceived price. We also show that the individual perceived price is higher under voluntary than compulsory insurance. The *distortion* of the healthcare market is measured by 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 an item of healthcare. The individual perceived price varies with the insurance scheme, and so do distortion and the willingness to pay.

We find that the distinction between the monetary evaluation of discomfort and healthcare price brings about four main results. First, only the presence of insurance allows healthcare to be sold at a price higher than the value of the discomfort. Without insurance, healthcare is sold until the actual price equals the value of the discomfort. Therefore, our model clearly

[1] Without modeling the insurance market, Santerre and Vernon (2005) consider the relationship between healthcare demand and individual out-of-pocket prices. We extend their approach by distinguishing between the individual's perceived price and their out-of-pocket price.

reveals distortions of the healthcare market, induced by the presence of insurance. Second, we find a counter-intuitive result under imperfect information. Adverse selection may have a negative effect on willingness to pay, hence healthcare may be sold at a lower price under imperfect information. Third, we highlight potential non-participation, despite the competitive insurance market. This non-participation is observed empirically. A similar result has previously been shown by Dahlby (1981) and Hansen and Keiding (2002). These authors compared well-being between compulsory and voluntary insurance markets in the presence of adverse selection.[2] Our model has the advantage of making less restrictive assumptions. We show that both high-risk and low-risk individuals, or just one of the two types, may be excluded from the insurance market under both perfect and imperfect information. Last, individuals may participate in the healthcare market even though excluded from the insurance market. This result specifically comes about for low-risk individuals under public voluntary insurance.

In addition, we show that the voluntary scheme Pareto dominates the compulsory scheme in the private regime, whereas this is no longer the case in the public regime.

Our paper proceeds as follows. Section 2 sets out our two-risk-type model relative to the classic model and discusses a preliminary result: the probability of healthcare consumption may be different from the probability of illness. In Section 3, we define perception of healthcare price, healthcare market distortion and willingness to pay. The two following sections then analyze 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 discuss the effect of optimal insurance contracts (derived in the Appendices) on the equilibrium price of healthcare. Section 6 summarizes and reinterprets our findings in terms of the relative power of insurers and healthcare suppliers in healthcare price negotiations.

2 Approach and notation

2.1 Distinction between discomfort and treatment

In Rothschild and Stiglitz standard model of insurance, the monetary evaluation of the discomfort due to the damage is exactly the price paid to repair this damage. Our approach distinguishes between this monetary evaluation of the discomfort, called D, and the price paid to repair this damage, P, whereas in the standard model, these are identical, and denoted P. The difference between D and P may be positive or negative in our model. Our approach is illustrated by many examples. Our approach can be illustrated by many different examples. For instance, the repair cost of a scrape on a car's bodywork (P) might be considered as way too high compared to the associated discomfort (D). On the contrary, many illnesses can be fatal if not treated with penicillin, and the cost of the latter is negligible compared to the potential

[2] Dahlby assumes the level of insurance to be 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 (see also Danzon, 2002). In our model, we do less restrictive these assumptions. First, we consider both the premium and coverage to be endogenous. Second, the non-participation result arises not only under the pooling contract but also with separate contracts.

discomfort. These two examples illustrate the gaps that may exist between the cost of repair (P) and the monetary evaluation of the discomfort (D).

In both approaches, P and D are assumed to be exogenous. Without loss of generality, we assume that repairs allow the agent to totally compensate for the damage D.

Table 1 shows wealth in each loss state in the standard model and in our model. Denoting the initial endowment by w_0, an insured agent pays a premium of α and is covered at rate x. She then receives a payout of xP for repairs after the damage in both models.

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

(Table 1)

In our model, the wealth of an uninsured agent depends on the discomfort and the repairs. Individual wealth in the loss state is $(w_0 - D)$ without repairs[3] and $(w_0 - D - P + D) = (w_0 - P)$ with repairs, while in the standard model her wealth is $(w_0 - P)$ in both cases. By distinguishing between D and P, we introduce a gap between the reservation utilities.[4] These differences in reservation utilities from the standard model have a considerable impact on the demand for treatment. The relation between insurance market organization and the demand for treatment is studied in detail in Sections 4 and 5.

To illustrate our model, and make interpretation easier, we consider the context of health insurance. Here, the monetary evaluation of the discomfort, *i.e.* the damage D, is caused by an illness and the amount of repairs corresponds to P, the price of treatment. However, our results apply beyond the field of health economics, to issues such as automobile insurance, housing insurance, life insurance or even unemployment insurance in the labor market.

2.2 Probability of illness and probability of consumption

The price of treatment P is the price of healthcare. Thus, in the absence of insurance, treatment costs an agent P. For the sake of simplicity, we assume that the healthcare enables agents to recover their initial level of health: treated agents suffer no monetary loss except P.[5]

We consider two types of agent. High-risk individuals, denoted H, have a higher probability p_H of having the illness than do low-risk individuals, denoted L, who have an illness probability p_L. We denote by $\overline{p}$ the probability of consuming healthcare over the entire population (insured or not). This depends on $\overline{p}_i$ (for $i = H, L$), the probability of consuming for

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

[4] This model has some similarities with models of fraud, where there is a gap between the *actual* and the *claimed* amount of repairs. However in these models, the monetary evaluation of the discomfort equals the cost of repairs.

[5] A positive monetary loss from illness could be introduced in this model without loss of generality. Moreover, we propose a static model. However, an extension with many periods using dynamic modelisation (see e.g. Dionne, 1983) could also be envisaged.

type i. We will show that $\overline{p}_i$ will take the value of either 0 or p_i $(i = H, L)$, depending on the insurance system. We can write

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

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

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

2.3 Individual preferences and isoprofit curves

The reservation expected utility of type i, *i.e.* without insurance, is:

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

with $E = (w_0, w_0 - \min\{D, P\})$ being the point of initial endowment. E is also called the point of no-insurance. In what follows, we 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 $\min\{D, P\}$ into reservation expected utility, we take into account the agent's possibility of purchasing care (at price P) in the case of illness, even if he is not insured. As usual, U is a *vNM* utility function, increasing and concave in wealth.

Any individual may take out a contract $C = (\alpha, x)$, which specifies the premium α paid to the insurer and the payout xP received by the insured in case of illness (with $x \in [0, 1]$ being the level of coverage). The expected utility of agent i insured by a contract (α_i, x_i) is:

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

In a voluntary system, an individual i will choose the contract (α_i, x_i) over no-insurance if $V_i(\alpha_i, x_i) \geq V_i(0, 0)$. It is obvious that no rational agent would choose to take out a contract whose coverage would not be used in the loss state.

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

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

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

Insurance plays a crucial role in the healthcare market. The agent's participation in the insurance market "distorts" his perception of the price of healthcare. In the next section, we define what we mean by *perception of healthcare price*, *individual distortion* and *critical price.*

3 Perception of healthcare price and the critical price

The *initial endowment* w_0 is exogenous, but *initial wealth* is endogenous and depends on the insurance scheme: a compulsory scheme implies that the agent is obliged to pay the premium, so that the initial wealth of the agent is $w_0 - \alpha_i$ whatever happens, while it is w_0 under a voluntary scheme (with a facultative insurance).

Definition of the agent's price perception

An individual i obtains some level of expected utility from being covered by insurance when he consumes healthcare at price P. For a given price P, the perception of price noted $Pe_i(P)$ is the fictive treatment price paid by an uninsured individual which yields the same level of expected utility as the individual enjoys when insured.

Algebraically,

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

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

The perceived price is a relative notion because it depends on initial wealth and not on the initial endowment (see the expression on the left-hand side of Equation (1)). Price perception is thus defined after the insurance premium has been paid (of course, for an uninsured agent this premium is zero). This individual perception depends on the participation of the $i - type$.

This perceived price is represented in wealth space in health and in illness in Figure 1.

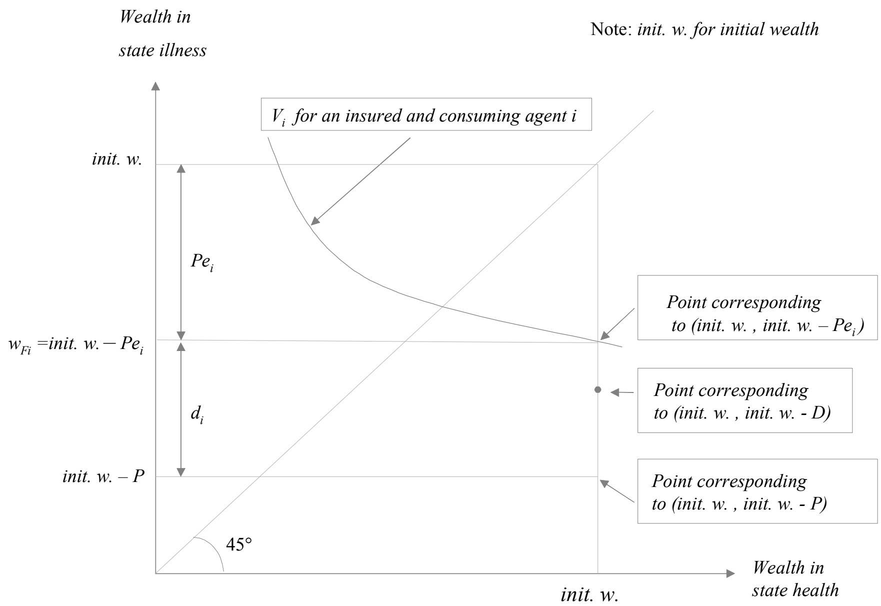

Figure 1: Individual perception and distortion

The 45° line represents the line of certainty. The point $(\textit{initial wealth}, \textit{initial wealth} - P)$ corresponds to the allocation of an individual who is not insured and who pays for his own treatment (at price P) when ill; it also corresponds to the allocation of an insured individual who does not ask for reimbursement of her treatment. This point, in the following figures, is denoted E_P in the voluntary case, and E'_{Pi} in the compulsory case (E'_{Pi} being the individual's initial endowment point minus the compulsory premium).

The point (*initial wealth*, *initial wealth* $- D$) corresponds to the allocation of an individual who is not insured and who suffers her discomfort when ill; it also corresponds to the allocation of an insured individual who prefers to suffer the discomfort when ill. In the following figures this point is denoted E_D in the voluntary case, and E'_{Di} in the compulsory case (E'_{Di} being the individual's initial endowment point minus the compulsory premium).

The value w_{Fi} is the Y-value of the intersection of the indifference curve of an insured and consuming agent i and the vertical line joining (*initial wealth*, *initial wealth* $- P$) with (*initial wealth*, *initial wealth* $- D$). In other words, an insured and consuming agent i has her initial wealth in state health and has w_{Fi} when ill. Therefore, the difference between the initial wealth and w_{Fi} provides the difference in wealth corresponding to what we called the perceived price. We have

$$Pe_i = \textit{initial wealth} - w_{Fi} \tag{2}$$

Therefore

$$w_{Fi} = \begin{cases} w_0 - Pe_i \text{ in the voluntary scheme} \\ w_0 - \alpha_i - Pe_i \text{ in the compulsory scheme} \end{cases} \quad \forall i = H, L \tag{3}$$

The presence of health insurance produces a level of utility which is the same as that enjoyed by an uninsured individual who buys treatment at price Pe_i. Insurance therefore provides a level of utility corresponding to the difference curve V_i which passes through (*initial wealth*, *initial wealth* $- Pe_i$).

Individual distortion

This distortion of the healthcare market d_i is measured as the difference between the actual price (P) and the individual perception (Pe_i), *i.e.*

$$d_i = P - Pe_i(P) \;\text{ with }\; Pe_i(P) \in \{Pe_L(P), Pe_H(P)\} \tag{4}$$

Graphically, the distortion is represented by the distance between w_{Fi} and (*initial wealth*, *initial wealth* $- P$).

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

$$Pe_i(P) = P \;\text{ for } i = H, L \tag{5}$$

Therefore distortion is trivially zero in this case. Thus, the distortion is due to the insurance market because it depends on the participation and the level of coverage of the $i - type$.

Critical price or willingness-to-pay

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

$$Pe_i(P^{C_i}) = D \quad \text{for } i = H, L \tag{6}$$

Our definition of the willingness to pay extends Strohmenger and Wambach's (2000) definition. There willingness to pay is defined as the maximum price that an *uninsured* agent would pay for healthcare, whereas we define it for any agent, insured or uninsured.

Trivially, the willingness to pay for an uninsured agent i from Equations (5) and (6), is

$$P^{C_i} = D$$

The uninsured agent will purchase healthcare if his utility under treatment is higher than his utility without treatment in the loss state [6] *i.e.* whenever,

$$\underbrace{U(w_0 - P)}_{\text{Utility if no insurance and treatment}} \geq \underbrace{U(w_0 - D)}_{\text{Utility if no insurance and no treatment}} \tag{7}$$

$$\iff P \leq D \tag{8}$$

Thus, as long as $P \leq D$ the demand for healthcare does not depend on the insurance market. When $P > D$ healthcare demand results only from insured agents, and the level of demand depends on the insurance system. Any healthcare consumption results from insurance that creates a market imperfection by allowing the sale of healthcare at a price higher than D.

Total demand depends on the probability of healthcare consumption of each type H and L. Since these probabilities themselves depend on whether insurance is compulsory or voluntary and the market is public or private, we consider healthcare demand under four different regimes. Demand also depends on the level of information. With asymmetric information, all individuals initially possess private information about their probability of suffering illness. The analytical resolution of each program is presented in the Appendices.

In the following sections, we study the impact of relaxing the assumption $P = D$ on different forms of health insurance and different levels of information. Indeed, different forms of health insurance exist between and within OECD countries. In the Netherlands and Switzerland, the insurance contract is based on competition between private insurers. Nevertheless, basic Swiss insurance is compulsory and insurers, who decide the premium, cannot discriminate between their members. In France, health insurance is provided by a public monopoly with respect to its compulsory element. The insurance premium is proportional to income. In the United States, individuals under the age of 65 may take out a voluntary insurance contract with a private insurer. A considerable[7] fraction of the population is uninsured. A certain part of

[6] We assume that, conditionally on illness, if type i is indifferent between treatment and no treatment he will consume healthcare.

[7] "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.

the population is also insured *via* their firm.[8] 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 insurance company would be higher. This situation can be compared to that of a monopoly private insurer. We therefore study different types of insurance schemes. By a private system, we mean competing insurers with the possibility of discriminating between types. We call public insurance a system with a monopoly insurer where discrimination is not possible. We also compare voluntary to compulsory regimes. The implementation of a compulsory regime in Quebec (Canada) seems to have had a positive impact on healthcare demand (Boyer and Léger, 2005). Berndt *et alii* (1996) empirically assess the effect of 26 different organizational dimensions of insurance in the US on patterns of care. Here, we show theoretically that the insurance scheme has a significant impact on healthcare demand.

4 Private insurance

In the case of private insurance, we imagine the insurance market to be competitive. In 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 that of voluntary insurance, first under full information and then under imperfect information.

4.1 Compulsory insurance

With compulsory insurance, agents are obliged to participate in the insurance market. All agents pay the premium α_i even if they choose not to consume the healthcare. In our model, we show that compulsory insurance is not always feasible, and if compulsory insurance is not feasible for one risk group, then it is not feasible for the other either (due to adverse selection).

4.1.1 Benchmark case: perfect information

With symmetric information, the insurer can distinguish low risks from high risks. If P is less than P^{C_i}, the critical price for type i, the insurer can propose a contract with full reimbursement against the actuarial premium, as high risks cannot pretend to be low risks. Given that each type i always pays the premium α_i, competitive contracts under full information are derived from Program Ia,

$$\underset{\alpha_i,x_i}{Max}\ p_i \max\{U(w_0-\alpha_i-P+x_iP); U(w_0-\alpha_i-\min\{D,P\})\}+(1-p_i)U(w_0-\alpha_i) \tag{Program Ia}$$

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

[8] "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.

for each type $i \in \{H, L\}$. Insurers thus trivially maximize the expected welfare of each type subject to a non-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 healthcare and Program Ia leads to an actuarial premium $\alpha_i^{PI} = p_i P$ against the guarantee of receiving P in the case of illness[9]. Under full information, each type i thus receives his full insurance contract called $C_i^{PI} : x_i^{PI} = 1$ (Fig. 2a and 2b).

In Figures 2a and 2b, w_0 is the initial endowment, from which individuals pay the insurance premium and the price of treatment. The private insurer can discriminate, and the premia paid by the high and low risks are α_H^{PI} and α_L^{PI} respectively. Lines H and L are the two zero-isoprofit lines; the tangent between these isoprofit lines and the indifference curves shows the points of full insurance, where wealth is the same in the health and illness states. At E_D, an individual is without insurance and suffers the discomfort in case of illness, while at E_P the individual is again without insurance but pays for treatment when ill. At E'_{D_L} (E'_{D_H}), an insured low-risk (high-risk) individual has paid her premium but does not take up treatment, and thus suffers the discomfort; at E'_{P_L} (E'_{P_H}) the insured low-risk (high-risk) individual pays for treatment herself and does not ask for reimbursement (and thus pays price P).

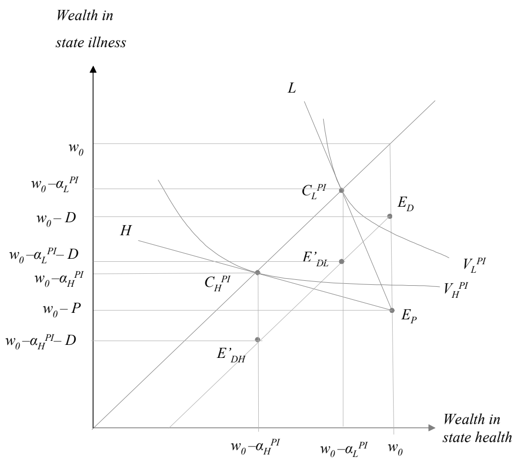

Figure 2a: Compulsory and private insurance with perfect information: C_i^{PI} always preferred to E'_{Di} by any type i

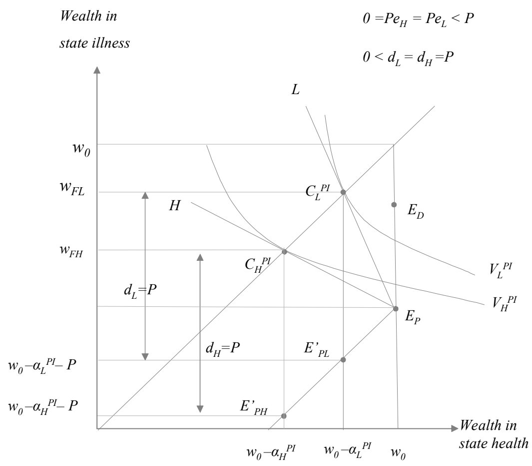

Figure 2b: Compulsory and private insurance with perfect information: Perception Pe_i and distortion d_i

Whatever the consumption decision, each type has to pay the compulsory premium α_i^{PI}. Therefore, initial wealth is $w_0 - \alpha_i^{PI}$. A fully-insured agent who chooses to consume has final wealth of $w_0 - \alpha_i^{PI}$ in both states, whereas an insured agent who chooses not to consume has final wealth in state illness $w_0 - \alpha_i^{PI} - D$ which is less than $w_0 - \alpha_i^{PI}$, whatever the level of discomfort D. As Figure 2a then illustrates, full insurance C_i^{PI} is then always preferred to paying the obligatory premium without consuming healthcare, as shown by the points E'_{D_i}, by any type i.

The individual perceptions and distortions are summarized in Lemma 1.

[9] When $P \leq P^{C_i}$, we have $\overline{p}_i = p_i$, *i.e.* each type consumes healthcare. The objective function is $p_i U(w_0 - \alpha_i - P + x_i P) + (1 - p_i) U(w_0 - \alpha_i)$. Given that the non-negative profit constraint is trivially binding, first order conditions of Program Ia lead trivially to $\alpha_i = p_i P$, $\forall i = \{H, L\}$.

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

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

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

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

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

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

The individual critical price, denoted P^{C_i} and defined by $Pe_i(P^{C_i}) = D$, is $\frac{D}{1 - x_i^{PI}}$.

Even though the critical price P^{C_i} looks like it tends to infinity under the 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 critical price is limited by $\frac{w_0}{\overline{p}_i}$.■

4.1.2 Imperfect information

Introducing adverse selection into the model of private insurance has significant effects on perception and distortion, as high risks can now pretend to be low risks. The menu of actuarial contracts with full insurance no longer pertains when the risk-type is not observable by insurers. We therefore introduce incentive constraints in Program Ib to derive the competitive contracts in this case. Insurers maximize the expected welfare of low risks, subject to the incentive constraints and the non-negative profit[10] constraints:

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

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 results from imperfect information. The expected welfare of low risks is maximized, as it is they who suffer from the negative externalities from the high risks.

[10] As usual, competition à la Rothschild and Stiglitz (1977) requires non-negative profits on each contract for an equilibrium to exist. No contract with cross-subsidization is compatible with equilibrium, as any situation in which some risks (here low risks) subsidize some others (high risks) produces the possibility for a rival company to earn positive profits by attracting only low risks, via a contract with a lower premium against the promise of a reduced coverage. Other authors (Crocker and Snow, 1984, and Neudeck and Podczeck, 1996) allow cross-subsidization, but require governement intervention or alternative concepts of equilibrium as in Grossman (1979).

From Appendix A, we find that for $P \leq P^{C_i}$ (with P^{C_i} being the critical price of 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 $P > P^{C_i}$, no-one is insured and no-one consumes the healthcare.

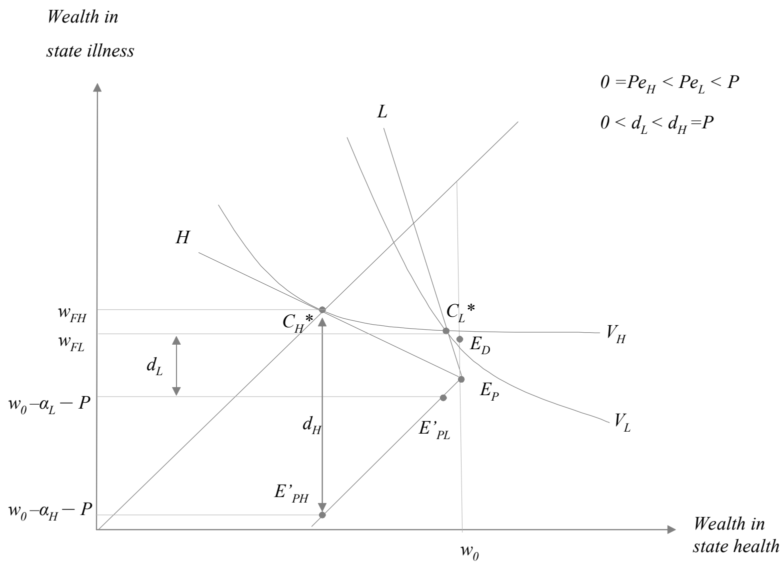

Figure 3: Compulsory and private insurance with imperfect information

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

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

Proof.

- As above, the perception is defined as the treatment price for which the expected utility of an insured agent is equal to that of an uninsured agent consuming healthcare. Here, "not insured" means that the agent does not receive any reimbursement in case of illness but, as insurance is compulsory, still pays the premium α_i. Thus, Pe_i is defined by

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

  Hence, $Pe_H = 0$ and $Pe_L(P) = P(1 - x_L) < P$. The individual distortion is equal to P as under perfect information for the high risks, and equals $x_L P$ for the 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 given by:

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

  The equation $P^{C_L} = \frac{D}{(1-x_L)}$ means that the $L-types'$ critical price corresponds to the out-of-pocket price. The $L-types'$ demand for healthcare will be positive as long as $P(1-x_L) \leq D$. Hence for a price $P > \frac{D}{(1-x_L)}$, $L-types$ pay the premium but do not consume healthcare. The effect of compulsory insurance is therefore ambiguous, as the premium demanded is such that the out-of-pocket expense $(P(1-x_L))$ is greater than the discomfort.

  For high risks, the definition of P^{C_H} is *a priori* more complex. As for low risks, $H-type$ agents choose between consuming or suffering the discomfort. In addition, they may be tempted by the contract intended for low risks. This implies that the incentive constraint of the $H-type$ has to be taken into account in the definition of the critical price of $H-types$ in order to make them indifferent between their own contract and the $L-types'$ contract.

  When $P > \frac{D}{(1-x_L)}$, separate contracts are no longer Rothschild and Stiglitz contracts. $H-types$ will prefer the $L-types'$ contract whenever

$$p_H U(w_0-\alpha_H-P+x_H P)+(1-p_H)U(w_0-\alpha_H) < p_H U(w_0-\alpha_L-D)+(1-p_H)U(w_0-\alpha_L) \tag{9}$$

  On the right-hand side of (9), the compulsory premium paid by $H-types$ is α_L instead of α_H because each type chooses to pay the lowest premium α_L when suffering the discomfort is preferable to consuming healthcare.

  Given that the incentive constraint is binding for the high risks, inequality (9) becomes

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

  Thus, the critical price of $H-types$ depends only on the extent of insurance coverage of $L-types$. ■

To conclude, when $P > \frac{D}{(1-x_L)}$ both types prefer not to consume healthcare. Whenever a compulsory contract fails for $L-types$, it will fail for $H-types$ as well. This result shows that without regulation of the price of healthcare, the compulsory aspect of insurance may be not relevant because even when insured, individuals do not consume healthcare.

Here, the perception of price[11] is equivalent to the universal notion of *out-of-pocket price* under the compulsory scheme. However, this is no longer true under the voluntary scheme, in which perception may be different from the out-of-pocket price.

[11] Fig. 3 illustrates $Pe_L = P(1-x_L)$.

4.2 Voluntary scheme

Here agents are not obliged to take out insurance. As under the compulsory scheme, an agent who takes out insurance necessarily consumes the healthcare. Note that this no longer holds under a public voluntary regime. In other words, consumption implies participation and *vice versa*.

4.2.1 Benchmark case: perfect information

Voluntary insurance does not guarantee that both types will participate in the insurance market. We thus explicitly consider the participation decision. In Program IIa, the choice of each type i to take out an insurance contract market is captured by $\max\{V_i(0,0); V_i(\alpha_i, x_i)\}$. The consumer i thus chooses between the best contract offered by competitive insurers and the "exit option". For each agent $i \in \{H, L\}$, the insurer proposes the contract given by,

$$\underset{\alpha_i, x_i}{Max} \; \{max\{V_i(0,0); V_i(\alpha_i, x_i)\}\} \qquad \text{(Program IIa)}$$

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

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

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

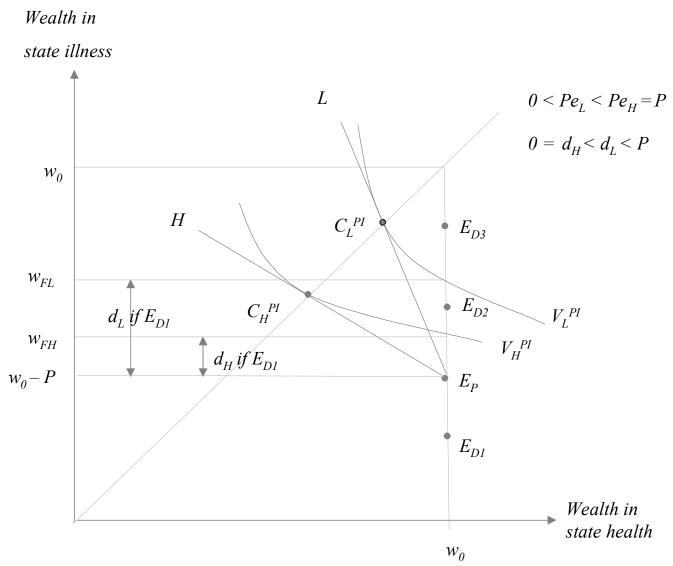

Figure 4: Voluntary and private insurance with perfect information

Individual i's price perception is defined by Pe_i such that:

$$p_i U(w_0 - \alpha_i^{PI} - P + x_i^{PI} P) + (1 - p_i) U(w_0 - \alpha_i^{PI}) = p_i U(\underbrace{w_0 - Pe_i}_{w_{Fi}}) + (1 - p_i) U(w_0) \qquad (10)$$

which implies the following Lemma,

Lemma 3: *Under perfect information, a voluntary private insurance system induces distortions of healthcare market which are higher for $L-types$ than for $H-types$, and low risks are willing to pay more than high risks for healthcare.*

Proof. When both types are insured, Eq. (10) becomes,

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

Moreover, $p_H > p_L$ implies that $U(w_0 - p_HP) - U(w_0) < U(w_0 - p_LP) - U(w_0)$ and we thus have

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

The distortion is thus higher for $L-types$ than for $H-types$. When only one type is insured it is the $L-type$. Therefore, their perception remains Pe_L while the perception of $H-types$ becomes P, so that $d_L > d_H = 0$. When no-one is insured, $Pe_i = P$ and $d_i = 0, \forall i$. Consequently, the critical price of $L-types$ is superior to that of $H-types$, so that high risks are the first to leave the insurance market when there is an attractive exit option.■

4.2.2 Imperfect information

Competitive contracts are derived from the maximization of the $L-type$'s welfare subject to the incentive and non-negative profit constraints:

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

Because contracts are separated and the insurance scheme is *voluntary*, the participation of one type in the insurance market does not depend on the participation of the other type (as opposed to the compulsory case). Four subcases are analyzed in Appendix B relating to the participation of each type i. From Appendix B, we have the following cases:

$$\begin{cases} \text{Both types are insured} \begin{cases} x_H^* = 1 \text{ and } \alpha_H^* = p_HP \\ x_L^* < 1 \text{ and } \alpha_L^* = x_L^* p_L P \end{cases} \\ \\ \text{Only the high risks are insured but not the low risks,} \begin{cases} x_H^* = 1 \text{ and } \alpha_H^* = p_HP \\ x_L^* = 0 \text{ and } \alpha_L^* = 0 \end{cases} \\ \\ \text{No-one is insured, } x_i^* = 0 \text{ and } \alpha_i^* = 0, \forall i \end{cases}$$

From optimal contracts, it follows that:

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 $H - types$ than for $L - types$, and $H - types$ are willing to pay more than $L - types$ for healthcare.*

Proof: The perception of healthcare price Pe_i for 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 agent i depends only on their participation in the insurance market, and is defined by $Pe_i(P^{C_i}) = D$:

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

The perception of price, and thus the critical price for each type, depends on the reimbursement level determined by the program, which latter is at the Rothschild and Stiglitz level. In equilibrium, the two types do not have the same reimbursement level: the $H - type$ is fully reimbursed but $L - types$ are only partially reimbursed. Therefore, the critical price for the $L - type$ is lower than that of the $H - type$.

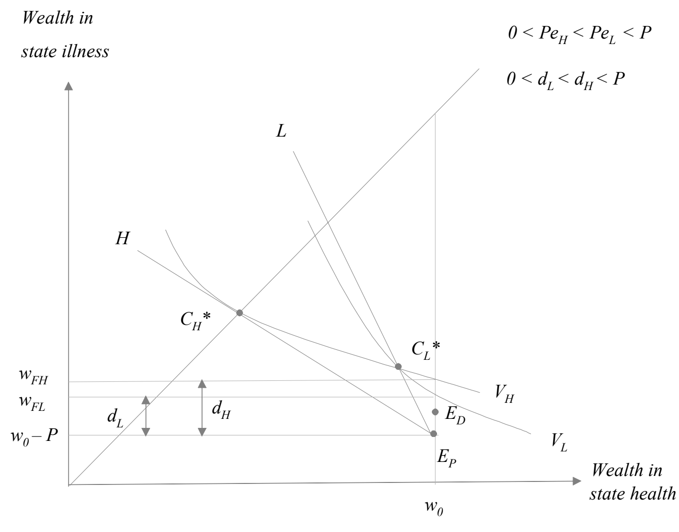

Figure 5: Imperfect information - voluntary and private insurance when both types are insured

In Figure 5, the healthcare price is such that the expected utility of uninsured agents who suffer the discomfort is lower than that of the insured. Both types prefer to be insured and consume healthcare. However, other situations may arise. Consider a price such that wealth after suffering the discomfort is between w_{FL} and w_{FH} (Fig. 6). The $L - type$ prefers not to be insured and to suffer the discomfort, whereas the $H - type$ has higher expected utility from choosing insurance. There is thus a price interval in which only the $H - type$ is insured. In this case, the perception for the $L - type$ becomes P, distortion is zero, and the critical price is D. Last, for a certain level of discomfort, both types may have higher expected utility from foregoing insurance (whenever $V_H(E_D) > V_H(\alpha_H^*, x_H^*)$). In this case, perceptions equal P, distortions are trivially zero and the critical prices are D, whatever the type.■

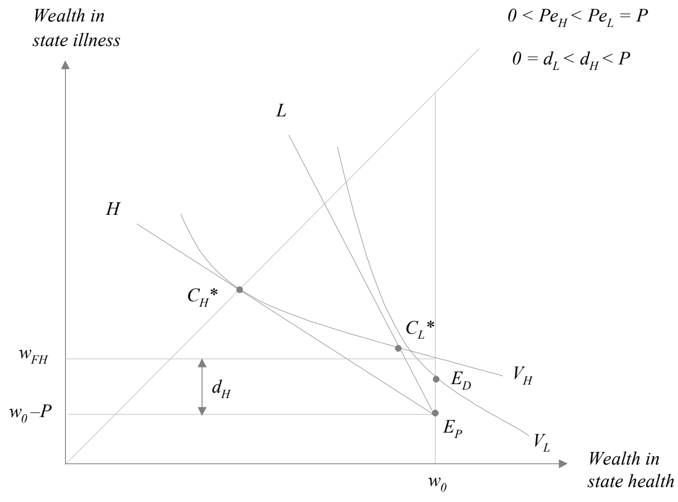

Figure 6: Imperfect information: voluntary and private insurance when only high risks are insured

We can now compare the situations of perfect and imperfect information. From Lemmata 1 and 3, we have,

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

Under perfect information, $H-types$ leave the insurance market before $L-types$, while the reverse holds under imperfect information. These results illustrate what is observed in health insurance markets. After a certain age, to be insured, agents have to fill out a questionnaire about their own health status and that of their relatives. Therefore, the level of information for health insurers is comparable to that pertaining under perfect information. Our result thus mirrors the empirical situation where individuals identified as high risk have difficulty in finding insurance and some of them are excluded from the market: the price, and thus the premium, is too high compared to the monetary evaluation of the discomfort[12]. This case may become more likely with the advent of individual genetic information.

Not all health information can be obtained from questionnaires. For the same questionnaire health status, agents may still be heterogenous. The questionnaire is more inefficient in younger populations because the occurrence of acute diseases is lower in this population. Insurers are again in a situation of asymmetric information. We observe empirically that being outside the insurance market is preferred to insurance for young people in good health (because of the level of the premium). This is what is predicted by our model with imperfect information, where low-risk individuals may prefer to be uninsured.

[12]We consider here that the initial endowment level (and income) is identical for all agents. Thus, the exclusion of one type is not due to monetary constraints.

The second part of Proposition 1 is explained as follows. With partial coverage, the incentive to quit the insurance market is greater than that under full coverage.[13] Under perfect information, both types are fully covered. Adverse selection leads the $L-type$ to have only partial coverage, and so lower willingness to pay. As a result, healthcare may be sold at a lower price with imperfect information.

Note that under the compulsory system, agents cannot choose whether to take out insurance: they are covered by the contract that the insurer offers. Hence, whatever the consumption decision, the $L-type$ pays the premium α_L^* and will consume as long as $P \leq \frac{D}{(1-x_L)}$. Under a voluntary system, the agent's insurance choice depends on his expected utility. There exist cases where, under voluntary insurance, the $L-type$ prefers to be uninsured, while under compulsory insurance he is obliged to be insured. Figure 3 displays such a possibility. This configuration may occur for $H-types$ as well. We show in Section 5 that under public insurance there are equally some individuals who are (by definition) covered by compulsory insurance, but who prefer not to be insured under a voluntary scheme.

5 Public insurance

By a public system, we mean both a monopoly insurance regime and no discrimination. A unique premium α is paid by each individual to a public body. For example, "basic" French health insurance can be viewed as being administered by a single public agency[14]. It also could be a private insurer offering a unique contract with non-discrimination such as that proposed by a firm to its employees. The premium α and the level of coverage x are thus the same for everyone.

For a given price P, the terms (α, x) of the optimal contract are derived from a program in which the public insurer maximizes social welfare $N_H V_H(\alpha, x) + N_L V_L(\alpha, x)$[15] under an aggregate non-negative profits constraint $\sum_i N_i(\alpha - \overline{p}_i x P) \geq 0$.

In the public regime, as there is no discrimination, incentive constraints do not apply. There is therefore no difference between the perfect and imperfect information cases. We consider both voluntary and compulsory insurance. The pooling contract noted PC in Figures 7 and 8 is proposed.

[13] The difference between the expected utility from insurance and no insurance is greater under perfect than imperfect information.

[14] The reality is a little more complex. To sum up, the majority of the population (the subpopulation of workers) pays a compulsory premium (contingent on income), to a single public agency. However, discrimination based on income may occur. In this paper, we assume that all agents have the same income.

[15] We assume that the insurer is utilitarian, so that the respective weights of H and L in the social welfare function represent the proportions of H and L in the population.

5.1 Compulsory insurance

Optimal public contracts are derived from Program III,

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

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

As shown in Appendix C, full-insurance pooling results, *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). Individuals are obliged to take out full insurance, with a unique premium α^* being paid by each individual.

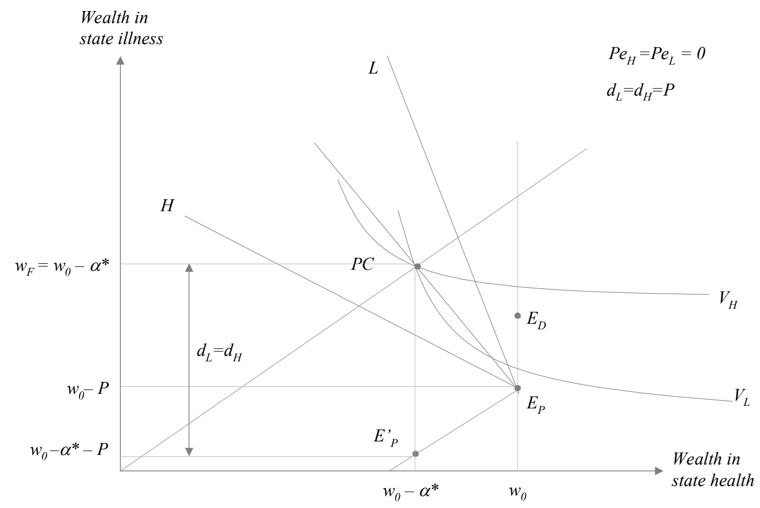

Figure 7: Compulsory and public insurance with full coverage
PC: Pooling contract

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

Lemma 5: *Under compulsory public insurance, healthcare demand does not depend on P, the healthcare price. Both types perceive the price as being zero, whatever the value of P. The insurance market induces the same distortion whatever the type, equal to P, and a unique willingness to pay, which is only bounded 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. Hence, in the health state, the wealth level of each type is $w_0-\alpha^*$, and in state illness each type chooses between consuming healthcare and being fully reimbursed (so that wealth is $w_0-\alpha^*$) or not consuming healthcare and suffering discomfort D (with wealth of $w_0-\alpha^*-D$). Whatever the level of P, each type will therefore prefer to consume healthcare in the case of illness ($w_0-\alpha^*>w_0-\alpha^*-D$, $\forall P$). *De facto*, the case where only one type i consumes healthcare is not possible.

We can also see that the perception of price Pe_i does not depend on the type. The price Pe_i is defined by

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

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

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

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

In a situation without insurance, the healthcare price P is bounded by D. Here, the presence of compulsory public insurance produces an unbounded price.[16] Whatever price the insured agent faces, their perception of price is zero.

French social security is a monopoly insurer that does not discriminate. A large part of healthcare is fully reimbursed. In a recent survey,[17] 64 % of respondents declared that they perceive the healthcare price to be zero. Our model illustrates this empirical fact, and shows the impact of price regulation on health expenditure. Insurance is imposed by public policy, and the type of insurance leads to a perceived price of zero. The public regulator is responsible for the level of health expenditure. The higher are healthcare prices relative to the monetary evaluation of the discomfort, the more health expenditure can be called into question.

5.2 Voluntary insurance

Contrary to the private system, when type i chooses not to take out insurance, he may still choose to consume healthcare.

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

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

There are four subcases, depending on which types take out insurance. From Appendix D, we have

$$\begin{cases} \text{Both types are insured if } x^* \leqq 1 \text{ and } \alpha^* = x^*\left(\dfrac{N_H}{N}p_H + \dfrac{N_L}{N}p_L\right)P \\ \\ \text{Only the high risks are insured but not the low risks if } x^* = 1 \text{ and } \alpha^* = p_H P \\ \\ \text{No-one is insured if } x^* = 0 \text{ and } \alpha^* = 0 \end{cases}$$

[16] Note that this infinite price does not mean that the types are insensitive to the price of healthcare: their expected utility always decreases in P, whatever the level of x.

[17] Source: Enquête santé, INSEE 2002-2003.

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

Why do insurers propose $x^* < 1$? Consider the case in Figure 8 where $x^* = 1$ in which the $L-type$ does not take out insurance. As we have $P > D$, the individual prefers not to consume healthcare. The pooling contract then only concerns the $H-type$. Arrow 1 shows the change in the $H-type$'s optimal contract depending on the participation of the $L-type$. Some situations exist where the insurer can increase the expected utility of both types by proposing a level of reimbursement $x^* < 1$ (Arrows 2 and 3).

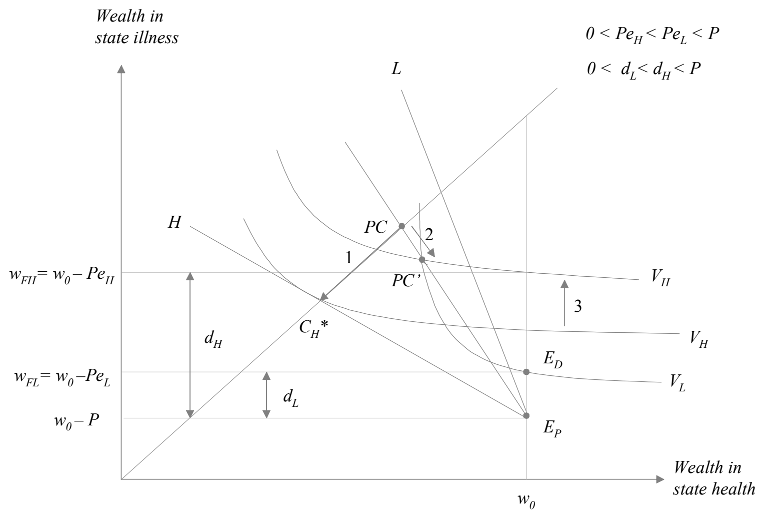

Figure 8: Voluntary and public insurance with full (PC) or partial (PC') coverage
PC: Pooling contract

There are two individual perceptions of healthcare price, Pe_i, associated with the pooling contract. These are 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 with private insurance, the definition of the critical price under a voluntary scheme depends on which types take out insurance. A pooling contract is proposed when both types participate in 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 will also necessarily do so. In addition, if $L-type$ agents participate, $H-type$ agents also necessarily do *i.e.* the existence of the pooling contract requires the $L-types'$ participation. Thus, the pooling contract only exists for values of P such that $P \leq P^{C_L}$. For P such that $P > P^{C_L}$, $L-types$ do not participate in the insurance market and do not consume.

Note that, even with $P < P^{C_L}$, participation in the insurance market is not guaranteed (see below Proposition 2 for details).

Only one type participates - definition of the $H - types'$ critical price It is possible that only the $H - type$ be insured. In this case the $L - type$ obtains higher utility from being uninsured (and undergoing the discomfort in case of illness) than from being insurance, and does not take out insurance. *De facto* the contract for $H - type$ agents corresponds to their separate full-insurance contract C_H^*.

For the $L - types$, as in the private system, price perception is P when uninsured and distortion is zero. For $H - types$, from the definition of perception, we have

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

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

No-one participates In the extreme no-one chooses the pooling contract. Whatever the level of reimbursement $x \leqq 1$, the $L - type$ does not take out insurance. In addition, the expected utility of the $H - type$ insured by C_H^* is lower than the expected utility of the uninsured $H - type$ who undergoes the discomfort D in case of illness. Both types then decide to suffer the discomfort in the case of illness by remaining uninsured. In this case, the perception of both types is the price P and distortion is zero.

From these three configurations, we have

Lemma 6: *Under voluntary public insurance, the distortion induced by the insurance market is higher for $H - types$ than for $L - types$. Willingness to pay for $L - types$ is lower than that for $H - types$ (under both perfect and imperfect information).*

From Lemmata 5 and 6, we obtain that under a public regime, the perception of price is zero under a compulsory scheme, whereas the perception is always strictly positive under a voluntary scheme, even for individuals who are fully insured. Moreover, the perception of price on the insurance market is higher for $L - types$ than for $H - types$.

Our model treats simultaneously the demand for health care and the demand for insurance. The advantage of this approach is that we can make the following prediction.

Proposition 2: *Under a voluntary public regime, the $L - type$ may still consume even though uninsured.*

This configuration arises under the following conditions. First, the optimal pooling contract (in terms of social welfare) is Pareto-dominated by the configuration where the $H - type$ is insured with a Rothschild and Stiglitz contract (C_H^*) and the $L - type$ is not insured. Second, the monetary evaluation of the discomfort D is greater than the healthcare price P, so that the expected utility of any uninsured agent is higher consuming the healthcare than suffering the discomfort.[18] Therefore, under a voluntary public regime, consumption does not imply participation.

We show that public price regulation does not need to be as strong as under a compulsory regime because both types have a non-zero perception of the healthcare price. However, we show that the higher is the healthcare price P compared to the monetary evaluation of the discomfort D, the lower is the level of reimbursement proposed by the insurer.

6 Insurance schemes and consequences

Distortion, willingness-to-pay and perception

Recall that distortion is defined as the difference between the actual price and the perceived price. The individual perception corresponding to the discomfort defines the maximal price, also called the willingness to pay. This maximal price level determining healthcare demand depends on both the insurance decision and insurance market organization. Thus, for a given price, the demands for healthcare and insurance depend on the form of the insurance scheme. We summarize the results obtained above in *Table 2.*

Insurance system	Price level	Individual distortion		Demand for health care	Demand for insurance
		$H-type$	$L-type$		
Private Compulsory	$P \le \frac{D}{1-x_L} \to \infty$ in PI $P \le \frac{D}{1-x_L}$ in AI	P	P in PI $< P$ in AI	$p_H N_H + p_L N_L$	N
	$P \le P^{C_H}$ in PI $P \le P^{C_L}_{AI}$ in AI	$d_H < P$	$d_L^{PI} > d_H$ in PI $d_L^{AI} < d_H$ in AI	$p_H N_H + p_L N_L$	N
Private Voluntary	$P^{C_H} < P \le P^{C_L}_{PI}$ in PI	0	$d_L^{PI} < P$	$p_L N_L$	N_L
	$P^{C_L}_{AI} < P \le P^{C_H}$ in AI	$d_H < P$	0	$p_H N_H$	N_H
	$P > P^{C_L}_{PI}$ in PI $P > P^{C_H}$ in AI	0	0	0	0
Public Compulsory	$P \le \frac{D}{1-x_i} \to \infty$	P	P	$p_H N_H + p_L N_L$	N
Public Voluntary	$P \le D(< P^{C_L}_{pooling})$	$d_H < P$ (Pool.) $d_H < P$ (R&S)	$d_L < d_H$ (Pool.) $d_L = 0$ (R&S)	$p_H N_H + p_L N_L$	N (Pool.) N_H (R&S)
	$D < P \le P^{C_L}_{pool.}$	$d_H^{pool.} < P$	$d_L^{pool} < d_H^{pool.}$	$p_H N_H + p_L N_L$	N
	$P^{C_L}_{pool.} < P \le P^{C_H}$	$d_H < P$	0	$p_H N_H$	N_H
	$P > P^{C_H}$	0	0	0	0

PI and AI stand for perfect information and asymmetric information, respectively.

For an agent i, P^{C_i} stands for willingness to pay and d_i stands for distortion

P^{C_H} and d_H defined for a H-type's contract under PI and AI

$P^{C_L}_{AI}$ and d_L^{AI} defined for a L-type's R&S contract and AI

$P^{C_L}_{PI}$ and d_L^{PI} defined for a L-type's contract under PI

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

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

From Table 2, we derive the following propositions.

Proposition 3: *Whatever the type of information, individual distortion is higher under compulsory than voluntary schemes. In addition, whatever the insurance system, with imperfect information, the distortion is higher for the $H-type$ than for the $L-type$.*

Proposition 4: *Under a voluntary scheme, the willingness to pay for the $H-type$ does not depend on the regime (private or public). Moreover, individual willingness to pay is always higher in compulsory than voluntary systems, except for the private regime with imperfect information. In the latter case, this assertion holds only when* $\frac{p_H}{1-x_L} > 1$.

Intuitively, we expect that, for given healthcare demand, compulsory insurance will allow higher prices than voluntary insurance. Proposition 4 shows that, for $\frac{p_H}{1-x_L} \leq 1$, compulsory insurance may actually produce lower prices than voluntary insurance. Proof of the second part is presented in Appendix E.

Proposition 5: *For all prices such that $P \leq D$, healthcare is always consumed in the case of illness and consumption does not depend on agent type. For $P > D$, healthcare is not consumed by uninsured agents but is consumed by insured agents.*

For an uninsured agent, the perception is the price of healthcare. As healthcare consumption depends on both insurance market organization and the insurance decision, the insurance system distorts the individual perception of price. Moreover, the distinction between price and discomfort leads to unusual situations: under voluntary insurance, only one type or even none of the types may actually consume healthcare, even under competition.

Price is exogenous, but healthcare demand depends on its level. Under compulsory insurance[19], healthcare demand is always maximal whatever the price of healthcare, while this does not hold under voluntary insurance.

Intuitively, we expect that, for a given price, public insurance will lead to higher healthcare demand than that under private insurance. This is actually not always true, and no unambiguous ranking is possible. For example, on the one hand (for $P > P_{pooling}^{C_L}$ in Table 2), a pooling contract leads to demand which is lower than that with a separate contract; on the other hand (for $P > \frac{D}{1-x_L}$), the demand is zero for compulsory private insurance but maximal for compulsory public insurance.

Demand and supply

In this paper, we simultaneously model the demands for health and insurance, and their implications. To obtain the equilibrium healthcare price, we can imagine modeling healthcare supply. However, this raises some separate issues. The supply of health care depends on *i)* the degree of competition between suppliers (for instance, pharmaceutical laboratories), and *ii)* policy regulation. The latter covers not only policy regarding healthcare organization (for instance, a single public insurer or competition with private insurance) but also regulation with

[19] Here we focus on the situation in which compulsory insurance may be implemented.

respect to healthcare price and healthcare reimbursement policy (*i.e.* preventative care, drugs, doctors visits etc.). Suppliers' bargaining power falls as healthcare regulation and competition increases. The more the healthcare market is regulated, the greater is the public part of insurance and the compulsory part of coverage; however, suppliers' bargaining power will be greater when there are only few suppliers. As such, a regulated competitive healthcare market offers the greatest bargaining power to a single insurer.

Including supply therefore requires a complicated model of three markets. We can however look at monopoly healthcare supply without regulation, which allows us to analyze a three-market model according to insurance type. A monopoly healthcare supplier has the greatest bargaining power in a competitive insurance market. Such a supplier can impose the healthcare price at its maximal level, *i.e.* at willingness to pay. Empirically, some Doctors or Specialists can be considered as monopoly suppliers due to their reputation, the density of suppliers in their area, and so on. Moreover, they may be not regulated, as in France.[20] Another example is drugs which are protected by a patent, allowing pharmaceutical firms to enjoy a temporary monopoly. However, willingness to pay may be multiple. With two individual willingnesses to pay, only one is the equilibrium price.[21] The supplier faces a trade-off (in terms of profit) between supplying all of the demand at a price equal to the lowest willingness to pay, and attracting only a subpopulation by fixing price at the highest willingness to pay. We have shown that, in a voluntary scheme, such a trade-off occurs. Note that if the trade-off leads to the exclusion of the $L-types$ from the healthcare market, the healthcare price which prevails is independent of the nature of the regime (private or public), and is equal to the willingness to pay of the $H-type$ (See Proposition 4).

From Proposition 4, the equilibrium price is higher in compulsory than in voluntary systems, except for a private regime with imperfect information. From Table 2, a public system may not lead to a higher equilibrium price than a private system. Last, from Proposition 1, the equilibrium price is higher under perfect than imperfect information. Adverse selection may therefore lead to lower market prices.

Insurance and welfare

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

Proposition 6: *Under perfect and imperfect information, voluntary schemes Pareto-dominate compulsory schemes in the private regime, whereas this is not the case in the public regime.*

Proof.

There are three possible situations in the private regime:

- both types are indifferent between the two schemes,

[20] In France, there are two groups of physicians, one of which is regulated (Secteur I) while the other is not (Secteur II).

[21] It holds with a n-type model.

- one type[22] prefers a voluntary system because he can then opt out of insurance, and the other one is indifferent

- both types prefer a voluntary system because they can then opt out of insurance.

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

7 Conclusion

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

Without insurance, the perceived price corresponds to the actual price, so that healthcare is always consumed until its price equals the value of discomfort. Only the presence of insurance permits its consumption at a higher price. Insurance affects the perceived price of healthcare, distorting 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 it here takes into account the probability that the individual takes out insurance. The perceived price is lower under compulsory than voluntary schemes; therefore, distortion is higher under a compulsory scheme. In terms of welfare, voluntary schemes Pareto-dominate compulsory schemes in the private regime, whereas this ranking does not hold in the public regime.

Our results provide some theoretical foundations, which to our knowledge have not been previously developed in insurance models, for two empirical phenomena: non-participation in insurance for some risk groups, and/or exclusion from the healthcare market.

The distinction between price and discomfort may lead to a situation where only one type consumes 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 a level where all agents are willing to pay. Indeed, for 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 group than the high risk group. This situation reflects an observed fact in various insurance markets. For instance, bad drivers or individuals with severe pathology have difficulty in finding private insurance contracts except at high premia because their characteristics are at least partially observable. This is reversed under asymmetric information: high-risk individ-

[22] The high-risk group under perfect information and the low-risk group under imperfect information.

uals participate in the insurance market at a higher level of healthcare price than do low-risk individuals. This exclusion of one group raises a public health issue.

The phenomenon of non-participation relies here on an argument which is different from the usual one of financial constraints: one group of individuals renounces insurance and treatment when the price of treatment, and hence the premium, is high compared to the monetary evaluation of the discomfort.

Surprisingly, adverse selection has a negative effect on willingness to pay under certain configurations. Thus, healthcare may be sold at a higher price under perfect than under imperfect information. Considering monopoly healthcare supply without regulation, willingness to pay is the equilibrium price. We thus have that *i)* the equilibrium price may be lower in compulsory than in voluntary systems for a private regime under imperfect information, and *ii)* contrary to intuition, adverse selection may lead to lower prices.

In addition, under voluntary public insurance, one type may prefer to be uninsured and consume the healthcare. This result mirrors the situation in the US (or European countries for supplementary insurance coverage) where some individuals do not take out insurance but participate in the healthcare market.

For simplicity, we have assumed only two risk types. Most of our results can be extended to N risk types. Moreover, we consider different insurance schemes separately; we could imagine a system where insured agents can choose complementary coverage in addition to their compulsory insurance, as in Blomqvist and Johansson (1997) or Hoel and Iversen (2002).

These results shed some light on the current debate over the reform of health systems world-wide, and particularly in OECD countries. They also provide a framework in which to think about 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 in 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 situation where discomfort may differ from the price.

8 Appendix

A: The Private System with Compulsory Insurance

In order to characterize optimal contracts under compulsory insurance, we derive the first-order conditions. The Lagrangian of Program Ib is:

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

with δ_i and μ_i being the multipliers associated with the incentive and profit constraints respectively. It is trivial to show that any competitive regime implies that the non-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 with respect to α_i and x_i yield Equations (1) to (4):

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

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

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

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

Four cases are possible, depending on which incentive constraints hold. It is easy to show that only the high risks' incentive constraint is binding, $\delta_H > 0$ and $\delta_L = 0$, so that optimal contracts are Rothschild and Stiglitz contracts. Equations (2) and (4) imply $\boxed{x_H^* = 1}$ and, from the non-negative profit constraint, $\boxed{\alpha_H^* = p_H P}$. Moreover, putting $\delta_L = 0$ in Equations (2) and (4) 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 of insurance implicitly requires that a strictly positive premium ($\alpha_i > 0$ $\forall i$) be charged against the promise of positive coverage ($x_i > 0$ $\forall i$). Therefore, $P > P^{C_i}$ for at least one $i \in \{H, L\}$ implies that healthcare is no longer consumed for both types. A regime of non-insurance prevails.

B: The Private System with Voluntary Insurance

In this regime, participation implies consumption and *vice versa*. Hence any uninsured agent is located at E_D. The Lagrangian of Program IIb is:

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

There are four cases to be analyzed, depending on the consumption of each type i.

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

Each type consumes healthcare when participating in the 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 is different from Program Ib, the first-order conditions after rearrangement are similar to those found in Appendix A, and the optimal contracts under voluntary insurance correspond to Rothschild and 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.* no-one consumes healthcare $\overline{p}_i = 0$

This case occurs when no-one 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 $P > P^{C_i}$ $\forall i \in \{H, L\}$. This implies that no-one consumes in case of illness. The optimal contracts are trivially: $\boxed{x_i^* = 0 \text{ and } \alpha_i^* = 0\ \forall i \in \{H, L\}}$.

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

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 in the insurance market, can never arise. Indeed, if a contract (α_L, x_L) exists which is preferred to no insurance by low risks, this contract will also necessarily be preferred to no insurance by high risks. More formally, we prove that

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

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 $U(w_0 - \alpha_L - P + x_L P) - \max\{U(w_0 - P); U(w_0 - D)\} > 0$ given that low risks take out insurance.

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

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

always holds. 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 preferred by high risks.

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

This 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 the first-order conditions relative to α_H and x_H imply, after rearrangement:

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

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

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 L's incentive constraint holds with 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 the premium and indemnity, we obtain

$\boxed{\alpha_H^* = p_H P,\ x_H^* = 1,\ \alpha_L^* = 0 \text{ and } x_L^* = 0}$ which means *L-types* leave the insurance market and the healthcare market, while *H-types* consume and are fully reimbursed.

C: The Public System with Compulsory Insurance

For a given price P, the Lagrangian of Program III is:

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

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

$$-(N_H p_H + N_L p_L)U'(w_0 - \alpha - P + xP) - (N - N_H p_H - N_L p_L)U'(w_0 - \alpha) + \mu N = 0 \quad (5)$$

$$(N_H p_H + N_L p_L)PU'(w_0 - \alpha - P + xP) = \mu(N_H p_H + N_L p_L)P \quad (6)$$

which yield

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

For the same reason as in Appendix A, $P > P^{C_i}$ for at least one $i \in \{H, L\}$ is not compatible with compulsory insurance. A non-insurance regime results.

D: The Public System with Voluntary Insurance

The optimal contracts are derived from Program IV, which can be expanded as follows

$$\underset{\alpha_i, x_i}{Max} \sum_i N_i max\{p_i U(w_0 - \min\{D; P\}) + (1 - p_i)U(w_0); p_i U(w_0 - \alpha - P + xP) + (1 - p_i)U(w_0 - \alpha)\}$$

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

with μ being the multiplier associated with the aggregate profit constraint. There are four cases, depending on which types consume healthcare. Note that under the assumption of voluntary insurance it is possible that an uninsured agent still consume healthcare. Participation in the insurance market thus implies healthcare consumption in the case of illness, but the inverse implication does not hold.

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

a) *Both types are insured*

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

$$L = \sum_i N_i max\{p_i U(w_0 - \min\{D; P\}) + (1 - p_i)U(w_0); p_i U(w_0 - \alpha - P + xP) + (1 - p_i)U(w_0 - \alpha)\}$$

$$+\mu \sum_i N_i(\alpha - \overline{p}_i xP)$$

$$+\delta[p_L U(w_0 - \alpha - P + xP) + (1 - p_L)U(w_0 - \alpha) - p_L U(w_0 - \min\{D; P\}) - (1 - p_L)U(w_0)]$$

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

The first-order conditions are,

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

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

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),

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

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

$\rightarrow$ When $\delta = 0$ the right-hand side equals 1, so that $\boxed{x^* = 1}$ and $\boxed{\alpha^* = (\frac{N_H}{N} p_H + \frac{N_L}{N} p_L)P}$.

$\rightarrow$ when $\delta > 0$, given that $p_L N < (N_H p_H + N_L p_L)$, if $(N - N_H p_H - N_L p_L - \delta p_L + \delta) > 0$ the right-hand side is less than 1, so that $\boxed{x^* < 1}$ and $\boxed{\alpha^* = x(\frac{N_H}{N} p_H + \frac{N_L}{N} p_L)P}$

b) *No-one 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:*

♦ If the $L - type$ is insured: It is trivial to show that any contract accepted by the $L - type$ is always accepted by the $H - type$, *i.e.* that

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

The case where only the $L - type$ is insured does not occur.

♦ If only the $H - type$ is insured we have

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

This unusual case occurs only when $P < D$ *i.e.* the healthcare is always purchased by each type in the case of illness. The Lagrangian is

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

We thus obtain $x^* = 1$ and $\alpha^* = p_H P$. A numerical example is given in Section 5.2.

• **2.** $P > P^{C_i}$ $\forall i \in \{H, L\}$ *i.e.* no-one consumes the healthcare $\overline{p}_i = 0$. This 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 to that above, no contract exists which would be preferred to no insurance by low risks and would not be taken out by high risks.

L-type uninsured. This case implies that both types are uninsured. Thus, the consumption decision does not depend on the type. We cannot therefore have $L-$ *types* who consume and not $H-$ *types*.

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 Lagrangian is

$$\begin{aligned} L &= N_H[p_H U(w_0 - \alpha - P + xP) + (1 - p_H)U(w_0 - \alpha)] \\ &\quad + N_L[p_L U(w_0 - D) + (1 - p_L)U(w_0)] + \mu N_H(\alpha - p_H x P) \end{aligned}$$

and the first-order conditions are:

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

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

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

$H-$type uninsured. This case implies that both types are uninsured. The consumption decision does not depend on the type. Therefore, we cannot have $H-$ *types* who consume and $L-$ *types* who do not.

E: Proof of Proposition 4

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 of the level of information:

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

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

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

The situation is more complicated. (a) For the $L-type$, the price is bounded by $\frac{D}{1-x_L}$ in a compulsory system and by $P_v^{C_L} < \frac{D}{1-x_L}$ in the voluntary system. (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 than in a voluntary system.

$P_v^{C_i}$ 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 $P_c^{C_L} = \frac{D}{1-x_L}$,

$$w_0 - \alpha_i - P_c^{C_L} + x_iP_c^{C_L} = w_0 - \alpha_i - \left(\frac{1-x_i}{1-x_L}\right)D$$

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

(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)

$$w_0 - \left(x_H^*p_HP_c^{C_L}\right) - P_c^{C_L} + x_H^*P_c^{C_L} = w_0 - p_HP_c^{C_L}$$

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

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

Then,

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

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

$p_HU(w_0 - \frac{p_H}{1-x_L}D) + (1 - p_H)U(w_0) < p_HU(w_0 - D) + (1 - p_H)U(w_0)$
$\Leftrightarrow p_HU(w_0 - \left(x_H^*p_HP_c^{C_L}\right) - P_c^{C_L} + x_H^*P_c^{C_L}) + (1 - p_H)U(w_0) < p_HU(w_0 - D) + (1 - p_H)U(w_0)$
from (A), $p_HU(w_0 - \alpha_H^* - (1 - x_H^*)P_v^{C_H}) + (1 - p_H)U(w_0 - \alpha_H^*) = p_HU(w_0 - D) + (1 - p_H)U(w_0)$

$$\Rightarrow \begin{array}{l} p_HU(w_0 - \left(x_H^*p_HP_c^{C_L}\right) - P_c^{C_L} + x_H^*P_c^{C_L}) + (1 - p_H)U(w_0) \\ < p_HU(w_0 - \alpha_H^* - (1 - x_H^*)P_v^{C_H}) + (1 - p_H)U(w_0 - \alpha_H^*) \end{array}$$

$$\Rightarrow \begin{array}{l} p_HU(w_0 - \left(x_H^*p_HP_c^{C_L}\right) - (1 - x_H^*)\, P_c^{C_L}) + (1 - p_H)U(w_0) \\ < p_HU(w_0 - \alpha_H^* - (1 - x_H^*)P_v^{C_H}) + (1 - p_H)U(w_0) \end{array}$$

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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