Risk based capital for health insurers in Colombia

Abstract

Defining the optimal capital requirements for health insurers is a matter of interest for policy-makers. Capital requirements in the health sector are related to the minimum number of enrollees per health insurer, conditional on their health characteristics and their geographical location. In this paper we develop a methodology for estimating the expected loss per health insurer in the statutory health care system of Colombia after considering their specific risk profile and the capitation formula with which they are paid. We assume the expected loss follows a normal distribution within risk pools consisting of a unique combination of long-term disease, age, gender, and location, and then define the minimum capital requirement of each insurer as the 1st quantile of its loss distribution. Our results show that under normal expenditures with ex-ante morbidity risk adjustment using long-term disease groups, the majority of health insurers should reduce capital when paid with the current government capitation formula, which reimburses only on demographic variables. But for the riskier insurers, capital requirements are significantly higher under the current capitation payment formula, compared to the capital if payments were conditional on long-term diseases.

Keywords: risk based capital, capitation, health insurers, risk adjustment, loss distribution.

Introduction

The financial stability of the health sector is vital for health policy design. Capital requirements of health insurers are the backbone of such policies. These requirements depend on the number of enrollees and the specific risk profile of each insurer. In Colombia the national government has recently updated the rules that specify capital requirements for insurers of the statutory health care system, to be implemented in the course of the next decade[1]. The mandated capital requirements do depend on the number of enrollees, and only indirectly on their risk profile. The requirements, however, do not arise from a known model that makes explicit its assumptions and limitations. Given the crucial importance of solvency regulation for health insurers and the importance it currently has in the Colombian policy agenda, it is important to have a clear understanding of the rationale for such regulation and the parameters that should inform its design and calibration.

In this paper we contribute to this understanding by explicitly modelling the underwriting risk of health insurers and, for given thresholds of tolerance to such risk, estimating the minimum levels of capital required to assure their solvency. In the section that follows we briefly explain how the Colombian statutory health care system is organized. Then we present a brief overview of the literature on solvency of health insurers. The next section shows descriptive statistics from the claims data used in the analysis. The following one presents the model. Lastly we present the results and discuss implications and limitations.

Health insurance in Colombia

Colombia's health sector is divided into two major regimes: contributory and subsidized. Each regime has its own network of insurers or 'Entidades Prestadoras de Servicio' (EPS). We focus our analysis on the insurers of the contributory regime because the data in the subsidized one is not complete. The contributory regime includes individuals that pay for health care services on a monthly basis and their respective families. Their contribution is fixed and depends positively on the individual's salary. The health insurer to which the individuals are enrolled receives a per capita payment that is adjusted based on age, gender and location, but does not

[1] Decree 2702 of 2014.

depend on the income of the contributor. Individuals who do not perceive salary or income belong to the subsidized regime.

The EPS are the institutions in charge of managing the financial and health risks associated to the provision of health services. They organize their own network of service providers (IPS) to guarantee effective access to and proper quality of the 'Plan Obligatorio de Salud' (POS). The POS is a list of services and drugs that every enrollee has the right to demand. In their role of insurers, the EPS are also responsible for representing their enrollees before the institutions that provide such services. All of these functions are important for determining the optimal number of enrollees.

Managing health risk and organizing health services depends on the geographical position of the EPS and the morbidity characteristics of its population. These variables should be considered in the estimation of the financial capital requirements. Currently, the per capita payment that EPS receive based on age, gender and location of the enrollee is complemented with a disease specific redistribution scheme. Ex-post information about the morbidity distribution of an EPS' population of enrollees determines whether or not they receive additional revenue from the Government through the High Cost Account (HCA). The account compensates the EPS for having enrollees with high-cost diseases, thus increasing its operational income and affecting its capital requirements. Overall, the HCA should be a zero sum account in the sense that the EPS with the healthier population of enrollees must transfer part of their revenue to the EPS with the sickest population of enrollees. However, when compensations exceed contributions, the Government pays the excess. We include the HCA in our estimations of the insurers' capital requirements.

EPS vary in terms of how they pay the service providers in their networks. For example, capitation contracts with the service provider transfer the financial risk to the latter. In this type of contract the EPS is obliged to pay a fixed amount per enrollee that does not vary with the number of services provided by the IPS. On the contrary, fee-for-service contracts, where payment varies per service and enrollee, retain the financial risk in the EPS. In the contributory regime, capitation contracts are frequent at the primary level of care, while fee-for-service is more prevalent in the secondary and tertiary levels. All this has important implications for solvency because in capitation contracts the insurer (EPS) essentially transfers the underlying financial risk to providers (IPS), while on the fee-for-service scheme the EPS bears all financial risks.

During 2011, the Government proposed raising the minimum size of the EPS in order to achieve greater solvency from a financial perspective. However, even if increasing the size of the institutions allows in certain way to reduce the insolvency risk it also poses major disadvantages for the health sector such as: reducing competition among insurers, raising barriers to entry, and increasing the financial vulnerability of the system since it would depend on bigger institutions that are "too big to fail". In fact, if the EPS grow in the number of enrollees but not in its capital levels, we could expect an increase in the insolvency risk, contrary to what is intended.

The solvency regulation, revised in December 2014, states that insurers should have capital level equivalent to at least 8% of annual revenue. The current decree does not cite an actuarial model on which the minimum capital is based. It does say that the ministry of Health and Finance will have the authority to revise the 8% figure when new information becomes available.

Solvency literature

Despite the importance of setting financial standards in the health sector, the literature on this matter is both scarce and outdated. Most articles about health insurers' solvency emerged during the 90s with the seminal works of Altman (1968) and Trieschmann and

Pinches (1973). The articles focus on estimating the default probability (Carson and Hoyt, 1995; BarNiv and Hershbarger, 1990; Brockett et al., 2004), finding predictors of financial insolvency in the health sector (Baranoff et al., 1999; Yang, 2006; Brockett et al., 2004), and comparing classification rates of different models (Ambrose and Seward, 1988; BarNiv and Hershbarger, 1990; Ambrose and Carroll 1994). However, none of them provide the capital levels that attain predefined default probabilities.

One of the models that does provide capital levels is the Risk-Based Capital (RBC). Although it is mostly applied for banks and other financial institutions, the Society of Actuaries (SOA) has defined five relevant risks in the health sector and adapted the RBC for such context (SOA record meetings, 2002): affiliate company, investment, underwriting, credit, and business risk. In this paper we estimate the optimal capital requirement for underwriting risk.

The need to adjust the RBC to health insurance companies is due to the particularities of this business sector. For instance, in contrast to life insurance where the moment of causation is the insured's death, health insurance does not have a unique moment of causation. Instead, it is caused every time the enrollee receives a health service during a year horizon. Also, enrollees cannot move as freely between health insurance companies as in life insurance, because risky individuals -such as people with chronic diseases or elders- usually cannot be charged with higher risk premiums. Hence, health insurers have incentives to decline those individuals. Yet in regulated health insurance markets like the Colombian one, insurers are not allowed to reject patients or price them according to their individual risk. If there is a systematic mismatch between the risk adjusted capitation and the risk profile of the individuals, the risk is borne by the insurer.

Another model for estimating minimum capital is the Value at Risk (VaR). The difference between RBC and VaR is that the latter assigns capital differentially by business line while the former assigns a unique value for the entire company. Despite its advantages, implementing VaR models requires high amounts of periodical information that are usually unavailable for health insurers.

In this paper we develop a model based on ruin theory. It focuses on underwriting risk. The model is developed and estimated in the context of the Colombian health care system, considering in particular the way that the central fund of the health sector pays health insurers.

Methods

Data

To estimate capital requirements by EPS we have cross sectional information from 2009 to 2011 about the claims of each enrollee of the statutory health care system. During 2009 there are nearly 23 million enrollees, 24 million in 2010 and 25 million in 2011. The enrollees are associated to approximately 340 million health services per year. For ease of computation we choose a random sample of one million enrollees per year and their claims, which leaves us with nearly 10.9 million services in 2009, 13.9 million in 2010 and 14.3 million in 2011. Some individuals have discontinuous enrollment periods due to short-term changes in their employment status or because they move from one insurer to another during the year. In these cases, their capitations are paid every according to the exact number of days they have been enrolled. In order to capture this heterogeneity we weight individuals in each EPS according to their number of days enrolled.

Per sampled person we observe: EPS to which he is enrolled, services he receives and IPS (provider) that provides them, cost per service, date of provision, medical diagnosis associated to each service, age, gender, municipality of residence, and type of contract between EPS and IPS. We calculate the total cost of an enrollee by adding the individual cost of all the services he receives during each year.

We construct risk groups that match those that the government currently uses for estimating and risk adjusting the capitation payments as follows. Firstly we match the municipality of residence to the payment geographic areas, defined by the National Administrative Department of Statistics (DANE): urban, normal and special. The first integrates metropolitan areas and its adjacent municipalities, the second small municipalities around the metropolitan areas, and the third peripheral municipalities. Then, we categorized the age variable in 12 groups: 0, 1-4, 5-14, 15-18, 19-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, and 75 or older. Finally, we create groups based on gender combined with age brackets and geographic areas. The following tables and figures show the distribution of enrollees over each of these dimensions.

Table (1) shows the annual distribution of enrollees per EPS, which can be considered as their market share. The market at the level of insurance is not concentrated. The EPS K has the largest share, 21% in 2009 and 22% in 2010 and 2011; followed by the EPS N with approximately 15% of the market each year. The EPS U is owned by the state and has third largest market share, on average 11% per year. On the other hand, the smallest EPS is the A, which insures only 0.1% of the enrollees each year.

Figure (1) shows the distribution of enrollees by geographic payment area. The graph exemplifies the high relative population density at metropolitan areas and adjacent municipalities. Most enrollees live in such areas, nearly 70%, followed by enrollees in special municipalities (on average 20% per year), and normal municipalities (on average 10% per year).

Table (2) shows the distribution of enrollees by age group. On average 44% are between 19 and 44 years old. There is also a high concentration of enrollees between 5 and 14 years old (16% in 2011), while elders (people with more than 75 years) and newborns (age zero) represent only 3% and 1% of the population, respectively. Individuals in these age groups are usually the costlier for the EPS. As we show below, the greater the proportion of affiliates in age groups 1 and 12, the greater the capital requirement of the insurer.

Figure (2) shows the annual distribution of enrollees by gender and table (3) disaggregates this measure by EPS. The proportion of women in the sample is slightly greater than the proportion of males each year. There are approximately 55% of women and 45% of males in each EPS. However, this is not the case of the EPS D, E, L, and others, for which the majority of their enrollees are males.

In addition to replicating the demographic and geographic risk groups that the government uses for estimating capitation payments, we classify every individual in the sample according to the medical diagnosis he receives, forming 29 long-term disease diagnosis groups following Alfonso et al. (2013).[2]

Table (4) shows the annual proportion of enrollees diagnosed with a long-term disease per EPS. We expect that the greater this proportion, the higher the capital requirement because people suffering from long-term illnesses usually demand services constantly. The table shows that the EPS I, J, O and U have the sickest population: 20%, 21%, 22% and 24%, respectively for 2009. While EPS A, B and M have the healthier population throughout the three years.

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[2] See www.alvaroriascos.com\reasearh\healthEconomics for details on these groups

Cost description

Figure (3) shows the annual mean cost of the enrollees by age group. The mean cost is U-shaped. It decreases monotonically for individuals between 0 and 5 years old, and then increases monotonically for individuals aged 5 or older. The mean cost of a newborn is greater than that of an adult between 45 and 54 years old. And people older than 75 years are the costlier individuals. Their mean cost more than doubles that of a newborn. This confirms that the greater the proportion of newborns and elders in an EPS, the higher its costs.

Figure (4) shows the annual mean cost by gender. Females are costlier to the system than males. Their mean cost is 26% greater than that of males and this difference is consistent through years. Given that the distribution of enrollees per EPS and gender shows that the majority of them insure females, then their total operating costs and capital requirements must respond to the differences in males and females' cost.

In figure (5) we can see in fact that the slight variations in the morbidity and demographic composition of an EPS' population, which we accounted for in this subsection, generates important variations in the mean cost of the EPS. Excluding the EPS A for which we believe there are misregistrations, the EPS U has the highest mean cost among the insurers, followed by the EPS H and the EPS F.

Model

Cost distribution

In this paper we assume the EPS bears all the financial risk. Based on this assumption we define the capital requirement as the 1st quantile of the EPS' loss distribution. In other words, the capital requirement is the level of capital for which there is a 1% default probability. To estimate the loss distribution we divide the national population of enrollees in *G* risk pools with a specified structure of gender, geographic location, age group, or diagnosis group, as described in the previous section. Each individual belongs to only one of the risk pools, which are homogeneous within and heterogeneous between.

In each risk pool, the annual costs of providing the benefits package (POS) to an insured individual follows an unknown probability distribution. With certain probability the enrollee will not demand health services, in which case his cost is zero, and with certain probability the cost of the enrollee is positive. In general, the mean (μ_g) and the variance (σ_g^2) characterize the cost distribution per risk pool g, i.e, the empirical distribution of the data.

We estimate these parameters using the actual cost of the individuals in the population that includes all EPS in year t. In the estimation of the mean cost per individual we allow for the fact that not all individuals have been enrolled all year long by weighting their annual cost with the number of insured days. The government also adjusts for this when estimating the per capita payment to the EPS also known as 'Unidad de Pago por Capitación' (UPC). Let n_g be the number enrollees in group g, X_i the total cost of enrollee i net of copays, d_i the number of insured days of enrollee i in the year, and $D_g = \sum_{i \in g} d_i$. The random variable that defines the annualized expenditure of enrollee i in group g adjusted for its insured days is:

$$G_i = 360 \times n_g \times \frac{X_i}{D_g}$$

Then the annualized mean cost and variance of each risk pool g are:

$$\mu_g = E[G_i] = 360 \times \frac{\sum_{i \in g} X_i}{D_g}$$

$$\sigma_g^2 = V[G_i] = \left(\frac{360 \times n_g}{D_g}\right)^2 \left[\sum_{i \in g} \frac{X_i^2}{n_g} - \left(\frac{\sum_{i \in g} X_i}{n_g}\right)^2\right]$$

We take these estimates as the population parameters. μ_g in fact reflects the actual government formula for the UPC. EPS enroll a given number of individuals in each risk pool[3]. Each of these individuals has a probability density function (pdf) for his or her annual health costs, which is given by the population distribution. We assume this distribution is different between risk pools because each of them has a unique combination of variables (age, gender, location, and diagnosis). We also assume that observations within a risk pool are independent but they have the same pdf. Health costs of individuals within each risk pool are thus conceived as independent draws from the population distribution of the respective risk pool.

We are interested in estimating the parameters of the distribution of total expenditures of each EPS j, this is the sum of the annual costs of the enrollees of EPS j which could belong to different risk pools:

$$G^j = \sum_{i \in j} G_i$$

Knowing that the mean of the sum of a set of random variables is equal to the sum of their means, and that under independence, the variance of the sum of random variables is equal to the sum of their variances, then the mean and variance of the total expenditure of an EPS are:

$$\mu_g^j = E[G^j] = \sum_{g \in G^j} n_g^j \, \mu_g$$

$$\left(\sigma_g{}^j\right)^2 = V[G^j] = \sum_{g \in G^j} n_g^j \, \sigma_g^2$$

where n_g^j is the number of enrollees of group g in EPS j.

[3] The number of individuals per risk group is not treated as a random variable.

Insurers' revenues

We assume insurers' revenues are deterministic while their cost is a random variable. The source of revenue is the capitated payment UPS, which is currently adjusted by demographic risk variables (no morbidity variables are used). The government uses data of prior years to estimate the risk adjustment parameters for the following year. To calculate the revenues of each EPS we use information of year $t-2$ following the methodology of Colombia's Ministry of Health. The cost of all services provided in year $t-2$ is updated with the inflation of year $t-1$ and year t. Hence, a health service that costs 100 COP in year $t-2$ will cost $100 \times (1+\delta_{t-1}) \times (1+\delta_t)$ in year t, where δ is inflation. With the updated costs, we calculate the UPC per risk pool, which defines revenues in year t for the insurers.

The essence of our analysis is the comparison of capital requirements of insurers under different scenarios of risk adjustment, guaranteeing that the system's total revenues remain constant under these scenarios. Insurers' revenues under each scenario of risk adjustment should be a redistribution of the system's total revenues. Let Y^T be the system's total revenues:

$$Y^T = \sum_{g' \in G} n_{g'} UPC_{g'}$$

where g' are the risk pools characterized by the combination of gender, age group, and location only, and where the annual capitation payment is given by:

$$UPC_{g'} = 360 \times \frac{\sum_{i \in g'} X_i}{\sum_{i \in g'} d_i} = 360 \times \frac{X_{g'}}{D_{g'}}$$

The annual UPC_i of an individual i that belongs to the cost risk pool g is:

$$UPC_i = 360\, \lambda_g UPC_g$$

Where the daily payment is given by,

$$UPC_g = \frac{X_g}{D_g}$$

and

$$\lambda_g = \frac{n_{g'}}{n_g}\frac{D_g}{D_{g'}}$$

Therefore, the system's total revenues under a scenario of risk adjustment using cost risk pools g are $\sum_{g\in G} n_g UPC_i$. In the appendix we show that $Y^T = \sum_{g\in G} n_g UPC_i$.

Notice the UPC_i guarantees the system's total revenues to remain the same under different scenarios of risk adjustment *during* year $t-2$, however after updating costs with inflation this is not necessarily the case in year t. We abstract from this refinement in our study.

Total revenues of an EPS j are then given by:

$$Y^j = \sum_{g=1}^{G} n_g^j \, UPC_g$$

and the benefits π^j are the deterministic revenues Y^j minus the random expenditure G^j, which we assume follows a normal distribution, and minus the administrative expenses which, by law, are allowed to be 10% of revenues:

$$\pi^j = 0.9\, Y^j - G^j$$

EPS have a certain amount of capital C^j with which they can cover eventual losses. Ruin occurs when π^j takes negative values and losses are greater than capital. The probability of the ruin event is given by:

$$Pr\left[(\pi^j + C^j) \leq 0\right]$$

If the regulator aspires to keep the probability of ruin under 1% the capital minimum capital requirement should satisfy the following equation:

$$Pr\left[(\pi^j + C^j) \leq 0\right] = 0.01$$

In the section that follows, we estimate the revenues of the EPS under three different scenarios.

- *Chronic's payment:* UPC per risk pool as a combination of gender, age group, geographic location, and diagnosis group, minus administrative expenses. In this scenario we set $p_g = \mu_g$.

- *Current payment*: UPC per risk pool as a combination of gender, age group and geographic location, plus HCA, minus administrative expenses. In this scenario we assign individuals to wider categories, following the risk groups that the Ministry of Health currently uses for estimating capitation payments. Unlike the previous scenario, these risk pools don't adjust for morbidity.

- *Unadjusted payment*: UPC without risk adjustment minus administrative expenses. In this case the capitation payment corresponds to the population mean health expenditures with all individuals in one single risk pool.

In all scenarios expenditures follow a normal distribution, the parameters of which are estimated using the morbidity adjustment of the 29 long-term disease risk groups. It has been shown in Camelo and Riascos (2013), Alfonso et al. (2013) and Riascos (2013) that this grouping is a much better predictor of individual health costs than the current government formula. By using this grouping we provide a much better approximation to the real health costs faced by the EPS.

Notice that in the first scenario the mean of the cost distribution in each risk pool equals the payment, hence the expected loss for insurers is near zero and the capital requirements will be determined to a great extent by the cost volatility. In the other two scenarios losses can arise because of: i) cost volatility or ii) miscalculation of the UPC. To the extent that the payment formula does not incorporate morbidity variables there can be individuals for whom the UPC is above or below their expected health costs.

The difference between the cost of insuring individuals and the payment under each scenario represents the loss (L^j) of an EPS. Since the cost follows a normal distribution and payment is deterministic, the expected loss will also follow a normal distribution. The greater the capital, the lower the default probability, and the greater the variance of the cost, the greater the default probability. We calculate the first quantile of this loss distribution and based on it we define the optimal capital requirement.

The Ministry of Health provided information about the HCA used in the current payment scenario as the ex-post morbidity risk adjustment. The EPS U is the insurer that receives the highest compensation from the HCA due to the morbidity distribution of its population of enrollees. During 2011 it received nearly 75 billion COP, which is approximately 95% of total compensations. Every year there is an unbalance between compensations and contributions that is covered by the government.

Since we are estimating capital requirements using a random sample of one million enrollees, we need to escalate our estimations in order for them to reflect the actual size of the EPS in the contributory regime. Let γ_t^j be the escalating factor of year t for EPS j:

$$\gamma_t^j = \frac{N_t^j}{n^j}$$

where N_t^j is the total number of enrollees of EPS j in the contributory regime (23,846,979 during 2009, 24,354,254 during 2010, and 25,695,491 during 2011) and n^j is the sample size for the EPS j. The expected loss of each EPS is multiplied by γ_t^j, and its standard deviation by the square root of γ_t^j. Notice that the standard deviation of the loss distribution equals that of the cost distribution since payment is deterministic.

Results

Capital requirements

We estimate the 1st quantile of the loss distribution under the three scenarios mentioned in the previous section using a random sample of one million enrollees during 2011. With the information of this year we estimate the empirical distribution of health costs and use the information of 2009 to calculate revenues. We are interested in redistributing among insurers the system's total revenues realized under the current payment formula: $\sum_{g' \in G} n_{g'} UPC_{g'}$ where g' are the risk pools that adjust for gender, age group, and location. Therefore $\lambda_{g'} = 1$ in the current payment scenario.

Assuming the loss of each EPS follows a normal distribution, table (5) shows the minimum total capital and minimum capital per enrollee each insurer must hold under the three risk adjustment scenarios so that their default probability is 1%. The latter is calculated by diving the total capital requirement into the number of enrollees in each EPS during 2011. Negative values indicate the insurer is being overcompensated under a specific payment formula. Given our model, negative capital requirements under the current formula occur when the mean payment for each risk pool, identified by the combination of gender, age group and geographic location, exceeds the mean cost of a risk pool that is specific to gender, age group, geographic location and long-term disease. In the chronic's payment formula, negative values indicate the income a particular EPS receives under the redistribution of the system's total revenues significantly exceeds its overall health costs. In the unadjusted payment, negative values occur when the capitation payment, which is the same to all enrollees in the contributory regime, exceeds the annualized expenditure per capita in the majority of risk pools in which a particular EPS is represented.

The EPS I, K, and N, which are among the 10 largest insurers in the contributory system, are also the ones with the largest capital requirements under the chronic's and current payment formulas, ranging from 80 to 120 billion COP. Evidence shows the EPS U has to accumulate 160.1 billion COP under the current payment formula, but it has to disaccumulate capital after risk adjusting ex-ante on morbidity using the 29 long-term disease groups. This result suggests the morbidity distribution of the EPS U is worse than that of the rest of insurers, in other words it has the sickest population. In fact, under the chronic payment scenario our methodology subtracts income from those EPS with a more favorable morbidity distribution -which is the case of insurers whose capital requirements under the current payment scenario are lower than under the chronic's formula- and adds them to the EPS with worse morbidity distribution.

For the insurers C, D, I, K, N, and O, which are being undercompensated by the current formula and therefore have positive capital requirements in such scenario, conditioning ex-ante for morbidity reduces their requirements significantly. For example, the total capital requirement of EPS D decreases 82% from the current to the chronic's payment scenario, 16% for the EPS K, and 51% for the EPS N. Also, except for the EPS U, under the chronic's payment none of the insurers turns out to be overcompensated unlike the current payment scenario.

The evidence presented in table (5) suggests that an ex-ante morbidity risk adjustment in the context of the Colombian health system is better than an ex-post adjustment because even after receiving compensations for high-cost diseases through the HCA, some insurers would have to accumulate larger capital than when compensated ex-ante as in the chronic's payment scenario. Moreover, since total government expenditure with the current UPC formula is the same as with the UPC that conditions on morbidity variables, but insurer's minimum capital under the former is higher than under the latter, then our methodology actually allows resources of the UPC to be distributed more properly among health insurers according to their risk profile.

If we focus on the third column that shows the capital requirements of the unadjusted payment, the majority of insurers should disaccumulate capital and for those with positive capital levels, requirements are significantly higher than when we condition payment to some risk factors. Thus, the unconditional UPC is the least adequate payment scenario.

Dynamics of capital requirements

Total and per-enrollee capital requirements are not necessarily a linear function of the number of enrollees. In this subsection we analyze the required capital levels as the population of enrollees grows continuously. Changing the size of the population implies changing the escalating factor γ_t^j, which affects the parameters of the loss distribution. For example, if we assume the population of enrollees in the contributory regime increases by 20%, then $\tilde{\gamma}_t^j = 1.2\gamma_t^j$ and the new average loss will be multiplied by $\tilde{\gamma}_t^j$ and its standard deviation by the square root of $\tilde{\gamma}_t^j$.

We compute the dynamics of total and per-enrollee capital levels for the EPS I and EPS U as a matter of exposition. Panel (a) of figure (6) shows total capital requirements for the EPS I when the population of enrollees increases 20%. Total capital increases with the number of enrollees but not proportionally. Growth rates decrease with the number of enrollees and this is consistent with a decreasing marginal capital as shown in figure (7). Notice that capital per-enrollee or marginal capital decreases at a decreasing rate with the number of enrollees. Reductions of the marginal capital are rapid at first, but then they tend to stabilize near an asymptote. Overall, total capital requirements are a concave function of the number of enrollees and per-enrollee capital requirements are a convex function of the number of enrollees.

The marginal capital of EPS I decrease more rapidly under the unadjusted payment scenario than under the current and chronic payment scenarios as shown in figure (7). As a result, total minimum capital also decreases more rapidly under the former than under the latter.

Panel (b) of figures (6) and (7) show the dynamics of total capital and capital per-enrollee for the EPS U, respectively. As in the previous case, total capital levels increase at a decreasing rate with the number of enrollees and marginal capital is decreasing in its domain approaching an asymptote.

Adjustment factors

We mentioned at the introduction of this paper that the national government in Colombia recently updated the rules that specify capital requirements for insurers. In addition to administrative requirements, these rules include an "adjustment factor" defined as the proportion of operational income that insurers have to accumulate as capital for managing insolvency risk. The adjustment factors are built following some accounting calculations that neither reflect the health costs uncertainty nor make explicit their assumptions and limitations. Our methodology also allows us to define the optimal adjustment factors.

An insurer's operational income as established by the Ministry of Health includes the following revenue accounts identified with the current accounting standards (`Plan Único de Cuentas') (PUC):

2325250101- Fondo de incapacidad por enfermedad general

416535- Unidad de pago por capitación

416540- Unidad de pago por capitación adicional

416542- Unidad de pago para actividades de promoción y prevención

416545- Cuota moderadora

416548- Copagos

416592- Contratos planes de atención complementaria

416575- Recobro de enfermedades de alto costo

In our exercise we define the operational income as the UPC since we are interested in reporting adjustment factors for the underwriting risk only. The adjustment factor currently established by the government for each EPS varies between 8 and 10%. In table (6) we show the estimated adjustment factor under the current payment formula (after HCA compensation and administrative costs) and under the chronic payment for those EPS that reported positive operational income and positive capital requirements during 2011.

For the EPS D and I, the adjustment factor should have been greater than 10% under the current scenario. While for the EPS C, E, J, Q and V the adjustment factor varies between 1 and 5%, which is significantly lower than the thresholds established by the government. Notice that for the EPS U, known to have the sickest population of enrollees, the adjustment factor does not exceed 10% under the current payment formula. Column (6) presents the estimations of adjustment factors under the chronic's payment. In this case, the majority of insurers should accumulate a lower proportion of their operational income (between 1 and 8%) compared to the current government thresholds. This means that the percentage fixed by the government is conservative, in fact reflecting the nature of solvency regulation. However, for 9 of the insurers, our methodology shows that the thresholds mandated by law underestimate their risk profile. For example, the EPS L and M should accumulate almost 16% more income than what the government determines. And in some cases the excess over the statutory adjustment factor reaches 20%.

Conclusions

Health insurance solvency regulation is mostly concerned with defining minimum capital requirements for health insurers to avoid bankruptcy. In this article we propose a model that defines minimum capital requirements for health insurers in Colombia so that their default probability does not exceed 1% in a year. Our model quantifies the insurers' underwriting risk by assuming annual health expenditures follow a normal distribution and revenues are deterministic. The expenditure distribution is assumed to vary according to morbidity (using 29 long-term disease groups) in addition to the three risk adjusters used by the government (age, gender, and location). Using claims data of the Colombian contributory health system during 2011, results show that characterizing the expenditure distribution with risk pools that adjust ex-ante for long-term diseases and computing revenues using the same risk pools generates more equitable capital requirements for insurers, compared to using only the combinations of age, gender, and location for calculating revenue and adding ex-post revenues due to morbidity adjustments. Fewer insurers would have to reduce capital in the former scenario and differences between the capital requirements of the riskier and larger insurers in relation to smaller ones are not significant. Hence, an ex-ante risk adjustment that includes morbidity as proposed in this article describes better the risk profile of each insurer. However, further research is needed in terms of relaxing the assumption of independence between the expenditure distributions of individuals in the risk pools, which allows us to sum over risk pools to find total capital requirements. For instance, independence might not hold in the case of contagious diseases.

We show total capital requirements are a concave rather than a linear function of the number of enrollees, thus, they increase at decreasing rates as the number of enrollees grow; while minimum capital levels per enrollee are a convex function of the number of enrollees. Finally, the Colombian health regulation defines minimum capital requirements in terms of a percentage of the insurers' operational income known as the adjustment factor, which currently ranges between 8 and 10% for all insurers. Using the capital requirements generated by our model under the payment scenario that risk adjusts for long-term diseases, age, gender, and location, we find the adjustment factor should be significantly lower than 8% for some insurers and significantly higher than 10% for others. In the latter case, this suggests current health regulation generates insufficient protection against insolvency originated in underwriting risk.

Appendix

We want to show that:

$$n \times UPC = \sum_{g \in G} n_g UPC_i$$

Beginning from the right-hand side of the equation,

$$= \sum_{g \in G} \left(360\, n_g \frac{n}{n_g} \frac{D_g}{\sum_{g \in G} D_g} \frac{X_g}{D_g} \right)$$

$$= 360n \times \frac{\sum_{g \in G} X_g}{\sum_{g \in G} D_g}$$

$$= n \times UPC$$

Thus, $n \times UPC = \sum_{g \in G} n_g UPC_i$ ■

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