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Policyholder Homogeneity and Equity in the Regulation of Compulsory Health Insurance in Developing Countries

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Abstract

This article analyses the agency relationship between the State (the social insurer) and the insured in the context of a public health insurance system designed to optimise social expenditure on reimbursement while making the insured more responsible. This public health insurance system had the following characteristics: growth of the co-payment as a function of the cost of care and the smoothed income of policyholders; growth of the deductible as a function of the smoothed income of policyholders; independence of the co-payment and deductible from income categories; exclusion of low-income policyholders from access to certain types of care. We have developed a moral hazard model with policyholder homogeneity, which has enabled us to identify the components of their optimal financial participation. The properties of these financial participation components highlight the characteristics of the public health insurance system, including the potential to exclude low-income policyholders from access to certain types of care. The assumption that agents are homogeneous has been identified as the source of this potential for exclusion.

Keywords

Health Insurance, Microeconomic Policy, Optimal Contract, Inequality

1. Introduction

Compulsory health insurance is a branch of social security in many countries. It serves an individual purpose insofar as it is in the interest of every person and every family to be insured against the risk of illness. It also serves a collective purpose insofar as insurance pools the risk of illness and health costs, and ultimately regulates the population's state of health.

Public policies on compulsory health cover, which are supposed to solve the problem of equity in access to care, reproduce the potential for exclusion of low-income policyholders, particularly in developing countries. This raises the following questions: how do public compulsory health insurance systems reproduce the exclusion of low-income individuals from access to certain types of care, and how can the objectives of equity and universality in the provision of public health insurance be achieved for all citizens in developing countries?

This article addresses the first aspect of the problem. The aim is to show that a policy of compulsory health insurance with risk sharing in countries where health insurance is not comprehensive cannot solve the problem of exclusion of low-income earners if it is based on the assumption that individuals are homogeneous.

There are two opposing principles when it comes to the distribution of health insurance risks: the insurance principle and the principle of solidarity.

The first principle underpins private health insurance. It links individual premiums or contributions to the expected risk. This form of health insurance is confronted with asymmetric information; in particular, the problem of anti-selection: insurers may be less well informed than policyholders. In this case, a uniform pricing policy can lead to market collapse [1], since the actuarial premium is such that only high-risk agents will take out insurance, with low-risk agents preferring not to insure because of the cost based on a higher average risk than their own. Insurance will then be in deficit and premiums will increase, which may lead to the disappearance of the insurance market [2].

To overcome this problem, insurance can use a policy of second-degree discrimination so that agents self-select and reveal their private information. For example, high-risk agents are given full, expensive insurance, while low-risk agents are given partial, low-cost insurance. This second-tier solution, characterised by poor cover for low-risk agents, reduces market inefficiency but may prove inequitable since it implies higher premiums for individuals in poorer health. Another solution is to acquire information. Insurance companies impose medical examinations or carry out epidemiological studies of known risks by age group or social group. These two strategies can reverse the asymmetry of information. As insurers are better informed than policyholders, they can implement risk-skimming or risk-selection policies.

The second principle, the principle of solidarity in health insurance, is the foundation of social insurance or public insurance. The lack of equity in access to care is a limitation of private health insurance and justifies state intervention. In fact, only universal insurance with premium and cover conditions that are independent of health status can ensure market efficiency, long-term insurance and fair treatment of policyholders by preventing the eviction of high-risk individuals. The principle of solidarity in health insurance disconnects premiums from individual risks and possibly links them to observable characteristics such as income. The health insurance mechanism proposed by the social insurer, the State, aims to meet three criteria: allocative efficiency, productive efficiency and equity.

The criterion of allocative efficiency implies that resources are well used, so that we cannot improve the population's state of health by using the same resources differently. This criterion of allocative efficiency also implies that the amounts are correct in the sense that we could not do better by spending less (more) on health to the benefit (detriment) of other collective services. The criterion of productive efficiency implies minimising the costs of obtaining a health outcome. This may involve minimising the costs of ensuring a given state of health or maximising the state of health for a given volume of expenditure.

In the quest for productive efficiency, the regulation of any health insurance system focuses on "making patients responsible", while introducing measures to moderate the consequences for low-income populations. Such an approach requires an understanding of the public health insurance system in terms of an agency relationship, where the social insurer (the state) is the principal and the insured is the agent. The social insurer leaves to the insured the preventive efforts intended to mitigate the risk of illness, which is partially or fully covered by the social insurer. This is the phenomenon of moral hazard, whereby the level of expenditure borne by the insurer depends on the behaviour of the insured. Moral hazard can be ex-ante if the agent makes less effort to prevent illness and ex-post if the agent tends to over-consume care.

To measure the effect of moral hazard, we evaluate the over-consumption of care in the case of health insurance compared with the consumption of care without health insurance. Analysis of the agency relationship in health economics between insurer and insured shows that the risk of over-consumption linked to the insured's moral hazard behaviour can be mitigated by financial participation (co-insurance) involving risk-sharing between the insurer and the insured [3].

Various studies have empirically evaluated the effect of this mechanism of financial participation by the insured in reducing moral hazard ([4]-[6]).

In addition to seeking allocative and productive efficiency, the public health insurance system aims for equity. The criterion of equity in access to care guarantees equality in the face of illness, regardless of state of health, risk of illness or income considerations. The possibility for all citizens to have access to a minimum level of care regardless of their income is based on an argument of distributive justice; health being a primary social good in the sense of Rawls where ex-ante insurance is equivalent ex-post to a redistribution between individuals with different risks [7].

As a social insurer, the State establishes rules for calculating premiums and cover rates, which are supposed to comply with the principles of allocative efficiency, productive efficiency and equity. The social insurer manages to limit its reimbursement costs by making policyholders responsible through their financial participation. This is achieved through mechanisms such as compulsory contributions, co-payments and deductibles. However, the level of co-payment can act as a barrier to access to care. Both co-payments and deductibles share the same shortcoming in terms of social justice; as they are independent of income, they weigh proportionately more heavily on lower incomes ([8] [9]).

Irrespective of income criteria, these mechanisms for financial participation can lead low-income patients to forego necessary care for financial reasons. [10] analyse that in France, the out-of-pocket expenses of households belonging to the first decile of the population (the poorest 10%) represented on average 10% of their gross income. [11] shows that in 2002, 23% of people with social insurance and no supplementary insurance said they had had to forego treatment for financial reasons. Financial participation mechanisms can therefore meet the criteria of allocative and productive efficiency while failing to satisfy the principle of equity.

In this article, our aim is to show that a theoretical ex-ante moral hazard model with homogeneous agents can be used to determine the optimal financial participation of these agents. The components of this financial participation are the compulsory contribution, the deductible and the co-payment. The properties of these components of financial participation highlight the characteristics of the public health insurance system in developing countries, including the potential to exclude low-income policyholders from access to certain types of care.

A compulsory contribution is the amount of money an individual must pay (as an entry fee) to become insured and benefit from basic cover. For example, in Côte d'Ivoire, where health cover has been compulsory since 2019, the compulsory contribution has been set at 1000 FCFA (or 1.5 euros) per month for each insured person. The excess is an additional sum applied to the price of medicines and/or the cost of treatment received by the insured person. The excess is established on the basis of social criteria or health care costs. The policyholder may or may not be exempted from paying it, depending on these criteria. Finally, the co-payment is a sum paid by a private supplementary health insurance organisation for the benefit of the insured person or, failing that, by the insured person him/herself.

The characteristics of the public health insurance system highlighted in this article are as follows: 1) the co-payment increases linearly with the cost of care; 2) the co-payment increases when income increases; 3) the co-payment increases with the smoothed income of the insured but is independent of the insured's income category; 4) the deductible increases with the smoothed income of the insured but is independent of the insured's income category; 5) the mechanisms of financial participation have the effect of excluding insureds on low incomes from access to certain types of care.

The theoretical approach chosen makes it possible to identify the assumption of homogeneity of agents as the source of the potential exclusion of low incomes from access to certain types of care. This assumption leads to the smoothing of income inequalities in the model.

The rest of the paper is organised as follows: first, Section 2 develops the theoretical model of ex-ante moral hazard and its main results. Next, we analyse the mechanisms of optimal financial participation in the light of the characteristics of the public health insurance system in developing countries (Section 3). Finally, Section 4 concludes the work and proposes some perspectives.

2. Modelling

We first present the assumptions of the model (2.1), then the optimisation programme for the social insurer (2.2), and finally, the optimal financial participation of the insured (2.3).

2.1. Model Assumptions

The insured is a representative agent with an income y. Health insurance is assumed to be compulsory, so there are no uninsured individuals. This allows the insured to pay only $t(x)$: the total cost of health care x, ($x>0$, single care). The policyholder's net income is therefore equivalent to his income after health care costs: $y-t(x)$. The policyholder's utility function depends on his income y, the monetary loss $t(x)$ and the disutility $w(e)$ associated with the effort e made to prevent illness. This utility function is separable. It is decomposed into a function of the policyholder's net income $v(y-t(x))$ where $v'>0$, $v''<0$ (the policyholder is risk averse) and an effort disutility function $w(e)$ with $w'>0$; $w''<0$. Formally, we have:

$$V=V(y-t(x);e)=v(y-t(x))-w(e) \tag{1}$$

The social insurer's objective is considered to be to minimise the costs of providing a given state of health. Although it has a duty to cover all or part of the insured person's healthcare costs, it has limited resources at its disposal. It therefore increases its utility by reducing the social share of healthcare expenditure for each insured person, *i.e.* $x-t(x)$.

As this social share of health expenditure is not known with certainty, we associate a probability distribution with it and define an expected utility function for the social insurer, of the Von Neumann-Morgenstern type $U(.)$ with $U'>0$. This last condition requires taking as the argument of $U(.)$ the term $[-x+t(x)]$ and not $[x-t(x)]$. Thus, the insurer's social utility function is a negative function of the expenditure x (monetary loss) and positive of the amount of financial participation $t(x)$ (the health expenditure) borne by the insured:

$$U=U(-x+t(x)) \tag{2}$$

The aim of the social insurer is to minimise costs (reimbursement expenditure). To do this, it puts in place an optimal incentive contract that takes into account the level of effort made by the insured to prevent illness, as well as the proportion of healthcare expenditure to be borne by the patient, in order to make the insured more responsible. In other words, the aim is to build an incentive contract that minimises the cost of social cover while minimising healthcare expenditure for insured individuals. The health insurance contract is drawn up by the State and offered to the insured without any possibility of negotiation or renegotiation. This is tantamount to seeking to maximise the utility of the social insurer under the constraints of policyholder participation and incentives.

The policyholder participation constraint assumes that the expected gain is greater than the opportunity cost: the utility derived should be greater than the disutility generated by participation. Furthermore, an individual's interest in participating in health insurance is reinforced by the assumption that $y > t(x)$. This reflects the idea that the absence of insurance leads to the individual becoming poorer with $t(x) \geq y$. Thus, an individual who has no insurance is considered as an insured who does not pay his contributions. This compulsory nature of health insurance, combined with the fact that it guarantees the individual's income by opening the door to a wide range of care, then induces that the individual's participation constraint is always satisfied. Put another way, the compulsory nature of health insurance means that rationing by quantity, *i.e.*, a reduction in the number of claimants, must be ruled out. There is no ex-ante exclusion from the health insurance contract. We should not therefore speak of adverse selection. The policyholder participation constraint is written as follows:

$$Ev\left(y - t(x)\right) - w(e) \geq 0 \tag{3}$$

The incentive constraint assumes that there is a potential conflict between the principal (the social insurer) and the agent (the insured). The principal wants to reduce the social share of individual healthcare expenditure $\left[x - t(x)\right]$ in order to increase its utility $U(.)$ via the increase in $\left[-x + t(x)\right]$. The agent, for his part, wants to reduce his financial contribution $t(x)$ to the total cost of his healthcare. This increases his utility V but reduces that of the principal. Since rationing by quantity is impossible given the compulsory nature of public health insurance, what remains is rationing by cost, involving the effort of the agent (the insured). The agent is self-motivated to make the greatest possible preventive effort in order to benefit from an expected utility that is at least equivalent to the disutility caused by this effort. The principal, who is assumed to be infallible and sufficiently credible, provides an incentive contract which functions as a mechanism that ensures the equivalence between the level of effort chosen by the agent and the level of effort desired by the principal and the reward provided by the latter.

$$Ev\left(y - t(x)\right) - w(e) \geq Ev\left(y - t(\tilde{x})\right) - w(\tilde{e}) \tag{4}$$

$\tilde{x}$ and $\tilde{e}$ represent respectively the level of the total cost of care and the level of prevention effort desired by the principal.

For the agent (the insured), satisfying the incentive constraint means maximising his utility function as a function of his disease prevention effort. This consists of obtaining the optimal level of effort that provides maximum utility. At this optimal level of effort, the marginal utility linked to net income is equal to the marginal disutility of the effort. See Equation (7).

$$e = \underset{e}{\text{Argmax}}\, Ev\left(y - t(x)\right) - w(e) \tag{5}$$

More formally, let us note the level of preventive effort made by the insured $e \in [\underline{e}; \overline{e}]$, with $\underline{e}$: low effort and $\overline{e}$: high effort. This level of unobservable effort by the social insurer induces an observable outcome x (which is the total cost of healthcare) according to a probability density distribution $f(x;e)$ and distribution function $F(x;e)$. Assume that $F(x;e)$ and $f(x;e)$ are differentiable and continuous for all x and e.

The first-order approach defines conditions known as the Monotone Likelihood Ratio Condition (MLRC) and the Concavity of Distribution Function Condition (CDFC). These conditions are necessary and sufficient to satisfy the policyholder incentive constraint. This approach has been developed by many authors: [12]-[16].

The MLRC condition, proved by [17], implies stochastic dominance; that is, $F_e(x;e) \le 0$, and states that a higher signal gives more information about the insured's effort. Formally $f(x;e)$ must satisfy the MLRC condition if:

$$\frac{f_e(x;e)}{f(x;e)} \text{ is non-decreasing } \forall x, e$$

The CDFC condition is a decreasing stochastic return condition. It applies to the production of information on the insured's effort. $(x;e)$ must also satisfy the CDFC condition:

$$F_{ee}(x;e) \ge 0 \tag{6}$$

According to the first-order approach, if the probability density $f(x;e)$ satisfies the MLRC and CDFC conditions, then the incentive constraint can be written as:

$$\frac{\partial}{\partial e}\Big[Ev\big(y - t(x)\big) - w(e)\Big] = 0 \tag{7}$$

Let's assume that:

The insured reduces the probability of becoming ill by choosing a high level of effort:

$$\frac{\partial f(0;e)}{\partial e} > 0 \tag{8}$$

In the event of illness, the insured reduces the likelihood of incurring a large monetary loss by making a high level of effort:

$$\frac{\partial f(x;e)}{\partial e} < 0 \tag{9}$$

$\int(x;e) = 1 - f(0;e)$: probability of the insured being ill. $f(x;e)$ is therefore discontinuous at $x = 0$.

The insured person derives a positive utility from public health insurance as long as his financial participation is lower than his income ($t(x) < y$) and the share of health expenditure ($\frac{t(x)}{x}$) decreases in relation to his total health expenditure (x): $\frac{\partial Q(x)}{\partial x} < 0$ with $Q(x) = \frac{t(x)}{x}$.

2.2. Optimisation Programme

The programme for determining the conditions of the optimal incentive contract between the social insurer and the insured is formally as follows:

$$\begin{cases} \underbrace{\max}_{e;t(.)} EU\left(-x+t(x)\right) \\ s/c\,; Ev\left(y-t(x)\right)-w(e)\geq 0 \\ \frac{\partial}{\partial e}\left[Ev\left(y-t(x)\right)-w(e)\right]=0 \end{cases}$$

$$\Rightarrow \begin{cases} \underbrace{\max}_{e;t(.)} \int U\left(-x+t(x)\right) f(x;e)\,\mathrm{d}x \\ s/c:\int v\left(y-t(x)\right)\mathrm{d}x-w(e)\geq 0 \qquad (\lambda) \\ \int v\left(y-t(x)\right) f_e(x;e)\,\mathrm{d}x-w'(e)=0 \quad (\mu) \end{cases}$$

Noting λ: Lagrange multiplier associated with the individual's participation constraint; μ: Lagrange multiplier associated with the insured's choice of effort level, the optimal incentive contract leads to the following equations:

$$\begin{cases} \dfrac{U'\left(-x+t(x)\right)}{v'\left(y-t(x)\right)}=\lambda+\mu\dfrac{f_e(x;e)}{f(x;e)} & (10) \\ t'(x)=\dfrac{U''\left(-x+t(x)\right)v'\left(y-t(x)\right)-{}^{1}\dfrac{\mathrm{d}}{\mathrm{d}x}\left[\dfrac{f_e(x;e)}{f(x;e)}\right]*\left[v'\left(y-t(x)\right)\right]^2}{\left[U''\left(-x+t(x)\right)v'\left(y-t(x)\right)+v''\left(y-t(x)\right)U'\left(x+t(x)\right)\right]} & (11) \end{cases}$$

There are two cases depending on whether the social insurer (the principal) is risk averse in relation to the agent's prevention effort ($U''_e<0$) or risk neutral ($U''_e=0$).

When the social insurer is risk averse, and with $v''<0$, the result is:

$$0<t'(x)<1 \tag{12}$$

The optimal incentive contract is such that, when the total cost of health care increases by one unit, the insured's financial participation increases, but proportionately less than the cost of care.

When the social insurer is risk-neutral, and with $v''<0$, we show that:

$$t'(x)=\frac{-\dfrac{\mathrm{d}}{\mathrm{d}x}\left[\dfrac{f_e(x;e)}{f(x;e)}\right]*\left[v'\left(y_0-t(x)\right)\right]^2}{\left[v''\left(y_0-t(x)\right)U'\left(x+t(x)\right)\right]}\Rightarrow t'(x)>0$$

The optimal contract is such that, as the total cost of healthcare increases, the insured's financial participation increases.

These results can be summarised in Proposition 1 below:

Proposition 1: The contract between the social insurer and the insured induces,

[1]Justification for the negative sign of the coefficient of μ: Since the level of effort or action chosen is a maximum (an interior point) of the agent's optimisation programme, then the coefficient of the Lagrange multiplier (μ) which represents the second derivative of this optimisation programme is negative or zero.

at the optimum, a sharing of risks between them, relating to the assumption of health care costs.

2.3. Optimum Financial Participation

Let's find the functional form of the optimal financial participation $t(x)$ of the insured in order to obtain the optimal levels of the compulsory contribution, the co-payment and the excess.

Starting from Equation (11), we obtain a primitive of $t'(x)$:

$$t(x)=\int \frac{U''(-x+t(x))v'(y-t(x))-\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]*\left[v'(y-t(x))\right]^2}{\left[U''(-x+t(x))v'(y-t(x))+v''(y-t(x))U'(x+t(x))\right]}\mathrm{d}x+b \quad (13)$$

with $b\in\mathbb{R}$. The expression for b is obtained from Equation (13) by posing $t(0)=K=b$. More precisely:

$$b=t(0)-\int \frac{U''(t(0))v'(y-t(0))-\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(0;e)}{f(0;e)}\right]*\left[v'(y-t(0))\right]^2}{\left[U''(t(0))v'(y-t(0))+v''(y-t(0))U'(t(0))\right]}\mathrm{d}x \quad (14)$$

Note:

$$A\equiv -\frac{U''(t(0))v'(y-t(0))-\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(0;e)}{f(0;e)}\right]*\left[v'(y-t(0))\right]^2}{\left[U''(t(0))v'(y-t(0))+v''(y-t(0))U'(t(0))\right]} \quad (15)$$

Note that A is a constant. By substituting Equation (14) into Equation (13), the expression for b reduces to:

$$b=K+\int A\mathrm{d}x=t(0)+\left[Ax\right]_0^x=K+Ax \quad (16)$$

Noting:

$$B(x)\equiv\int \frac{U''(-x+t(x))v'(y-t(x))-\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]*\left[v'(y-t(x))\right]^2}{\left[U''(-x+t(x))v'(y-t(x))+v''(y-t(x))U'(x+t(x))\right]}\mathrm{d}x \quad (17)$$

Ultimately, the functional form of the optimal financial contribution is written as:

$$t(x)=K+Ax+B(x) \quad (18)$$

K is the optimal compulsory contribution paid by the insured; Ax is the optimal co-payment amount; (x) the optimal excess.

It is also possible to determine the fixed amount of the excess that triggers coverage. To do this, we need to return to the non-negativity constraint on the insured's net income, which guarantees that his financial contribution to health insurance, remaining lower than his income, does not make him poorer:

$$y-t(x)>0\Rightarrow y-K-Ax-B(x)>0 \quad (19)$$

The principal (the State) must ensure that when the total cost of healthcare x

exceeds a certain threshold, so that the insured person's financial participation impoverishes him or her, the latter is exempt from paying the excess. This health care cost threshold is the level of x that cancels out the insured person's net income. Let's note $\hat{x}$. We have:

$$y - K - A\hat{x} - B(\hat{x}) = 0 \tag{20}$$

We simply show that when the healthcare cost exceeds the threshold, $x \geq \hat{x}$, the insured's net income becomes negative:

$x \geq \hat{x} \Rightarrow y - K - Ax - B(x) \geq y - K - A\hat{x} - B(\hat{x})$ puisque $B(x) \geq B(\hat{x})$ et $Ax \geq A\hat{x}$.

So:

$$y - K - Ax - B(x) \geq 0$$

In this case, the State (the social insurer) must, as far as possible, set the excess at 0. The insured is exempt from the excess. When the insured's expenditure on care is below the threshold, $\hat{x}$, his excess is $B(x) < B(\hat{x})$ and his net income becomes positive: $y - K - Ax - B(x) > 0$.

Formally, the social insurer can, at optimum, maintain the excess $B(x)$. The insured is not exempt from the excess. Noting $B(\hat{x}) = \hat{B}$, we formally obtain:

$$\begin{cases} B(x) > 0 \text{ si } B(x) < \hat{B}: & \text{l'insured is not exempt from deductible} \\ B(x) = 0 \text{ si } B(x) \geq \hat{B}: & \text{l'insured is exempt from the excess} \end{cases}$$

Let's summarise this result in Proposition 2 below:

Proposition 2: The optimal incentive contract proposed by the social insurer to minimise its social expenditure and make the insured more responsible, consists of a combination of compulsory contribution, co-payment, deductible and a fixed threshold of cost in care *B*, which triggers the assumption of responsibility (exemption from the deductible), such that:

$$\begin{cases} t(x) = K + Ax + B(x) \text{ si } B(x) < \hat{B}: & \text{l'insured is not exempt from deductible} \\ t(x) = K + Ax \text{ si } B(x) \geq \hat{B}: & \text{l'insured is exempt from the excess} \end{cases}$$

With:

$$A \equiv -\frac{U''(K)v'(y-K) - \frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(0;e)}{f(0;e)}\right] * \left[v'(y-K)\right]^2}{\left[U''(K)v'(y-K) + v''(y-K)U'(K)\right]} \tag{21}$$

$$B(x) \equiv \int \frac{U''(-x+t(x))v'(y-t(x)) - \frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right] * \left[v'(y-t(x))\right]^2}{\left[U''(-x+t(x))v'(y-t(x)) + v''(y-t(x))U'(x+t(x))\right]} \mathrm{d}x \tag{22}$$

3. Mechanisms for Optimal Financial Participation in the Light of the Characteristics of the Public Health Insurance System in Developing Countries

We show that our ex-ante moral hazard model reproduces the characteristics of the public health insurance system in developing countries, in particular the co-payment (3.1), the deductible (3.2) and the potential exclusion of low-income policyholders from access to certain types of care (3.3).

3.1. Co-Payment: *Ax*

We show that the co-payment is an increasing linear function of the total cost of care x, for a particular type of care. This is because the co-payment parameter A is a positive constant. In fact, $A > 0$ implies that:

$$\frac{U''(K)}{v'(y-K)} < \frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(0;e)}{f(0;e)}\right] \tag{23}$$

This relation is always verified since $U''(K)/v'(y-K) < 0$ and by virtue of the MLRC condition, we have:

$$\forall x, e \geq 0;\ \frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(0;e)}{f(0;e)}\right] \geq 0 \tag{24}$$

This property of the co-payment increasing linearly with the total cost of health care is consistent with characteristic 1 of the public health insurance system in developing countries mentioned earlier.

In particular, the co-payment parameter A increases with income y, for the same type of care. Indeed:

$$\frac{\partial A}{\partial y} > 0 \text{ if and only if } U''(K)v'(y-K) < 2\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(0;e)}{f(0;e)}\right]v'(y-K)$$

This condition is always satisfied since:

$$\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(0;e)}{f(0;e)}\right]v'(y-K) > 0 \text{ et } U''(K)v'(y-K) < 0$$

This growth in co-payments with income is in line with characteristic 2 of the public health insurance system in developing countries, as described above.

Finally, to say that the co-payment increases with income does not mean that the co-payment is differentiated according to the income level of the insured. In fact, the income taken into account in our theoretical model is a smoothed income that does not distinguish between high and low incomes. This income smoothes out income inequalities between high and low incomes. The optimal co-payment increases with policyholders' smoothed income but is independent of policyholders' income categories. This result is compatible with characteristic 3 of the public health insurance system in developing countries.

3.2. The Deductible: $B(x)$

The optimal deductible is positive ($B(x) > 0$) and grows with the cost of care ($B'(x) > 0$). See the **Appendix** for the proof.

According to identity (21), the optimal deductible grows with smoothed income *y*. Indeed, we show that:

$$\frac{\partial B(x)}{\partial y} > 0 \text{ si et seulement si } U''(t(x))v''(y-t(x)) < 2\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]v'(y-t(x))$$

This is always the case since:

$$\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]v'(y-t(x)) > U''(t(x))v''(y-t(x)) < 0 \tag{25}$$

The optimal level of *Bx* grows with the smoothed income of policyholders but is independent of policyholders' income categories. Consequently, this deductible does not take into account income inequalities between policyholders. These results concerning the optimal level of the deductible are compatible with characteristic 4 of the public health insurance system in DCs.

3.3. Optimal Contract and Equity in Access to Care

The ex-ante moral hazard model developed in this article assumes the homogeneity of the insured. As a result, the policyholder taken into account in the model is an "average individual" in the statistical sense of the term. The optimal level of financial participation *tx* does not take into account income inequalities between policyholders. Are the results of this model in line with characteristic 5 concerning the exclusion of low-income policyholders?

We first show that low income is underestimated while high income is overestimated in the determination of the optimal health insurance contract. To do this, consider that the economy is composed of high-income policyholders y in proportion θ ($avec\ \theta \in]0,1]$) and low-income policyholders y in proportion $1-\theta$. It then follows that the insured's income is the sum of the low income y and a positive differential reflecting income inequality $\theta\Delta y$. It is also the difference between high income y and $\theta\Delta y$. Indeed, on the one hand:

$$y = \theta\overline{y} + (1-\theta)\underline{y} = \theta(\overline{y} - \underline{y}) + \underline{y} = \underline{y} + \theta\Delta y;$$

and on the other hand: $y = \overline{y} - \theta\Delta y$, où $\underline{y} < y < \overline{y}$ et $y \equiv \overline{y} - \underline{y} > 0$.

Secondly, we show how the deductible used in the optimal contract may not be sufficient to guarantee the participation of low-income agents in the health insurance contract. Remember that the rationale behind the deductible was to prevent the insured's net income from becoming negative (impoverishment). As we have seen, when the total cost of healthcare exceeds the *x* threshold, the policyholder is exempt from paying the excess. The deductible is triggered in relation to the policyholder's income and the total cost of care, but not in relation to the policyholder's expected utility. In fact, it is possible that the level of the total cost of healthcare exempts the policyholder from paying the excess, thus reducing his net income to a positive level, while his expected utility becomes negative. To see this, let's return to the policyholder participation constraint:

$$Ev(y-t(x)) - w(e) \geq 0 \tag{26}$$

Introducing the expression ($\theta\Delta y$) into this participation constraint gives;

$$Ev\left(\underline{y}-\theta\Delta y-t(x)\right)-w(e)\geq 0 \tag{27}$$

$$Ev\left(\overline{y}+\theta\Delta y-t(x)\right)-w(e)\geq 0 \tag{28}$$

Let x be a level of healthcare costs that saturates the policyholder participation constraint:

$$Ev\left(\underline{y}-\theta\Delta y-t(x)\right)-w(e)=0 \tag{29}$$

$$Ev\left(\overline{y}+\theta\Delta y-t(x)\right)-w(e)=0 \tag{30}$$

From the fact that $v'>0$, it comes that $\forall\ \theta>0$ and $\Delta y>0$, we have:

$$Ev\left(\underline{y}+\theta\Delta y-t(\tilde{x})\right)-w(e)>Ev\left(\underline{y}-t(\tilde{x})\right)-w(e) \tag{31}$$

$$Ev\left(\overline{y}-\theta\Delta y-t(\tilde{x})\right)-w(e)<Ev\left(\overline{y}-t(\tilde{x})\right)-w(e) \tag{32}$$

Thus, at the level of care $\tilde{x}$, the participation constraint of the low-income insured becomes negative and that of the high-income insured becomes positive:

$$Ev\left(\underline{y}-t(\tilde{x})\right)-w(e)<0 \tag{33}$$

$$Ev\left(\overline{y}-t(\tilde{x})\right)-w(e)>0 \tag{34}$$

With $t(\tilde{x})=K+A\tilde{x}+B(\tilde{x})$, these inequalities become:

$$Ev\left(\underline{y}-K-A\tilde{x}-B(\tilde{x})\right)-w(e)<0 \tag{35}$$

$$Ev\left(\overline{y}-K-A\tilde{x}-B(\tilde{x})\right)-w(e)>0 \tag{36}$$

For a total cost of care $\tilde{x}$ ($\tilde{x}\geq\hat{x}$), the low-income insured is exempt from the deductible and his expected utility becomes:

$$Ev\left(\underline{y}-K-A\tilde{x}\right)-w(e).$$

This utility remains negative as long as $\tilde{x}>\left[\left(\underline{y}-K-Ev^{-1}\left(w(e)\right)\right)/A\right]=\hat{x}$, with $Ev^{-1}\left(w(e)\right)=e$.

In this case, the low-income insured, even with an exemption from the deductible, will forgo these types of care ($\tilde{x}>\hat{x}$).

Under these conditions, even the deductible present in the optimal incentive contract is not sufficient to ensure that low-income agents have access to the types of care for which $\tilde{x}\geq\hat{x}$.

We summarise this result in the following **proposition 3**:

By guaranteeing the participation of the insured, the optimal public health insurance contract excludes the low-income insured from access to certain types of care.

This result from the ex-ante moral hazard model reproduces feature 5 of the public health insurance system in DCs. We summarise the types of care according to cost and accessibility for the low-income insured as follows:

$$\begin{cases}\tilde{x}<\hat{x} & \text{acces to the care}\\ \tilde{x}=\hat{x} & \text{acces, if } B(x)\geq\hat{B}\\ \tilde{x}=\hat{x} & \text{exclusion, if } B(x)<\hat{B}\\ \tilde{x}>\hat{x} & \text{exclusion}\end{cases}$$

The optimal level of financial participation does not satisfy the criterion of equity, which is consubstantial with any public health insurance system.

4. Conclusions

The results of this work shed light on the question of setting up a public health insurance system in developing countries, where health coverage remains partial. The model presented in this article is distinctive in its theoretical approach, which is based on an agency relationship between the state, as social insurer, and the insured. The main objective of this public policy is to guarantee universal health cover while optimising social expenditure, particularly healthcare reimbursements, and making the insured more responsible.

The ex-ante moral hazard model, which assumes the homogeneity of the insured, shows that although public health insurance policy aims to share risks between the State and the insured, it does not solve the crucial problem of the exclusion of low-income insured from certain types of care. This exclusion is particularly obvious when the system is based on the assumption that the insured are homogeneous, *i.e.* that all insured have identical behaviour and care needs. The absence of differentiation between insured persons can lead to inequalities in access to care, particularly for the most vulnerable groups, through cost mechanisms such as co-payments or deductibles.

The assumption of homogeneity has significant consequences for the design of such a system. By considering all insured persons in the same way, the model does not take into account disparities in terms of ability to pay and health needs. Policyholders on low incomes, in particular, are more likely to be excluded from certain types of care, because the cost mechanisms (co-payments, deductibles) are not adapted to their economic capacities. This situation creates inequalities in access, contradicting the objective of universal health cover. To remedy this limitation, the article proposes that a more effective public health insurance model should take account of the heterogeneity of the insured. By recognising the differences between policyholders, particularly in terms of income, health needs and care behaviour, it becomes possible to design financing and reimbursement mechanisms that are adapted to these various factors. For example, deductibles differentiated according to income or targeted support schemes for low-income populations could better meet the specific needs of each group, while ensuring equitable access to care.

However, the transition from homogeneity to heterogeneity of insured persons raises complex questions in terms of public economics. These include challenges such as defining heterogeneity criteria (how to measure and classify policyholders according to their needs and abilities), managing the risks associated with the diversity of policyholder profiles, and the financial implications of adapting funding mechanisms. This approach could also lead to increased administrative costs, due to the need to monitor and adapt policyholder contributions according to their individual characteristics. These issues will have to be taken into account when the system is actually implemented.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Rothschild, M. and Stiglitz, J. (1976) Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information. *The Quarterly Journal of Economics*, **90**, 629-649. https://doi.org/10.2307/1885326

[2] Stiglitz, J.E. (1977) Monopoly, Non-Linear Pricing and Imperfect Information: The Insurance Market. *The Review of Economic Studies*, **44**, 407-430. https://doi.org/10.2307/2296899

[3] Laffont, J. (1987) Le risque moral dans la relation de mandat. *Revue économique*, **38**, 5-23. https://doi.org/10.2307/3501509

[4] Newhouse, J., *et al.* (1993) Free for all? Lesson from the Health Insurance Experiment. Harvard University Press.

[5] Caussat, L. and Glaude, M. (1993) Dépenses médicales et couverture sociale. *Economie et statistique*, **265**, 31-43. https://doi.org/10.3406/estat.1993.5755

[6] Genier, P. (1998) Assurance et recours aux soins. Une analyse microéconométrique à partir de l'enquête Santé 1991-1992 de l'Insee. *Revue économique*, **49**, 809-819. https://doi.org/10.2307/3502811

[7] Henriet, D. and Rochet, J. (1998) Les justifications de l'intervention publique dans les systèmes de santé. *Économie publique/Public economics*, 02|1998/2. https://doi.org/10.4000/economiepublique.1862

[8] de Lagasnerie, G. (2009) Justice sociale et efficacité: Pour une nouvelle régulation de la demande de soins. *Regards croisés sur l'économie*, **5**, 112-119. https://doi.org/10.3917/rce.005.0112

[9] Geoffard, P. and de Lagasnerie, G. (2012) Réformer le système de remboursement pour les soins de ville, une analyse par microsimulation. *Economie et statistique*, **455**, 89-113. https://doi.org/10.3406/estat.2012.10019

[10] Caussat, L., Le Minez, S. and Raynaud, D. (2005) L'assurance-maladie contribue-t-elle à redistribuer les revenus? *Dossiers Solidarité et santé*, **1**, 7-41.

[11] Raynaud, D. (2005) Les déterminants individuels des dépenses de santé: L'influence de la catégorie sociale et de l'assurance maladie complémentaire. DREES, Études et résultats.

[12] Ross, S. (1973) The Economic Theory of Agency: The Principal's Problem. *American Economic Review*, **63**, 134-139.

[13] Holmstrom, B. (1979) Moral Hazard and Observability. *The Bell Journal of Economics*, **10**, 74-91. https://doi.org/10.2307/3003320

[14] Shavell, S. (1979) Risk Sharing and Incentives in the Principal and Agent Relationship. *The Bell Journal of Economics*, **10**, 55-73. https://doi.org/10.2307/3003319

[15] Mirrlees, J. (1979) The Implications of Moral Hazard for Optimal Insurance, Seminar Given at the Conference in Honor of Karl Borch. Mimeo.

[16] Aron-Dine, A., Einav, L., Finkelstein, A. and Cullen, M. (2015) Moral Hazard in Health Insurance: Do Dynamic Incentives Matter? *Review of Economics and Statistics*, **97**, 725-741. https://doi.org/10.1162/rest_a_00518

[17] Whitt, W. (1980) Uniform Conditional Stochastic Order. *Journal of Applied Probability*, **17**, 112-123. https://doi.org/10.2307/3212929

Appendix

Proof of Equation (10):

The Lagrangian of the social insurer optimization program:

$$L=\int U\left(-x+t(x)\right)f(x;e)\mathrm{d}x+\lambda\left[\int v\left(y_0-t(x)\right)f(x;e)\mathrm{d}x-w(e)\right]$$
$$+\mu\left[\int v\left(y_0-t(x)\right)f_e(x;e)\mathrm{d}x-w'(e)\right]$$

The conditions of the optimal incentive contract such that the State minimises its expenditure and the agent is encouraged to make the optimal prevention effort are given by the following first-order conditions:

$$\frac{\partial}{\partial e}\left[Ev\left(y_0-t(x)\right)-w(e)\right]=0\Rightarrow\int v\left(y_0-t(x)\right)f_e(x;e)\mathrm{d}x-w'(e)=0$$

$$\frac{\partial L}{\partial e}=0\quad\Rightarrow U\left(-x+t(x)\right)f_e(x;e)\mathrm{d}x+\mu\left[v\left(y_0-t(x)\right)f_e(x;e)\mathrm{d}x-w''(e)\right]=0\qquad(1')$$

$$\Rightarrow\int U\left(-x+t(x)\right)f_e(x;e)\mathrm{d}x+\mu\left[\int v\left(y_0-t(x)\right)f_e(x;e)\mathrm{d}x\right]=\mu*w''(e)$$

$$\Rightarrow t'(x)U\left(-x+t(x)\right)f(x;e)\mathrm{d}x-\lambda t'(x)v'\left(y_0-t(x)\right)f(x;e)\mathrm{d}x$$
$$-\mu t'(x)v'\left(y_0-t(x)\right)f_e(x;e)\mathrm{d}x=0\qquad(2')$$

$$\Rightarrow t'(x)U'\left(-x+t(x)\right)f(x;e)$$
$$=\lambda t'(x)v'\left(y_0-t(x)\right)f(x;e)\mathrm{d}x+\mu t'(x)v'\left(y_0-t'(x)\right)f_e(x;e)\mathrm{d}x$$

$$\Rightarrow U'\left(-x+t(x)\right)=\frac{\lambda t'(x)v'\left(y_0-t(x)\right)f(x;e)\mathrm{d}x+\mu t'(x)v'\left(y_0-t(x)\right)f_e(x;e)\mathrm{d}x}{t'(x)f(x;e)\mathrm{d}x}$$

$$\Rightarrow U'\left(-x+t(x)\right)=\lambda v'\left(y_0-t(x)\right)+\mu v'\left(y_0-t(x)\right)\frac{f_e(x;e)\mathrm{d}x}{f(x;e)}$$

$$\Rightarrow U'\left(-x+t(x)\right)=v'\left(y_0-t(x)\right)\left[\lambda+\mu\frac{f_e(x;e)\mathrm{d}x}{f(x;e)}\right]$$

The optimal contract satisfies the following equation:

$$\frac{U'\left(-x+t(x)\right)}{v'\left(y_0-t(x)\right)}=\lambda+\mu\frac{f_e(x;e)}{f(x;e)}\qquad(10)$$

Proof Equation (11) and inequation (12):

Starting from Equation (10), it is possible to show that the optimum is compatible with risk sharing between the insurer and the insured by showing that: $0<t'(x)<1$.

To do this, we start by differentiating (10). This gives:

$$\frac{\mathrm{d}\lambda}{\mathrm{d}x}=0$$
$$\Rightarrow\frac{\left(-1+t'(x)\right)U''\left(-x+t(x)\right)v'\left(y_0-t(x)\right)+t'(x)v''\left(y_0-t(x)\right)U'\left(-x+t(x)\right)}{\left[v'\left(y_0-t(x)\right)\right]^2}$$
$$-\mu\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]=0$$

$$\Rightarrow \frac{t'(x)\left[U''(-x+t(x))v'(y_0-t(x))+v''(y_0-t(x))U'(x+t(x))\right]-U''(-x+t(x))v'(y_0-t(x))}{\left[v'(y_0-t(x))\right]^2}$$

$$-\mu\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]=0$$

$$\Rightarrow t'(x)=\frac{\left[v'(-x+t(x))\right]^2}{\left[U''(-x+t(x))v'(y_0-t(x))+v''(y_0-t(x))U'(x+t(x))\right]}$$

$$*\left[\frac{U''(-x+t(x))v'(-x+t(x))}{\left[v'(x+t(x))\right]^2}+\mu\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]\right]$$

$$t'(x)=\frac{U''(-x+t(x))v'(y_0-t(x))-\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]*\left[v'(y_0-t(x))\right]^2}{\left[U''(-x+t(x))v'(y_0-t(x))+v''(y_0-t(x))U'(x+t(x))\right]}>0$$

Furthermore, positing that $-\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]*\left[v'(y_0-t(x))\right]^2<v''(y_0-t(x))U'(x+t(x))$, we show that $U''(-x+t(x))v'(y_0-t(x))-\frac{\mathrm{d}}{\mathrm{d}x}\left[\frac{f_e(x;e)}{f(x;e)}\right]*\left[v'(y_0-t(x))\right]^2$ $<\left[U''(-x+t(x))v'(y_0-t(x))+v''(y_0-t(x))U'(x+t(x))\right]$, which implies that $t'(x)<1$. Ultimately, we have: $0<t'(x)<1$

Evidence for $B(x)>0$.

Partant de l'identité (21), on constate que: $\forall x\geq 0$, le dénominateur $\left[U''(-x+t(x))v'(y-t(x))+v''(y-t(x))U'(x+t(x))\right]$ et le numérateur de la fraction sont tous deux négatifs. par conséquent $B(x)>0$ et $B'(x)>0$.