Can risk-rating of incremental premiums improve consumer sorting across coverage options in mandatory health insurance markets?

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ABSTRACT

Several mandatory health insurance schemes include some consumer choice of coverage (e.g., in terms of deductible levels). Premiums in these schemes are typically community-rated per insurance plan. While community-rated premiums help achieve objectives of fairness, they can also lead to adverse selection across coverage options. Consequently, consumers may sort inefficiently across these coverage options resulting in forgone welfare gains. This paper aims to explore under what conditions risk rating of incremental premiums for more comprehensive coverage (compared to a basic plan) can improve consumer sorting. In a simulation analysis on Chilean data, results show that under perfect risk adjustment, risk rating of incremental premiums can improve consumer sorting. With imperfect risk adjustment, however, the effects of risk rating on consumer sorting are ambigous as incremental premiums will not just reflect the direct effect of more comprehensive coverage on healthcare spending, but also the under/overcompensation from the (imperfect) risk adjustment system. Moreover, we find that in the presence of imperfect risk adjustment, risk rating improves welfare over community rating but does not fully solve the problem of inefficient sorting.

1. Introduction

Several mandatory health insurance schemes include some consumer choice of coverage. In Switzerland, the Netherlands and in the US under the Affordable Care Act (ACA), consumers can choose between a predefined level of minimum coverage (which we hence refer to as 'basic coverage') and additional coverage (e.g., in the form of a lower deductible) (Schmid et al., 2018; Van Kleef, Eijkenaar, van Vliet, and van de Ven, 2018; Layton, Montz, and Shepard, 2018). In theory, this allows consumers to pick a plan that matches their needs and preferences, potentially leading to a welfare gain (Dixit and Stiglitz, 1977).

To ensure fairness and access, premiums are typically community-rated per insurance plan. This approach is employed in countries

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such as Switzerland and the Netherlands, where insurers must charge the same premium to consumers who choose the same insurance plan in terms of the deductible and other plan features (Van Kleef, Eijkenaar, van Vliet, and van de Ven, 2018). However, it is well established that community rating can lead to adverse selection (Ericson and Sydnor, 2017). Adverse selection can result in inefficient sorting of consumers across coverage options, resulting in a forgone welfare gain from consumer choice (Rothschild and Stiglitz, 1978; Akerlof, 1970; Einav and Finkelstein, 2011; Handel, Hendel, and Whinston, 2015; Geruso, Layton, McCormack, and Shepard, 2021; Marone and Sabety, 2022).

One of the proposed solutions for adverse selection across coverage options mentioned in the literature is risk rating of *incremental* premiums. For example, this could involve maintaining community-rated premiums for basic coverage (to which a mandate applies), while risk rating the *incremental* premium for additional coverage (on top of basic coverage) based on individual characteristics (Bundorf, Levin, and Mahoney, 2012; Layton, Ellis, McGuire, and van Kleef, 2017; Geruso, 2017; Van Winssen, van Kleef, and van de Ven, 2018). The essence behind this idea is that risk rating leads to a better alignment of the marginal cost and premium of additional coverage. When the incremental premium for additional coverage for individual i perfectly reflects the marginal cost of additional coverage for individual i, then adverse selection will be absent. Consequently, consumers are expected to sort efficiently across coverage options.

In this paper, we show that risk rating of incremental premiums requires perfect risk adjustment of basic coverage to yield optimal consumer sorting. The reason is that consumer preferences regarding additional coverage are likely to be correlated with insurer spending on basic coverage (Van Kleef, Hamstra, Pirktl, and Holly, 2024). As a result of this correlation, the sorting of consumers between yes/no additional coverage can reveal (substantial) unpriced risk heterogeneity regarding basic coverage. Consequently, the actuarially fair premium for additional coverage will not just reflect the 'marginal cost of additional coverage' but also the expected difference in the cost of basic coverage between consumers who sort into additional coverage and those who do not. In this case, the effect of risk rating of incremental premiums is unclear. This has important policy implications since state-of-the-art risk adjustment models do not perfectly compensate for unpriced risk heterogeneity regarding basic coverage (Eijkenaar and van Vliet, 2018; Withagen-Koster, van Kleef, and Eijkenaar, 2024).

This paper explores under what circumstances, risk rating of incremental premiums for additional coverage (on top of basic coverage) can improve consumer sorting. We build on the graphical framework developed by Einav, Finkelstein and Cullen (EFC) 2010, which has been widely used to depict markets with selection, estimate welfare effects of adverse selection, and study the effects of various public policies, including risk adjustment (Einav and Finkelstein, 2011; Geruso, Layton, McCormack, and Shepard, 2021, 2023). In particular, we use this framework to study the interaction between risk rating of incremental premiums for additional coverage, moral hazard resulting from additional coverage, and imperfect risk adjustment regarding basic coverage.

We use data from Chile's private health insurance market to empirically illustrate our arguments. Chile's healthcare system is characterized by a consolidated public–private mix with social insurance principles, similar to other countries like Ireland and Australia. Individuals must allocate 7 % of their taxable income (with a cap) to enroll in either public or private primary health insurance coverage. Private health insurance covers about 15 % of the population (~3 million individuals), and is an alternative to the public insurer, which covers approximately 79 % of the population (~15 million individuals). Compared to the overall Chilean population, private health insurance enrollees tend to be younger, male, have high incomes, and report better self-assessed health (Pardo and Schott, 2014). Since 2006, both public and private health coverage must offer a basic benefit package, namely, Garantías Explícitas en Salud (GES), currently covering 87 health conditions. The premium for this benefit package is community-rated, and a cell-based age and gender risk adjustment is utilized to mitigate risk selection (Velasco, Henríquez, and Paolucci, 2018). Bundled with GES, 'complementary plans' (additional coverage outside the GES framework or to enhance access/network beyond GES) feature risk-rated premiums based on age and enrollee type (policyholder or dependent). Roughly ~1118 plans are available for purchase in the current market across 7 open insurers (Superintendencia de Salud, 2024). No subsidies are in place for individuals selecting private plans, while the public insurer receives government contributions to supplement its budget.

Recent reform proposals have focused on standardizing coverage through a comprehensive benefit package (including GES and the 'complementary plans'), and deductible options as a form of standardizing cost-sharing arrangements (Ministerio de Salud, 2019). Risk rated premiums have been suggested, supported by a risk adjustment scheme. This paper is thus motivated by the proposals. While our analysis is grounded in the Chilean context, the proposed reforms (mandatory coverage with consumer choice options) have strong similarities with systems like the Netherlands, Switzerland and Germany. Thus, findings have broader relevance for the design of other health insurance schemes.

The purpose of the simulations is to show the direction of the effects resulting from the interaction of risk rating, moral hazard, and imperfect risk adjustment in consumer sorting rather than to estimate the magnitude of welfare effects. Welfare consequences are considered by computing a relative welfare measure that allows for comparisons across different scenarios.

The rest of the paper is structured as follows. Section 2 adapts the EFC graphical framework to our setting of interest and describes the impact of risk rating of incremental premiums for additional coverage, moral hazard from additional coverage and imperfect risk adjustment regarding basic coverage on consumer sorting and welfare. Section 3 describes the data, while Section 4 presents the methods used in our simulations. Section 5 presents the results, and Section 6 contains the discussion and conclusion of our findings. The appendix and references follow at the end of the paper.

2. Conceptual framework

We use Einav, Finkelstein, and Cullen (EFC) 2010 to explore under what circumstances risk rating of incremental premiums for additional coverage (on top of basic coverage) can improve consumer sorting. For our analysis, we make the following assumptions:

- the insurance market has an effective mandate for buying basic coverage (such as the basic health insurance schemes in the Netherlands, Switzerland, and Germany);
- basic coverage is subject to a deductible;
- on top of basic coverage, consumers can opt for additional coverage in the form of full coverage of spending below the deductible (we will refer to this plan as 'full coverage');
- the market operates under conditions of perfect competition: there are no frictions on the side of insurers and consumers, and the premium for a plan reflects the mean expected insurer cost of consumers choosing that plan;
- consumers are risk-averse.

2.1. Risk rating with perfect risk adjustment and no moral hazard

Fig. 1 illustrates the initial set-up. As individuals choose between the basic plan (deductible) and the full coverage plan (no deductible), the X-axis represents the quantity (percentage or fraction) of individuals choosing the full coverage plan. In the presence of an effective mandate for the basic plan, the X-axis includes the entire population of interest. In other words, selection on the extensive margin (whether to buy insurance) is absent. Given this, our paper is concerned with selection on the intensive margin (which plan to buy) (Geruso, Layton, McCormack, and Shepard, 2021). Additionally, sorting of individuals is based on their incremental willingness to pay (WTP) for full coverage over the deductible plan: consumers with the highest incremental WTP are on the left, and those with the lowest incremental WTP are on the right. The Y-axis captures the incremental price/WTP of an individual enrolling in full coverage compared to the deductible plan.

In Fig. 1, the demand for full coverage over the deductible plan is captured by the cumulative distribution of individuals' incremental WTP for the full coverage plan relative to the deductible plan. Consumers with higher expected incremental costs for full coverage have higher incremental WTP for full coverage (compared to the deductible plan). Since consumers are assumed to be risk-averse, the incremental WTP exceeds the incremental marginal cost (MC).[1] Since they are risk-averse, consumers are willing to pay a risk premium (RP) on top of the incremental marginal cost.

Unlike other commodity markets, health insurance markets are subject to adverse selection because the incremental WTP curve and incremental MC curve are tightly linked since risk type affects both curves. In other words, the insurers' costs depend on which consumers purchase their plans (instead of costs relating to the firm's production function alone).

Assuming insurers can only set an incremental community-rated premium for full coverage over the deductible plan, the relevant cost curve for insurers is the incremental <u>average</u> cost (AC) curve. Thus, pricing reflects the incremental average expected costs of all consumers enrolled in the full coverage plan, not the marginal consumer (Einav and Finkelstein, 2023). The market equilibrium occurs where the incremental AC curve intersects with the incremental WTP curve. Individuals will opt for the full coverage plan only if their incremental WTP is greater than the incremental AC. This is represented by the individuals located on the left of the intersection (Q*). For those on the right of the intersection (Q*), the community-rated premium exceeds their incremental WTP for full coverage. These consumers will not enroll in full coverage even though their incremental WTP exceeds the incremental marginal costs, which implies a forgone welfare gain. This is noted in the shaded area of Fig. 1. The efficient equilibrium would occur when Q is at Max = Eff point, as represented by the vertical dashed line in Fig. 1. This point represents the maximum efficiency in the market as all individuals' incremental WTP for full coverage lies above the incremental MC.

With the introduction of perfect risk rating, insurers face the incremental MC curve as the relevant cost curve. In this scenario, market equilibrium occurs when everyone opts for the full coverage plan, as the incremental WTP consistently lies above the incremental MC curve. Consequently, this leads to optimal sorting (Van Kleef, Schut, and van de Ven, 2018).

### 2.2. Risk rating in the presence of moral hazard

Fig. 1 implicitly assumes the presence of perfect risk adjustment for basic coverage and the absence of moral hazard. In this subsection, we adapt the EFC framework by including moral hazard[2] and discuss the implications in terms of market equilibrium, consumer sorting and welfare. Fig. 2 illustrates the inclusion of moral hazard in the adapted EFC framework.

Moral hazard is a 'direct' effect that occurs as the full coverage plan reduces the marginal price of health services to zero, compared to the deductible plan, increasing the use of health services (Zweifel and Manning, 2000). In Fig. 2, we show this by shifting the incremental MC curve of Fig. 1 upwards (incremental MC full coverage with moral hazard > incremental MC full coverage without moral hazard). Consequently, this affects the incremental AC curve and thus the incremental premium for full coverage.

In the presence of moral hazard with community rating, the equilibrium price (P*) for full coverage, determined by the intersection of the incremental WTP and the incremental AC curve, will be higher than without moral hazard (now at P* with moral hazard). This increase in price leads to decreased enrollment in the full coverage plan. The magnitude of the forgone welfare gain is contingent upon the shape and location of the incremental WTP and incremental cost curves, factors that can be empirically determined. The extent of the decrease in enrollment in the full coverage plan is influenced by several factors, such as the magnitude of moral hazard, the slope of

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[1] That is, the additional cost reflecting the increased coverage provided by the full coverage plan relative to the deductible plan.

[2] In Einav and Finkelstein (2011) moral hazard is considered in a framework of no selection, and in Einav, Finkelstein, Ryan, Schrimpf, and Cullen (2013) the focus is selection on moral hazard.
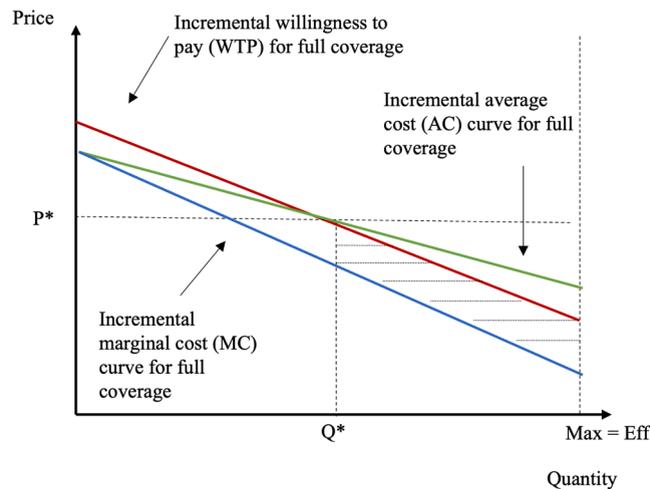
Fig. 1. Adapted EFC framework to characterize the choice between full coverage (no deductible) and basic coverage (deductible) with perfect risk adjustment, no moral hazard and the effective insurance mandate for basic coverage.

Note: The X axis captures the quantity of individuals choosing the full coverage plan. The Y-axis captures the incremental price/WTP of an individual enrolling in full coverage compared to the deductible plan. Max = Eff represents the efficient equilibrium.
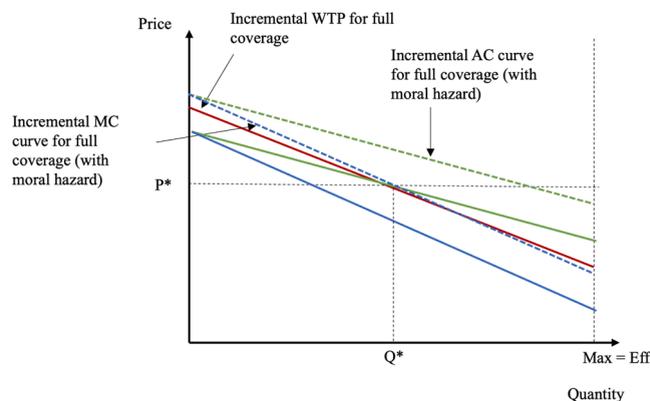
Fig. 2. Inclusion of moral hazard in the adapted EFC framework to characterize the choice between full coverage (no deductible) and basic coverage (deductible) and the effective insurance mandate for basic coverage.

Note: The solid green and blue lines capture the Incremental AC curve for full coverage (without moral hazard), and the Incremental MC curve for full coverage (without moral hazard), respectively, and remain unchanged from Fig. 1. The X axis captures the quantity of individuals choosing the full coverage plan. The Y-axis captures the incremental price/WTP of an individual enrolling in full coverage compared to the deductible plan. Max = Eff represents the efficient equilibrium.

the incremental MC curve and the risk aversion of individuals. A more pronounced moral hazard effect drives the incremental MC further upwards. Consequently, this elevates the incremental AC curve, which may cause this curve to lie significantly above the incremental WTP curve across a wider distribution of enrollees, resulting in a larger decrease in full coverage enrollment (and a greater forgone welfare gain) (the decrease is equal to the distance between Q* with and without moral hazard). A flatter incremental MC curve (affecting similarly the incremental AC) can also exacerbate the decrease in full coverage enrollment. This is because a flatter cost curve intersects the WTP curve at a point further to the left on the X-axis. If individuals exhibit lower levels of risk aversion, the incremental WTP curve will lie close to the incremental MC curve (and AC curve). This proximity reduces the consumer surplus from full coverage, potentially leading to lower enrollment. In an extreme case with community rating, no consumer enrolls in the full coverage plan as the incremental AC curve would lie consistently above the incremental WTP curve.

From a welfare perspective, the presence of moral hazard means that full coverage is generally not socially optimal. The efficient equilibrium is reached where WTP equals the incremental MC curve that would exist without moral hazard. Thus, if WTP falls below the MC (Fig. 1), it is socially optimal for individuals not to purchase that additional coverage. In practice, this implies that the socially optimal level of coverage lies below full coverage, with the gap between equilibrium (Q*) and Max=Eff depending on the extent of moral hazard, the slope of the cost curves, and the degree of risk aversion in the population.

With risk rating, the incremental MC curve determines the equilibrium. The effect of risk rating in the presence of moral hazard is

again dependent on the shape and location of the incremental costs and incremental WTP curves. Results could range from all individuals enrolling in full coverage to decreased enrollment. If the incremental MC is relatively steep and lies close to WTP, high-risk individuals may not opt for the full coverage plan, enrolling in the deductible plan instead, while low-risk individuals would opt for the full coverage plan as the incremental MC would lie below their incremental WTP due to their risk aversion.

2.3. Risk rating in the presence of moral hazard and imperfect risk adjustment

So far, we have considered a setting with perfect risk adjustment regarding basic coverage. By perfect risk adjustment, we mean that insurers are perfectly compensated for variation in expected insurer spending regarding the deductible plan (i.e., spending above the deductible). More specifically, we have assumed that the incremental MC (and AC) curves consist of the 'direct' cost of incremental (additional) coverage compared to the basic plan. In our case of the yes/no deductible, the direct incremental cost of full coverage is composed of the additional spending covered (i.e., the cost that shifts from the consumer to the insurer) and moral hazard.[3]

In mandatory insurance markets, this is not realistic since state-of-the-art risk adjustment schemes do not completely compensate for variation in expected spending across individuals. Insurers are typically overcompensated for low-risk consumers and undercompensated for high-risk consumers (van Kleef, Eijkenaar, and van Vliet, 2020). When under/overcompensations are correlated with the incremental WTP for full coverage, consumer sorting may reveal some of these under/overcompensations. For example, in the case of a lower deductible, consumers with the highest WTP are likely undercompensated by risk adjustment, while those with the lowest WTP are overcompensated by risk adjustment (Cohen and Einav, 2007). Adverse selection, therefore, affects the cost structures of the full coverage plan and the deductible plan. In a competitive market, insurers will base their premiums on the net costs per plan and will be forced to reflect these under/overcompensations in the incremental premium for full coverage (Van Kleef, Pirktl, Stam, Hamstra and Holly, 2024). Consequently, the incremental premium for full coverage not only reflects the direct incremental cost of full coverage (additional coverage and moral hazard), but also the under/overcompensations by risk adjustment regarding the deductible plan.

Fig. 3 illustrates the inclusion of moral hazard and imperfect risk adjustment in the adapted EFC framework. In our scenario of imperfect risk adjustment, the incremental MC curve rotates clockwise, assuming undercompensations for consumers on the left and overcompensations for consumers on the right. This rotation preserves the average MC across the population, considering the fact that on average the over and under-compensations add up to zero. Similarly, the incremental AC curve rotates clockwise, with the origin on the right remaining fixed. When the entire market is enrolled in full coverage (far right), the under- and overcompensations, which sum to zero, have no impact on AC. However, when we move to the left, the market contains a disproportionate share of undercompensated individuals, which increases the AC.

With community-rated premiums, imperfect risk adjustment will cause the incremental AC curve for the full coverage plan to shift upwards to include the undercompensation associated with those opting for full coverage and reduce enrollment in the full coverage plan. At the point where the entire population has full coverage, the AC remains the same as depicted in Fig. 2. Therefore, on the right side of the Fig. 3, the AC curve maintains the same origin as in Fig. 2 but rotates clockwise from that fixed point. In the case of a large undercompensation of those with the highest WTP for full coverage, the incremental AC curve may be expected to lie consistently above the incremental WTP, leading to no consumers enrolling in full coverage. The magnitude of the effect of imperfect risk adjustment will depend on the underlying risks of the population, and particularly on the model utilized.[4]

With risk-rated incremental premiums, the equilibrium occurs where the incremental MC curve with (imperfect) risk adjustment meets the incremental WTP. This new curve reflects increased costs for the high risks and lowers the costs for the low risks, making the incremental MC curve steeper. As a result, the incremental MC curve will exceed the incremental WTP given that imperfect risk adjustment affects the MC curve but not WTP, causing some high-risk individuals to not enroll in the full coverage plan. The greater the undercompensation for high risks, and overcompensation for low risks, the more high risks will be crowded out of the full coverage plan. The point where the incremental MC curve crosses the incremental WTP depends on the risk adjustment model in place and remains an empirical question, making the consequences of risk adjustment less clear and contingent on the method used. The reflection of risk adjustment under/overcompensation in premiums may create a paradoxical scenario where those with the lowest incremental WTP enroll in full coverage, rather than those with the highest incremental WTP.

3. Data

We use data provided by the Superintendence of Health, which comprises two-years (2016–17) of anonymized information on all enrollees of the Chilean private health insurance market (Isapres). The dataset includes information on spending, demographics, socioeconomic factors, inpatient diagnostics, and plan characteristics for individuals within the system. Our analysis focuses on a sample of $N = 2150513$ individuals who were continuously enrolled in both years and were of adult age (>18 years old).

Table 1 presents the descriptive statistics. The average age in the sample is 41 years, with the majority of individuals (41.6 %) falling within the 35–54 age group, while only 7.6 % are aged 65 or above. Males constitute the majority of the sample (54.8 %). The mean total health spending (representing the total cost of services utilized by enrollees over the year) amounts to $1425.5 (SD = $6172.7) for 2017 and $1288.8 (SD = 5034) for 2016. The mean total co-payments in 2017 (reflecting the total out-of-pocket costs

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[3] This is different to Layton (2017) which studies risk adjustment with no moral hazard under community rating.

[4] Here we do not consider the effects of different sophistication levels of risk adjustment. We leave readers to consult Layton (2017) for the intuition and the way different risk adjustment payments would affect market equilibrium using the EF framework.
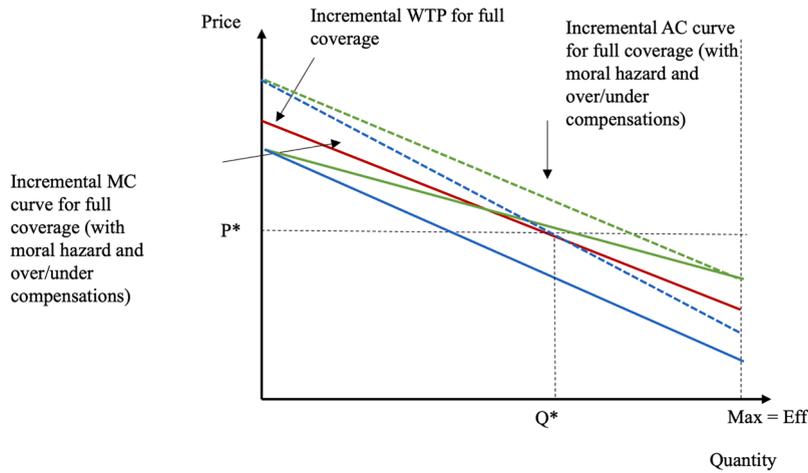
Fig. 3. Inclusion of moral hazard and imperfect risk adjustment in the adapted EFC framework to characterize the choice between full coverage (no deductible),basic coverage (deductible) and the effective insurance mandate for basic coverage.

Note: The solid green and blue lines capture the incremental AC curve for full coverage (without moral hazard), and the Incremental MC curve for full coverage (without moral hazard), respectively – both of which remain unchanged from Fig. 1. The X axis captures the quantity of individuals choosing the full coverage plan. The Y-axis captures the incremental price/WTP of an individual enrolling in full coverage compared to the deductible plan. Max = Eff represents the efficient equilibrium.

paid by enrollees over the year) reached $509.5 (SD = 2537) and therefore account for 35.7 % of total healthcare spending in 2017. Finally, a large segment of the population (92.5 %) did not have any recorded pathologies (based on inpatient diagnosis derived from hospital discharges).

4. Methods

The objective of this paper is to assess whether, and under what circumstances risk rating of the incremental premium for additional coverage (beyond basic coverage) can improve consumer sorting and, in turn, welfare. Our motivation is grounded in recent reform proposals in Chile, and we empirically simulate scenarios aligned with these proposals.

Following the assumptions laid out in the conceptual framework (Section 2), we assume an insurance market with a mandate of buying basic coverage. Basic coverage is subject to a deductible (D) of $500, which was chosen following the average total copayment in the market in the period considered ($ 510, see Table 1). Additionally, consumers can opt for additional coverage - a full coverage (FC) plan that does not involve a deductible.

Throughout the analysis, we assume community rating for the D plan. Additionally, we assume that all individuals in the market can afford the FC plan, regardless of the premium settings (we consider the implications of this below). This allows us to focus on 'willingness to pay' without having to worry about 'ability to pay'. For simplicity, we do not take into account any loading fee in the premiums to cover for administrative and management expenses, but discuss its implication in the Conclusion and Discussion section.

The adapted EFC graphical framework allows us to show the shape and direction of the curves including the incremental WTP, incremental AC curve, and incremental MC curve, as a result of the interaction between risk rating of incremental premiums for additional coverage, moral hazard resulting from the FC plan, and over/under compensation due to imperfect risk adjustment regarding the D plan.

The incremental MC curve represents the expected incremental costs of the FC plan over the D plan. The incremental WTP curve for the FC plan is computed by adding a risk premium (RP) to the incremental MC curve. The incremental AC curve represents the average incremental spending in the *total population* under the FC plan, reflecting the incremental (price) or expected costs individuals must pay under community rating.

With risk rating, the relevant cost curve for insurers is the incremental MC curve (we assume zero reclassification risk). An individual will opt for the FC plan only if their incremental WTP is equal to or exceeds the relevant incremental cost curve. The forgone welfare gain represents the loss associated with individuals who would have preferred the FC plan but do not choose it because the incremental premium for the FC exceeds their incremental WTP. This loss is depicted by the vertical distance between the incremental cost curves (AC curve and MC curve) and the incremental WTP.

Table 1
Descriptive Statistics.

Variable	Percentage	Mean (Std Dev)
Age groups		41 years old (14.9 years)
18 - 34	38.1	
35 - 54	41.6	
55 - 64	12.6	
65+	7.6	
Gender		
Male	54.8	
Female	45.2	
Total Health Spending 2017		$ 1425.5 ($6172.7)
Total Health Spending 2016		$1288.8 ($5034.4)
Total Copayments 2017		$ 509.5 ($2537)
Pathologies[1]		
0	92.5	
≥1	7.5	

Note: This table reports descriptive statistics of the variables used in the analysis. Values are in US dollars and a conversion rate of 1 CLP to 0.001525 USD was used.

We simulate the curves under three scenarios that vary in assumptions and complexity, incorporating moral hazard and over/ undercompensations due to imperfect risk adjustment:

1) *Scenario 1*: this serves as our baseline, assuming the absence of moral hazard and the presence of perfect risk adjustment.
2) *Scenario 2*: we introduce moral hazard due to the FC plan while maintaining perfect risk adjustment.
3) *Scenario 3*: this builds on the second scenario, but introduces over- and undercompensation due to imperfect risk adjustment.

In what follows, we will provide details of the computations performed in each scenario.

4.1. Scenario 1 – Baseline

In this scenario, we assume the absence of moral hazard and the presence of perfect risk adjustment. Eq. (1) depicts the least squares linear regression used to simulate the incremental MC curve:

$$IMC_i = \beta age_i + \delta Lagged\_Spending_i \tag{1}$$

The dependent variable, IMC_i, captures the *actual* incremental spending for individual i under the FC plan compared to the D plan. Specifically, it captures the additional spending covered by the FC plan, calculated as the total healthcare spending[5] in 2017 capped at $500 (i.e., the deductible amount).[6]

As explanatory variables, we include age (age_i) and lagged spending ($Lagged\_Spending_i$). Age_i is included as 63 dummy variables (18–80+), one per year. Lagged spending is included as 100 dummy variables that capture the percentiles of spending in the previous year. Lagged spending is highly right-skewed with a large mass at zero, a common feature of the distribution of healthcare spending (Deb and Norton, 2018). Modelling this variable as continuous would impose linearity and allow extreme values to exert undue influence on predictions. Using percentile indicators provides a flexible, semi-parametric specification that allows the effect of prior year spending to vary across the distribution while limiting the impact of outliers and improving the stability of fitted values. Each individual in our dataset falls in exactly one age class and one lagged-spending class.

The incremental MC curve will be the *expected* incremental spending under the FC plan compared to the D plan ($\widehat{IMC_i}$). This comes from the predicted values of Equation (1).[7] In the Figures in the Results section, we graph this for each percentile p (100 bins) of the $\widehat{IMC_i}$.

Next, we compute the incremental WTP for the FC plan, which is the sum of the *expected* incremental spending under the FC plan compared to the D plan ($\widehat{IMC_i}$) and the RP under the FC plan. The RP reflects the degree of risk aversion of each individual. The literature provides mixed findings on the estimation and magnitude of risk aversion (see Outreville (2014) for a comprehensive review). Related studies such as Handel, Hendel, and Whinston (2015) utilize a simulation to estimate the constant absolute risk aversion (CARA) coefficient, utilizing the mean of healthcare spending and the ratio of the variance of total healthcare spending to this mean. Einav, Finkelstein, and Schrimpf (2010) utilize a similar method to estimate CARA.

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[5] Total healthcare spending represents all healthcare spendings claims in the private market, for each individual in a given year.

[6] The marginal costs for the D plan equates the costs for which the insurer is responsible of (that is, total spending minus the out of pocket borne by consumers). Practically, this means all costs exceeding the deductible amount. Therefore, the incremental marginal costs for insurers offering the FC plan include all costs below the deductible amount, which would not be covered under the deductible plan.

[7] The descriptive statistics of the *expected* incremental spending are as follows: mean = 294.13, SD = 105.85, min = 103.8, 1st pct = 104.3, median = 302.45, 99th pct = 471.08, max = 501.06)

In line with the aim of our analysis, we adopt a pragmatic approach. We assume the RP for individual i to be a percentage ($\varphi = 50$ %)[8] of the standard deviation of the healthcare spending in 2017 capped at \$500 ($RP_i = \varphi(\sigma_p)$) by percentile p (100 bins) of the expected incremental spending (see above). The standard deviation provides a reference point for the RP as it reflects the variability or dispersion of the spending. By doing so, we assign higher risk premiums to individuals who face more uncertainty and financial risk. The RP is always positive since all individuals are risk-averse and there are no other market frictions. The level of the standard deviation for each percentile (bin) is graphically reported in the Appendix Fig. A1.

That said, the incremental WTP curve is represented by the sum of the incremental MC curve and the RP is outlined in Eq. (2):

$$\text{Incremental } WTP_i = \widehat{IMC}_i + \varphi(\sigma_p) \tag{2}$$

Finally, Eq. (3) defines the incremental AC curve as the cumulative average of incremental expected spending (i.e., expected incremental MC) under the FC plan. For each subset of individuals I, ordered by expected spending from highest to lowest, the average is calculated by summing the $\widehat{IMC}_i$ values for all $i \in I$, and then dividing by $|I|$, the number of individuals in that subset:

$$\text{Incremental } AC_I = \frac{\sum_{i \in I} \widehat{IMC}_i}{|I|} \tag{3}$$

Where I denotes the subset of individuals included up to a given point in the distribution, and $|I|$ represents the number of individuals in that subset. As I expands sequentially, starting with the individual with the highest expected spending and moving down, the curve traces how the average expected incremental MC evolves across the distribution.

Under community rating (risk rating), individuals will opt for the FC plan when the incremental WTP $\geq$ incremental AC (MC), whilst those with an incremental WTP $<$ incremental AC (MC) will remain in the D plan.

4.2. Scenario 2 – Introduction of moral hazard due to FC plan

In the second scenario, we introduce moral hazard (MH) due to FC. We calculate MH within the Chilean health insurance market as a constant percentage (γ) of the incremental MC under the FC ($\gamma(\widehat{IMC}_i)$). We assume an *average* effect for the consumers as it allows us to relax assumptions on the individual consumers' response.[9]

To increase the robustness and completeness of the analysis, we run a sensitivity analysis with varying levels of γ, starting at 20 % based on the RAND estimates (Manning et al., 1987), and then testing 15 %, 10 % and 5 % (see Appendix).

In terms of the curves presented in Scenario 1, MH will be added to the incremental MC (i.e., $(\widehat{IMC}_i) + \gamma(\widehat{IMC}_i)$) and, therefore, the incremental AC will change accordingly. These are presented by percentiles p in the Figures reported in the Results. It is not obvious whether MH should be included in the incremental WTP. This decision depends on our assumption about how consumers value the additional care resulting from MH. We assume consumers do not attribute any additional value to the care received due to MH, and, therefore, perceive it to be indistinguishable from regular care. We ran a sensitivity check to test the implications of this assumption in terms of our outcome measure (see Appendix).

4.3. Scenario 3 –Introduction of over and under compensations due to imperfect risk adjustment

As a final step, we introduce over and under compensation due to imperfect risk adjustment under the D plan. Eq. (4) depicts this imperfect risk adjustment, which is calculated using a concurrent model (where 2017 spending is modelled on 2017 insured characteristics) through least squares linear regression, following common policy applications (Ellis, Martins, and Rose, 2018).

$$y_i = \theta x_i + e_i \tag{4}$$

The dependent variable (y_i) captures the insurers spending responsibility under D plan. This is calculated as the total healthcare spending that individual i would have had in the case of FC plan minus the out-of-pocket of individual i when choosing the D plan.

As risk adjusters, captured in x_i, we include age and gender, where two gender groups (Female/Male) are interacted with age

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[8] We run sensitivity checks with different levels of φ (see Fig. A2) (e.g., 25%, 15%). These checks show that changes to the RP function, which reduce individuals' risk aversion or their willingness to pay (WTP) for the FC plan, shift the incremental WTP curve downwards across scenarios. In Scenario 1, under community rating, fewer individuals enroll in the FC plan, while under risk rating, all individuals still enroll in the FC plan. In Scenario 2, with moral hazard, community rating results in individuals not choosing the FC plan, whereas risk rating exacerbates the selection effect, pricing high-risk individuals out of the FC plan. Finally, in Scenario 3, with imperfect risk adjustment, the market unravels under community rating, while changes under risk rating are marginal across different RP values.

[9] For simplicity we do not take into consideration the selection component (Nyman, 1999) or the selection on MH component (Einav, Finkelstein, Ryan, Schrimpf, and Cullen, 2013).

(baseline: 18–19/Female) divided into 14 classes (18–19, then 5 year gaps until 80+), and a count of the number of diagnoses[10] each individual had during the year based on the mapping of ICD-10 codes to the classification specified by Ash et al. (1989).

We calculate the over and undercompensation arising from imperfect risk adjustment for each percentile p as the difference between the average expected insurer's responsibility under the D plan ($\widetilde{RAP}_p$, risk adjusted), and the average actual insurer's responsibility under the D plan ($\bar{y}_p$). A negative value indicates undercompensation (i.e., expected responsibility is less than actual), while a positive value indicates overcompensation (i.e., predicted responsibility exceeds actual).

We adjust the incremental MC curve (Eq. (1)) and the incremental AC curve (Eq. (3)) to incorporate the over and undercompensation deriving from imperfect risk adjustment (i.e., $\widetilde{RAP}_p$-$\bar{y}_p$). This reflects a competitive market where an insurer's actuarially fair premium for FC plan reflects the expected difference in the cost of the D plan between consumers who sort into the FC plan and those who do not.

Last, considering MH, the incremental MC (and AC) curves are computed as: $\widehat{IMC}_i + \gamma(\widehat{IMC}_i) - \left(\widetilde{RAP}_p - \bar{y}_p \right)$.

4.4. Forgone welfare gain measure

As reported in Fig. 1, the forgone welfare gain is depicted by the vertical distance between the incremental cost curves (AC curve and MC curve – depending on the premium setting) and the incremental WTP. This is reflected in the shaded area. In practice, this is quantified as the sum of the RP over all enrollees who do not opt for the FC plan (i.e., $\sum_i^n RP_i$ if FC=0).

To facilitate comparisons across scenarios, we use a relative measure. We are particularly interested in the effects of imperfect risk adjustment compared to the scenario with perfect risk adjustment. First, we calculate the forgone welfare gain for each scenario (e.g. compute the sum of RPs for the population who do not opt for the FC plan under Scenario 2 and 3) and premium settings (community rating and risk rating) to determine our numerator. This is divided by the forgone welfare gain in Scenario 2 under community rating, our baseline, which serves as the denominator. Each result of the relative measure is expressed relative to the baseline case of Scenario 2 with community rating, which is normalized to 1. This means that the value for Scenario 3 with community rating should be read as the forgone welfare in that case divided by the forgone welfare in Scenario 2 with community rating. Likewise, the entry for Scenario 2 with risk rating represents the ratio of forgone welfare in Scenario 2 under risk rating to the same baseline, and the entry for Scenario 3 with risk rating is the forgone welfare under Scenario 3 with risk rating divided by the Scenario 2 community rating baseline. This relative scaling allows us to interpret higher (smaller) values of this measure as increased (reduced) forgone welfare gains compared to the baseline. It also ensures that differences between premium settings can be expressed as proportional reductions.

5. Results

In this section, we present the results of our simulations across three scenarios. First, we establish a baseline (Scenario 1) that assumes no moral hazard and perfect risk adjustment. Next, we introduce moral hazard under the full coverage (FC) plan while maintaining perfect risk adjustment (Scenario 2). Finally, we extend the analysis by incorporating the effects of imperfect risk adjustment, which generates over- and undercompensation (Scenario 3). To facilitate comparisons, we evaluate outcomes across scenarios using a relative measure and conclude by presenting the resulting estimates of forgone welfare gain.
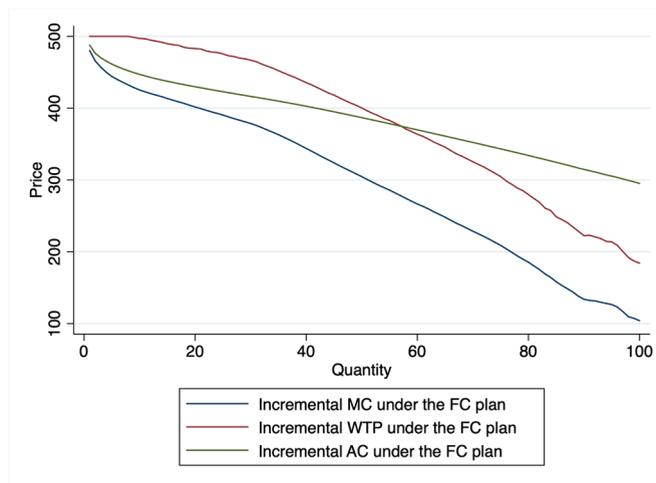
5.1. Scenario 1– Baseline

Fig. 4 captures the baseline scenario, illustrating the equilibrium in a simulated mandatory health insurance market where individuals choose between a D plan and a FC plan.

With community rating, the equilibrium lies in the intersection of the incremental WTP and the incremental AC curve. In this equilibrium, 57 % of the population opts for the FC plan. We observe that relatively high-risk individuals (those to the left on the X-axis) are more likely to choose the FC plan since their WTP is higher than the premium charged by the insurers. We observe the opposite for relatively low-risk individuals (those to the right on the X-axis). Under community rating, individuals select the FC plan if their incremental WTP exceeds the premium charged by insurers (determined by the intersection of WTP and AC curves), while those with WTP below the premium choose the D plan. This community-rated incremental premium for the FC plan leads to inefficient sorting of consumers between the plans, resulting in a foregone welfare gain, represented by the difference between the incremental WTP and the incremental MC curve. This occurs because some risk-averse consumers, who value the FC plan, due to better risk protection, more than the D plan, are expected not to choose the FC plan.

When insurers have complete information about applicants and can implement a perfect risk-rating system for the incremental premium of the FC plan, the relevant cost curve for insurers becomes the incremental MC curve. Consumer sorting and welfare

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[10] We employ a count of diagnoses rather than individual diagnostic dummies for two key reasons. First, many individual diagnoses occur infrequently in our data, creating potential outliers that substantially increase model variance without proportional gains in explanatory power. Second, Chile's healthcare system lacks a validated diagnosis grouping such as those used in US systems (e.g., HCCs), making the creation of diagnostic categories methodologically arbitrary. The count approach provides a parsimonious measure of overall morbidity burden while maintaining statistical stability.

Fig. 4. Market equilibrium - Baseline Scenario.
Notes: MC = marginal cost, WTP = willingness to pay, AC = average cost, FC = full coverage. The X-axis represents the quantity (percentage or fraction) of individuals choosing the FC plan. In the presence of an effective mandate – the X-axis includes the entire population of interest, divided into percentiles and sorted from highest to lowest incremental MC. Each bin corresponds to a homogeneous population segment comprising approximately 21,500 individuals. The Y-axis captures the incremental price/WTP for FC compared to the D plan. The baseline scenario depicts a market equilibrium without moral hazard and with perfect risk adjustment. The curves represent: incremental marginal cost (MC) of the FC plan (blue) over the D plan, incremental willingness to pay (WTP) for the FC plan versus D plan (red), and incremental average cost (AC) curve (green) for the FC plan versus D plan.
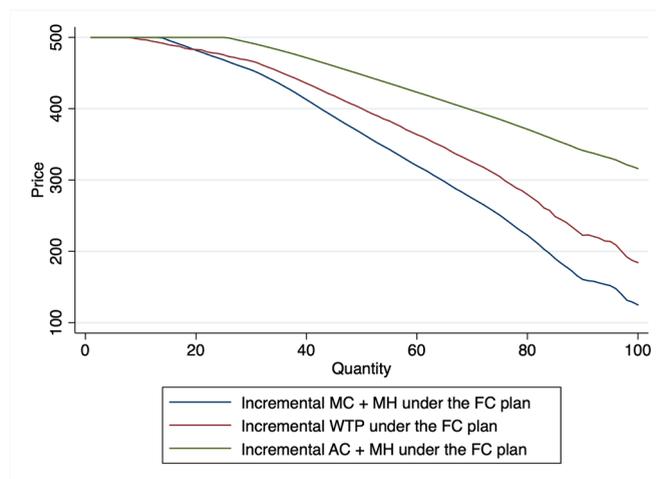
Fig. 5. Market equilibrium - Introduction of 20 % moral hazard due to FC plan.
Notes: MC = marginal cost; WTP = willingness to pay; AC = average cost; FC = full coverage; MH = Moral hazard. Figure 5 captures a market equilibrium with MH and with perfect risk adjustment. The X-axis represents the quantity (percentage or fraction) of individuals choosing the FC plan. In the presence of an effective mandate – the X-axis includes the entire population of interest, divided into percentiles and sorted from highest to lowest incremental MC. Each bin corresponds to a homogeneous population segment comprising approximately 21,500 individuals. The Y-axis captures the incremental price/WTP for FC compared to the D plan. The blue curve captures the incremental MC under the FC plan including MH, the red curve depicts incremental WTP for the FC curve compared to the D plan which remains unchanged to Fig. 4 and the green line represent the incremental AC curve, which also now includes MH effect.

implications are then assessed by comparing the incremental WTP with the incremental MC curve. If individuals are risk averse, the incremental WTP consistently lies above the incremental MC curve as individuals are willing to pay a risk premium for the FC plan that consistently exceeds the premium charged by the insurer. Consequently, all individuals opt for the FC plan (Van Kleef, Schut, and van de Ven, 2018), resulting in maximum sorting efficiency with no foregone welfare.

5.2. Scenario 2 – Introduction of moral hazard due to FC plan

Fig. 5 introduces moral hazard (MH) to the previous scenario and maintains perfect risk adjustment. Specifically, we add MH assuming a constant function ($\gamma = 20\%$) of the incremental MC under the FC (see the Appendix Fig. A3 for the sensitivity checks[11]).

MH alters the cost structure in the market by increasing overall costs for insurers. The increased utilization of healthcare services by individuals under the FC plan leads to increased incremental MC and incremental AC compared to those in Scenario 1 (baseline). This upward shift reflects higher overall premiums. Accordingly, more individuals, particularly those in higher-risk groups, reach the $500 deductible threshold compared to Scenario 1 - Baseline. This effect is visually represented by the flattening of the three curves as a greater number of consumers reach the deductible ceiling.

Under community rating, the equilibrium is determined by the intersection of the incremental WTP curve (constructed under the assumption that individuals do not value additional care due to MH; see the Appendix Fig. A4 for the sensitivity check),[12] and the incremental AC curve. This intersection lies to the left of the X-axis. As a result, in the presence of MH, the equilibrium price under community rating increases, and fewer individuals opt for the FC plan. This alters the equilibrium outcome relative to the benchmark scenario without moral hazard, with implications for consumer sorting. Specifically, only 8 % of the population opts for the FC plan, a substantial reduction from the 57 % observed in Scenario 1.

When premiums are risk rated, our focus is on the incremental MC curve. The incremental WTP for the FC plan (red curve) remains above the incremental MC curve (blue curve) for most individuals, leading them to choose the FC plan, particularly, 89 % of the population opts for FC plan. However, there is a noticeable reduction in FC plan enrollment compared to Scenario 1 (-11 percentage points). This illustrates the paradox discussed in the conceptual framework section: relatively high-risk individuals (to the left of the X-axis) may drop out of the FC plan because their incremental WTP lies below the incremental MC curve. Conversely, relatively low risk individuals (those to the right of the X-axis) tend to remain in the FC plan. MH incentivizes individuals to opt out of the more comprehensive FC plan, revealing its selection effect. As a result, MH reduces the potential welfare gain from risk rating, as evidenced by the decreased difference between incremental WTP and incremental MC.

5.3. Scenario 3- Incorporating over and under compensation due to imperfect risk adjustment

Fig. 6 shows the market equilibrium with moral hazard (as a percentage of incremental MC under the FC), and imperfect risk adjustment, that is, over and undercompensation. Unlike previous scenarios where insurers based their premiums only on the marginal cost of additional coverage, imperfect risk adjustment forces insurers in a competitive market to account for the over and under compensation deriving from the payment system.

Several observations can be made from Fig. 6. First, imperfect risk adjustment causes both MC and AC curves to rotate clockwise. The MC curve rotates around its center, creating higher costs for undercompensated consumers on the left and lower costs for overcompensated consumers on the right. The AC curve rotates from a fixed right endpoint, rising as coverage decreases because undercompensated individuals disproportionately remain in the market.

Second, with community rating, the shape of the dotted green incremental AC curve, compared to the incremental AC curve in the absence of imperfect risk adjustment, indicates that insurers are incorporating significant under-compensation for high-risk individuals, as reflected in the steep slope at the far left of Fig. 6. Given that the new green dotted incremental AC does not intersect the incremental WTP curves, no one opts for the FC plan, leading to a complete market unravelling. This outcome highlights the failure of risk adjustment to sufficiently influence the distribution of enrollees via transfers between plans, such as those from groups adversely selected, like younger enrollees, to older, higher-risk individuals. As a result, these transfers do not enhance the attractiveness of the FC plan, causing the market to collapse.

Third, with risk rating, the market equilibrium is determined by the intersection of the new dotted blue incremental MC curve (which includes MH and over/under compensation) and the incremental WTP curve. It is important to note that the incremental MC curve is not smooth due to variations in the distribution of over/under compensation across percentiles (see in the Appendix Fig. A6 the graphical representation). This results in 69 % of individuals opting for the FC plan, a 20 percentage point reduction from Scenario 2 and a 31 percentage point reduction from Scenario 1. This indicates an increase in forgone welfare gain from risk rating compared to

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[11] Sensitivity checks indicate that under community rating, reducing moral hazard decreases the number of individuals reaching the deductible threshold and inversely affects FC plan enrollments. Under risk rating, the FC plan enrollment increases, aligning with the no-moral hazard Scenario 1. For over- and under-compensationfrom the introduction of imperfect risk adjustment, the market unravels under community rating, while under risk rating, marginally more individuals choose the FC plan.

[12] Sensitivity checks reveal that in Scenario 2, the inclusion of MH flattens the incremental WTP curve for the deductible of $500. Under community rating, this results in significantly more individuals enrolling in the FC plan. Under risk rating, all individuals still enroll in the FC plan. In Scenario 3, over- and under-compensation do not substantially change enrollment in either the community-rated setting or under risk rating for the incremental premium of the FC plan.
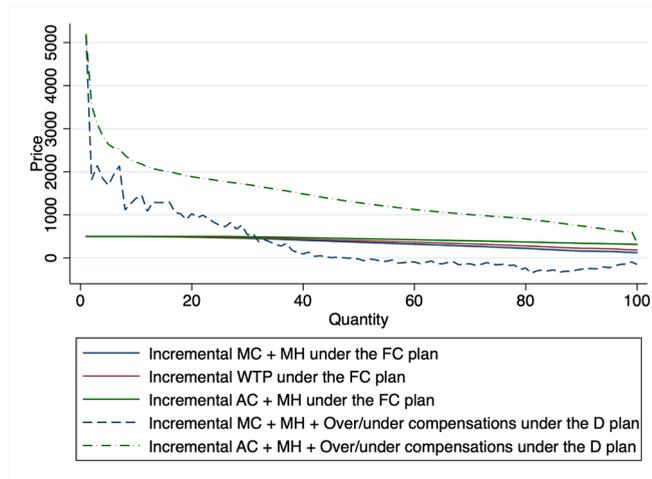
Fig. 6. Market equilibrium - Introduction of 20 % moral hazard due to FC plan and imperfect risk adjustment.

Notes: MC = marginal cost; WTP = willingness to pay; AC = average cost; FC = full coverage; MH = Moral hazard. Fig. 6 captures a market equilibrium with moral hazard and with imperfect risk adjustment. The X-axis represents the quantity (percentage or fraction) of individuals choosing the FC plan. In the presence of an effective mandate – the X-axis includes the entire population of interest, divided into percentiles and sorted from highest to lowest incremental MC. Each bin corresponds to a homogeneous population segment comprising approximately 21,500 individuals. The Y-axis captures the incremental price/WTP for FC compared to the D plan. The solid blue curve represents the incremental MC plus MH, the solid red curve shows the incremental WTP, and the solid green curve depicts the incremental AC plus MH. These curves are consistent with those in Fig. 5. The dotted green (incremental AC including MH and over and under compensations) and dotted blue curve (incremental MC including MH and over and under compensations under the D plan) denote the new curves that are added because of over and undercompensations due to imperfect risk adjustment. In Appendix Fig. A5 the case of the absence of risk adjustment can be found.

previous scenarios (which we quantify in Section 5.4). The individuals who are priced out of the FC plan tend to be higher-risk individuals, whose incremental WTP falls below the incremental MC (including moral hazard and over/under compensation), while lower-risk individuals continue to choose the FC plan as their WTP exceeds the incremental MC.

When MH and imperfect risk adjustment are present, adverse selection effects can be exacerbated. This is because over and under compensation (which is correlated with WTP), affect both the premiums for the FC and D plans. However, previous work has primarily examined the effects of risk adjustment on the distribution of premiums (reducing the premium range) (Klein, van Kleef, Henriquez, and Paolucci, 2023), as well as the effects of risk adjustment across coverage tiers, which reflect cross-subsidies between plans preferred by low-risk individuals and those adversely selected by high-risk individuals (Henriquez, van Kleef, Matthews, McGuire, and Paolucci, 2023).

5.4. Relative forgone welfare gain in each scenario

To quantify the welfare effects of risk rating of incremental premiums, we start by adding up the RP over enrollees who do not opt for the FC plan (i.e., $\sum_i^n RP_i$ if FC=0). Recalling, the RP is set at 50 % of the standard deviation of the healthcare spending (capped at $500), per spending percentile. This represents the absolute forgone welfare gain in each scenario and under each premium setting (e. g., community rating and risk rating). Higher values of forgone welfare indicate greater inefficiency, reflecting that more individuals are not in the efficient quantity, which negatively affects overall welfare in the market.

Since our main interest lies in the effect of imperfect risk adjustment, the key comparison is between Scenario 3 (imperfect risk adjustment) and Scenario 2 (perfect risk adjustment with moral hazard). Comparing Scenario 3 directly to Scenario 1 would also

Table 2
Relative forgone welfare gain under the different scenarios and premium setting.

	Moral hazard and perfect risk adjustment (Scenario 2)	Moral hazard and imperfect risk adjustment (Scenario 3)
Community rating	1	1.06
Risk rating	0.10	0.28
Proportional reduction	90 %	73 %

Notes: The absolute forgone welfare gain under Scenario 2 and Community rating equals $178,194,224 (1 is obtained by dividing $178,194,224/ $178,194,224); under Scenario 3 and Community rating it equals $188,212,134 (1.06 is obtained by dividing $188,212,134/$178,194,224); under Scenario 2 and Risk rating it equals $18,340,624 (0.10 is obtained by dividing $18,340,624 /$178,194,224); under Scenario 3 and Risk rating it equals $50,359,848 (0.28 is obtained by dividing $50,359,848/$178,194,224). The proportional reduction (%) is calculated as (Community rating−Risk rating)/Community rating × 100, in each scenario.

capture the effect of introducing moral hazard, which is not our focus here. We do so by constructing a relative measure. Particularly, we divide the absolute values in each scenario and premium setting by the forgone welfare under Scenario 2 with community rating. This normalization means that the entry for Scenario 2 under community rating equals 1, and all other values are expressed relative to it. The "Proportional reduction" row reports the proportional reduction in forgone welfare gain from community rating to risk rating.

The results in Table 2 indicate that imperfect risk adjustment increases forgone welfare under community rating relative to the case with perfect risk adjustment, as shown by the rise from 1 to 1.06. This reflects the additional inefficiency introduced when risk adjustment does not fully account for differences in expected costs. At the same time, the efficiency gains from moving to risk rating are diminished. Under perfect risk adjustment, risk rating reduces forgone welfare by 90 percent relative to community rating, while with imperfect risk adjustment, this reduction falls to 73 percent. Taken together, these findings show that while risk rating continues to mitigate inefficiencies, its effectiveness is weakened when risk adjustment is imperfect, at least in our simulation here.

6. Discussion and conclusion

It is well known that community rating in competitive mandatory health insurance markets can cause inefficient sorting of consumers across coverage options. A potential solution is the risk rating of incremental premiums, aiming to align marginal costs and premiums of additional coverage (on top of basic coverage). This paper explored under what circumstances, the risk rating of incremental premiums for additional coverage (e.g., full coverage) compared to a basic plan (e.g., the deductible option) can improve consumer sorting. To do so, we adapted the EFC graphical framework and simulated the incremental willingness to pay and cost curves using data from the Chilean private health insurance market. The study investigated the complex interactions between risk rating for additional coverage, moral hazard due to additional coverage, and imperfect risk adjustment in influencing consumer sorting and welfare outcomes.

Our findings show that under perfect risk adjustment, no moral hazard and an effective insurance mandate for basic coverage, community rating leads low-risk consumers to forgo full coverage. In contrast, under perfect risk-rating, all individuals choose the full-coverage plan, maximizing welfare gains. The increase in marginal costs and therefore premiums in the presence of moral hazard reduces enrollment in the full coverage plan with both community rating and risk rating. Particularly, with risk rating, we observe that for the group of high risk individuals, the incremental premiums exceed their willingness to pay, leading to reduced enrollment for this group in the full coverage plan. These findings contribute to the literature, such as Powell & Goldman (2021), which highlight how adverse selection can exacerbate inefficiencies when premium increases due to moral hazard lead to cost discrepancies for those who value additional coverage the most. Moreover, our findings resonate with Buchner & Schut (2025), who show that adverse selection and welfare consequences are not exclusive to low-risk individuals, and thus, welfare analysis necessitates including the extreme skewness of healthcare spending and the welfare loss due to the exclusion of high-risk individuals in voluntary insurance markets.

In the presence of imperfect risk adjustment (i.e., over and under compensations) for basic coverage, community rating can lead the market (for the full coverage plan) to unravel completely, with no individuals opting for this coverage. This is in line with Saltzman (2021), who shows that policy inefficiencies due to adverse selection lead to underinsurance. Contributing to the literature that has proposed risk rating as a solution to inefficient consumer sorting (Bundorf, Levin, and Mahoney, 2012; Layton, Ellis, McGuire, and van Kleef, 2017; Geruso, 2017; Van Winssen, van Kleef, and van de Ven, 2018), we show that in the presence of imperfect risk adjustment, high-risk individuals are actually excluded from the full coverage plan. This is contrary to the expectation that high-risk individuals would buy more comprehensive coverage, and goes against the usual assumption of risk adjustment, which suggests that transfers between plans should make comprehensive coverage more appealing. These findings highlight significant selection effects in the basic plan (Brown, Duggan, Kuziemko, and Woolston, 2014). This outcome is due to the observation that consumers' willingness to pay for additional coverage positively correlates with under compensations from the risk adjustment system regarding costs covered by the basic plan.

The relative forgone welfare gain calculations further underscore the impacts of these market forces. While risk rating continues to mitigate inefficiencies, its effectiveness is weakened when risk adjustment is imperfect.

Our analysis relies on several assumptions. First, we consider an insurance market with an effective mandate for buying basic coverage (such as the basic health insurance schemes in the Netherlands, Switzerland, and Germany) (Wasem, Buchner, Lux, and Schillo, 2018; Schmid, Beck, and Kauer, 2018; Van Kleef, Eijkenaar, van Vliet, and van de Ven, 2018). In some markets, such as the US marketplaces, individuals can opt-out from the market and remain uninsured, and in cases such as Ireland and Australia, "carrot and stick" type incentives to enroll act as soft-mandates (Armstrong, 2018; Paolucci, Sequeira, Fouda, and Matthews, 2018).

Relaxing the effective mandate assumption would require evaluating the "two-margin problem" as described by Geruso, Layton, McCormack, & Shepard (2021). The authors find that policies targeting one selection margin create unintended cross-margin effects. Particularly, that a strong mandate that boosts overall enrollment can substantially reduce the market share of more comprehensive plans, while a more sophisticated risk adjustment that encourages more comprehensive coverage can significantly reduce overall

participation. In settings like ours, where a public insurance system serves as an opt-out option, relaxing the effective mandate assumption combined with imperfect risk adjustment would likely cause low-risk individuals to switch to the public system. This adverse selection would increase the costs of basic coverage relative to comprehensive plans, potentially affecting marginal consumers' decisions to purchase high-coverage plans. The ultimate impact of these policies depends on consumer price responsiveness (Kettlewell and Zhang, 2024).

Moreover, we assume a market in which individuals participate for a variety of reasons, including risk aversion. Relaxing the effective mandate, following the above discussion, would result in a less risky pool remaining in the market. If opt-outs substantially reduce the overall level of risk heterogeneity in the pool, the magnitude of selection effects may be diminished. Ultimately, answering this question requires empirical assessment, which is the subject of future research.

Throughout the paper, we have assumed a perfectly competitive market in line with the Einav et al. (2010a) literature, without a loading fee or inclusion of profit margins. If insurers charge a fixed loading fee, the incremental cost curves shift upward, and the equilibrium moves to the right. Douven, et al. (2022) provide further discussion on the inclusion of profit margins and costs related to solvency requirements.

Additionally, our analysis focused on a simplified market with only two plans that differ in their financial coverage, the D plan and the FC plan. In real social health insurance systems, multiple plan options are available and might also differ in terms of quality. Nevertheless, following the EFC framework, this is enough to recover the key equilibria and welfare in markets with selection, and thus, allow us to isolate the impact of different premium settings and their interaction with moral hazard, risk adjustment and their effects on consumer sorting and welfare. The two-plan case is analytically clean and captures the core identification in larger menus because counterfactuals hinge on marginal movers between adjacent generosity levels. Related work with larger menus (e.g., in Medicare Part D and exchanges) also evaluate choice difficulties arising from market frictions and the impact of multiple plans with varying quality (Abaluck and Gruber, 2011, 2016; Bhargava, Loewenstein, and Sydnor, 2017; Handel, Kolstad, and Spinnewijn, 2019; Samek and Sydnor, 2020; Bundorf, Polyakova, and Tai-Seale, 2022).

In our analysis, we adopted a pragmatic approach to estimate risk premiums by assuming them to be a percentage of the standard deviation of healthcare spending. While this method effectively assigns higher premiums to individuals facing greater uncertainty, consistent with our empirical objectives, it simplifies the underlying theoretical foundations of risk aversion. Future research could strengthen this framework by deriving risk premiums from explicit utility functions, incorporating individual-specific risk aversion parameters to better capture heterogeneity in preferences for insurance coverage.

Last, we acknowledge that under risk rating, private and socially optimal allocations align. In markets with selection, this alignment may not be possible. While this is exacerbated by community rating, it can persist under risk-rated premiums due to information asymmetries and other market imperfections (Handel, 2013; Marone and Sabety, 2022).

Future research could relax these assumptions, and recognize that risk rating (even under perfect risk adjustment) alone may not suffice to ensure welfare gains if individuals struggle to select the optimal plan, possibly needing complementary strategies, such as smart defaults or guided plan selection frameworks to steer consumers towards value-maximizing choices (Handel, Kolstad, Minten, and Spinnewijn, 2020; Handel and Kolstad, 2015). In addition, the inclusion of other common market features, such as taxes and subsidies, that affect premiums, would allow to shed light on the complexity of regulation of health insurance markets. Further, while the direction of the results remains consistent when varying the levels of risk aversion and moral hazard, the simplifications made overlook heterogeneity in preferences and use in response to health coverage, which future research could examine more closely (Ericson and Starc, 2012). Indeed, Antonini, van Kleef, Henriquez, & Paolucci (2021) show that risk rating can increase the ability of voluntary deductibles to reduce moral hazard, although this advantage diminishes when high-risk individuals reduce utilisation less than low-risk individuals.

The goal of the paper was to explore under what circumstances risk rating of the incremental premium of more comprehensive coverage can improve consumer sorting and therefore welfare. This paper has shown that without perfect risk adjustment, the welfare effects of risk rating are ambiguous, as consumers with the highest willingness to pay for additional coverage are more likely to not enroll in additional coverage. This paper's findings have important policy implications for the design of health insurance markets, as state-of-the-art risk adjustment models do not perfectly compensate for predictable variation in health care spending regarding basic coverage. While risk rating of incremental premiums consistently improves welfare over community-rating, its ability to address inefficient consumer sorting depends on the adequacy of risk adjustment. Given the results, risk rating would have to be paired with a risk adjustment system that explicitly focuses on reducing the under compensations such that the high risk individuals are not adversely selected out of the full coverage plan (Glazer and McGuire, 2000; van Kleef R. C., McGuire, van Vliet, and van de Ven, 2017; Lorenz, 2017), as in the scenarios considered, risk rating alone would not fully resolve sorting inefficiencies and may introduce fairness and access concerns.

Declaration of competing interest

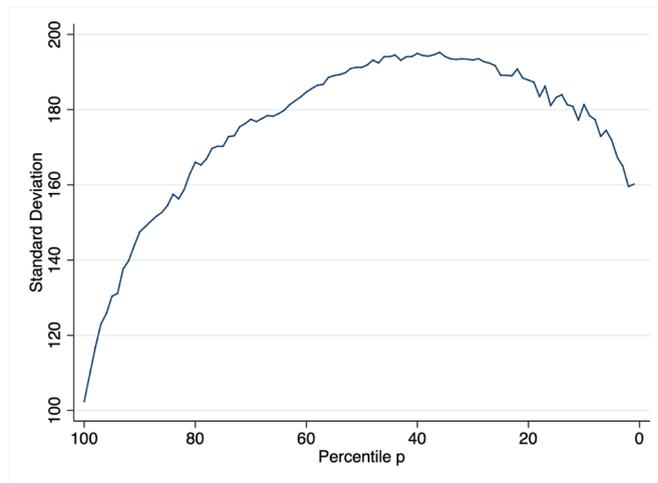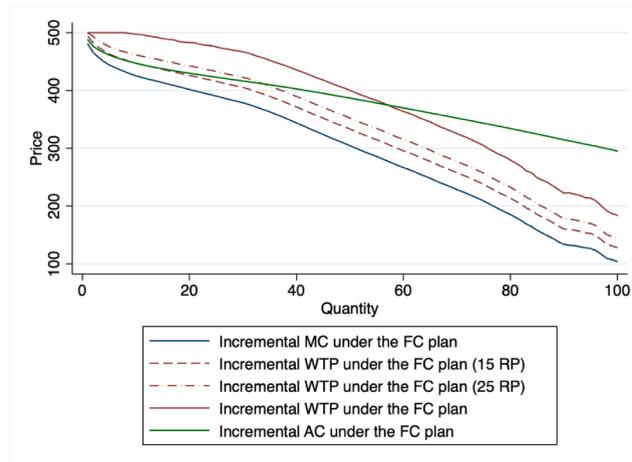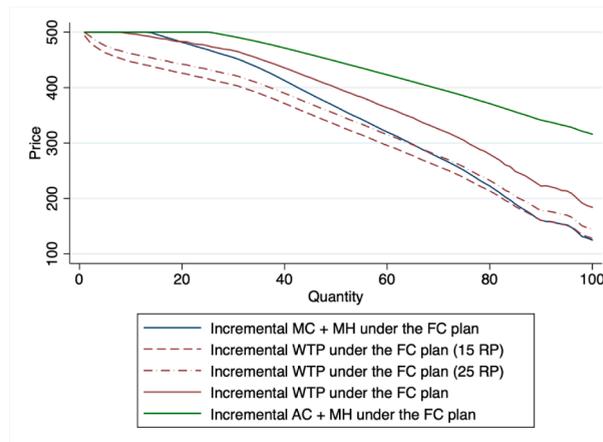The authors declare no competing interests.

Appendix

Fig. A1. Distribution of the Standard deviation of total health spending capped at $500 by percentile p.
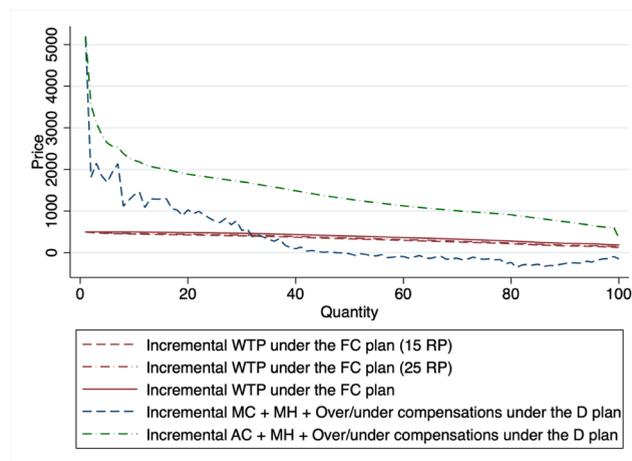
Panel 1: Scenario 1– Baseline

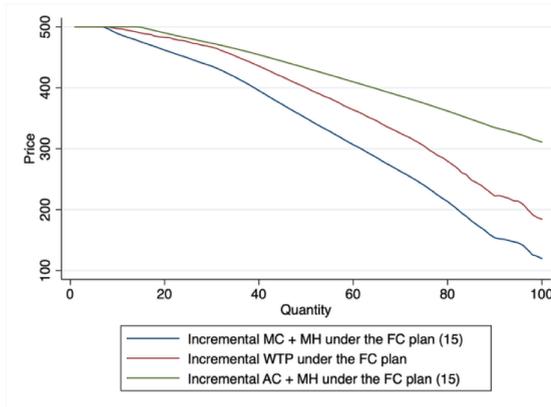Panel 2: Scenario 2 – Introduction of moral hazard due to FC plan

Panel 3: Scenario 3 – Introduction of 20% moral hazard due to FC plan and imperfec
risk adjustment

Note: the figure excludes the Incremental MC and AC curves in the absence of imperfect risk
adjustment. MC = marginal cost, WTP = willingness to pay, AC = average cost, FC =full coverage,
MH = Moral hazard. 15 RP = 15% risk premium; 25 RP = 25% risk premium

Fig. A2. Different degrees of risk aversion.

Panel 1: Scenario 2 – Introduction of moral hazard (15% constant function) due to FC plan
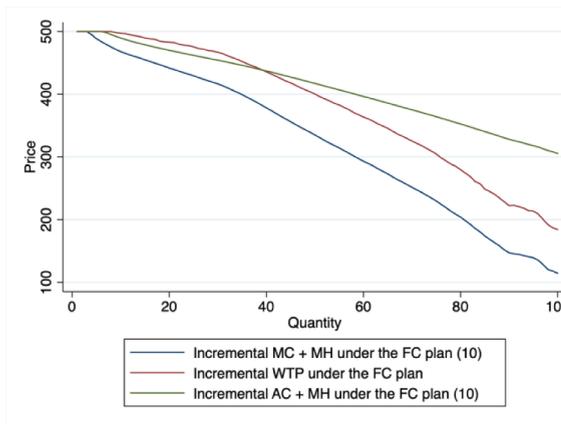
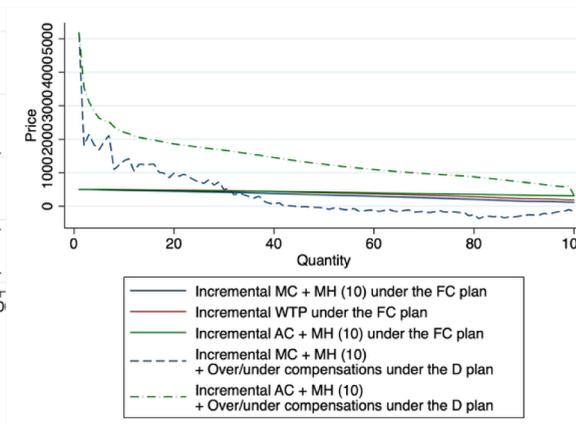Panel 2: Scenario 3 – Incorporating imperfect risk adjustment (moral hazard of 15% constant function)
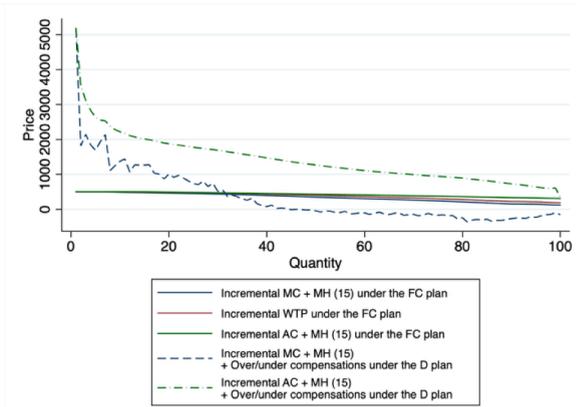
Note: MC = marginal cost, WTP = willingness to pay, AC = average cost, FC =full coverage, MH = Moral hazard;

15 = 15% constant function of moral hazard

Panel 3: Scenario 2 – Introduction of moral hazard (10% constant function) due to FC plan

Panel 4: Scenario 3 – Incorporating imperfect risk adjustment (moral hazard of 10% constant function)
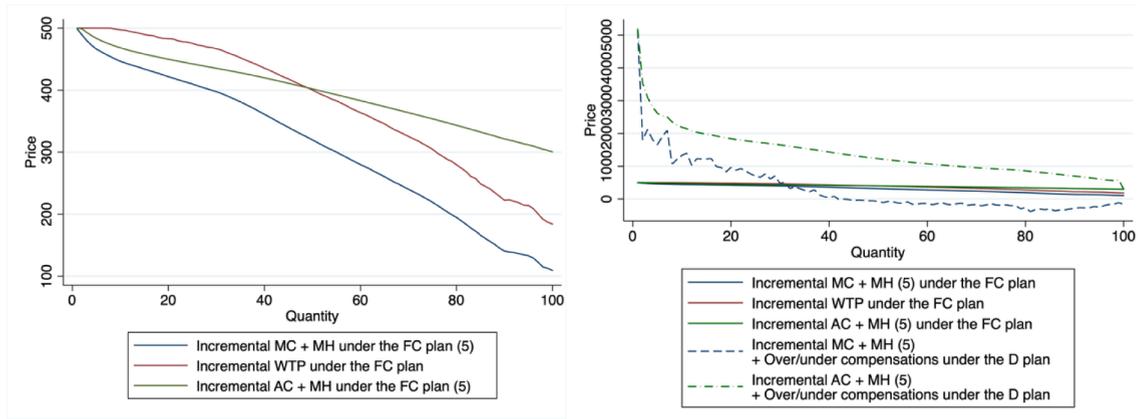

Note: MC = marginal cost, WTP = willingness to pay, AC = average cost, FC =full coverage, MH = Moral hazard;

10 = 10% constant function of moral hazard

Fig. A3. Assuming 15 %, 10 % and 5 % Moral Hazard.

Panel 5: Scenario 2 – Introduction of moral hazard (5% constant function) due to FC plan

Panel 6: Scenario 3 – Incorporating imperfect risk adjustment (moral hazard of 5% constant function)
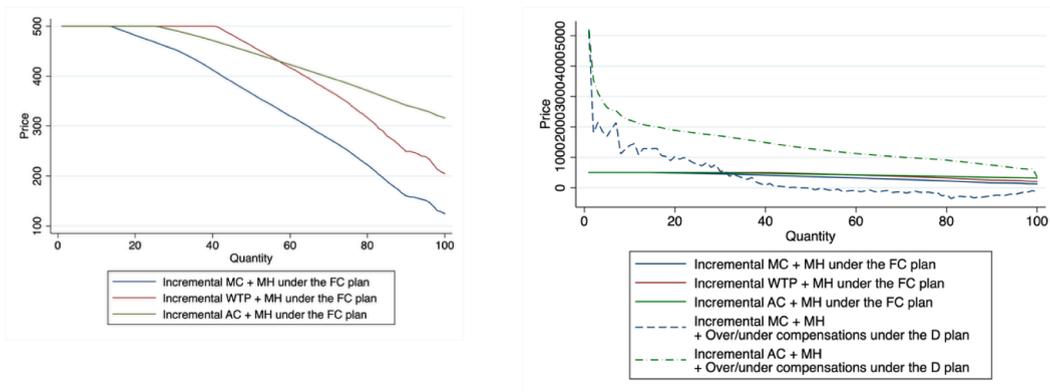

Note: MC = marginal cost, WTP = willingness to pay, AC = average cost, FC =full coverage,

MH = Moral hazard;

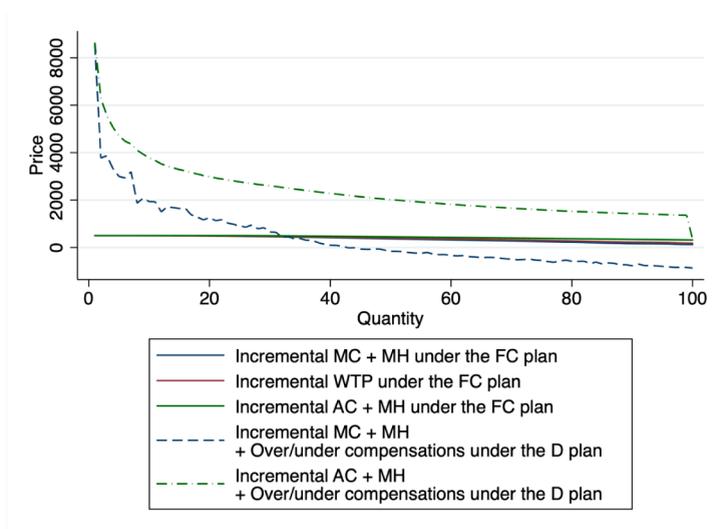5 = 5% constant function of moral hazard

Fig. A3. (*continued*).

Panel 1: Scenario 2 – Introduction of moral hazard due to FC plan

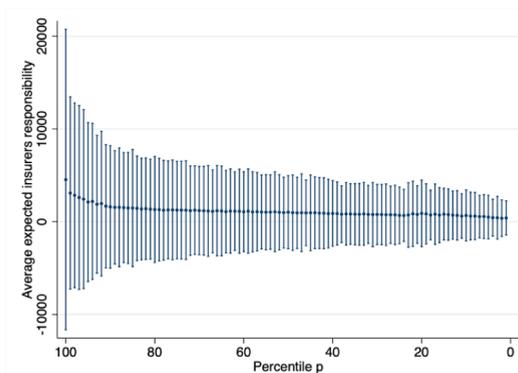Panel 2: Scenario 3 – Incorporating imperfect risk adjustment

Note: MC = marginal cost, WTP = willingness to pay, AC = average cost, FC =full coverage,

MH = Moral hazard

Fig. A4. Inclusion of MH in the incremental WTP (For scenario 2 and scenario 3 with 20 % MH).
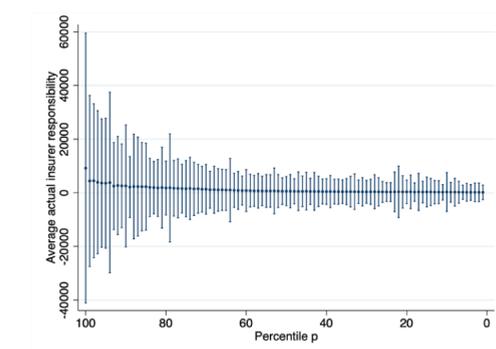
Note: MC = marginal cost, WTP = willingness to pay, AC = average cost, FC =full coverage,

MH = Moral hazard

Fig. A5. No risk adjustment.

Panel 1: Distribution of the expected insurers responsibility under D plan ($\overline{\overline{RAP}}_p$, risk adjusted) per percentile p

Panel 2: Distribution of the actual insurers responsibility under the D plan ($\bar{y}_p$) per percentile p

Note: The dot points in the figure denote the average of the measures, while the bars show the standard errors.

Fig. A6. Distribution of the expected and actual insurers responsibility under D plan.

Data availability

Data can be accessed upon direct request to the Superintendence of Health of Chile through their website.

References

Abaluck, J., Gruber, J., 2011. Choice inconsistencies among the elderly: evidence from plan choice in the medicare part D program. Am. Econ. Rev. 101 (4), 1180–1210.

Abaluck, J., Gruber, J., 2016. Evolving choice inconsistencies in choice of prescription drug insurance. Am. Econ. Rev. 106 (8), 2145–2184.

Akerlof, G., 1970. The market for "lemons": quality, uncertainty and the market mechanism. Q. J. Econ.

Antonini, M., van Kleef, R.C., Henriquez, J., Paolucci, F., 2021. Can risk rating increase the ability of voluntary deductibles to reduce moral hazard? Geneva Pap. Risk Insur. Issues Pract. 48 (1), 130.

Armstrong, J., 2018. Health plan payment in Ireland. In: McGuire, T., Van Kleef, R. (Eds.), Risk adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets. Academic Press, pp. 331–364.

Ash, A.P., 1989. Adjusting Medicare capitation payments using prior hospitalization data. Health Care Financ. Rev. 10 (4), 17–29.

Bhargava, S., Loewenstein, G., Sydnor, J., 2017. Choose to lose: health plan choices from a menu with dominated options. Q. J. Econ. 132 (3), 1319–1372.

Brown, J., Duggan, M., Kuziemko, I., Woolston, W., 2014. How does risk selection respond to risk adjustment? New evidence from the Medicare Advantage program. Am. Econ. Rev. 104 (10), 3335–3364.

Buchner, F., Schut, F., 2025. High-risk individuals in voluntary health insurance markets: the elephant in the room? Health Econ. Policy Law 1–14.

Bundorf, M., Levin, J., Mahoney, N., 2012. Pricing and welfare in health plan choice. Am. Econ. Rev. 102 (7), 3214–3248.

Bundorf, M., Polyakova, M., & Tai-Seale, M. (2022). How do humans interact with algorithms? experimental evidence from health insurance. *National Bureau of Economic Research, WORKING PAPER* 25976.

Cohen, A., Einav, L., 2007. Estimating risk preferences from deductible choice. Am. Econ. Rev. 97 (3), 745–788.

Deb, P., Norton, E., 2018. Modeling health care expenditures and use. Annu. Rev. Public Health 39, 489–505.

Dixit, A., Stiglitz, J., 1977. Monopolistic competition and optimum product diversity. Am. Econ. Rev. 67 (3), 297–308.

Douven, R., Kauer, L., Demme, S., Paolucci, F., van de Ven, W., Wasem, J., Zhao, X., 2022. Should administrative costs in health insurance be included in the risk-equalization? An analysis of five countries. Eur. J. Health Econ. 1437–1453.

Eijkenaar, F., van Vliet, R.C., 2018. Improving risk equalization using information on physiotherapy diagnoses. Eur. J. Health Econ. 19 (2), 203–211.

Einav, L., Finkelstein, A., 2011. Selection in insurance markets: theory and empirics in pictures. J. Econ. Perspect. 25 (1), 115–138.

Einav, L., Finkelstein, A., 2023. Empirical analyses of selection and welfare in insurance markets: a self-indulgent survey. Geneva Risk Insur. Rev. 48, 167–191.

Einav, L., Finkelstein, A., Cullen, M., 2010a. Estimating welfare in insurance markets using variation in prices. Q. J. Econ. 125 (3), 877–921.

Einav, L., Finkelstein, A., Schrimpf, P., 2010b. Optimal mandates and the welfare cost of asymmetric information: evidence from the uk annuity market. Econometrica 78 (3), 1031–1092.

Einav, L., Finkelstein, A., Ryan, S., Schrimpf, P., Cullen, M., 2013. Selection on moral hazard in health insur. Am. Econ. Rev. 103 (1), 178–219.

Ellis, R., Martins, B., Rose, S., 2018. Risk adjustment for health plan payment. In: McGuire, T., van Kleef, R. (Eds.), Risk Adjustment, Risk Sharing and Premium Regulations in Health Insurance Markets: Theory and Practice. Academic Press, pp. 55–104.

Ericson, K., Starc, A., 2012. Heuristics and heterogeneity in health insurance exchanges: evidence from the Massachusetts connector. Am. Econ. Rev. 102 (3), 493–497.

Ericson, K., Sydnor, J., 2017. The questionable value of having a choice of levels of health insurance coverage. J. Econ. Perspect. 31 (4), 51–72.

Geruso, M., 2017. Demand heterogeneity in insurance markets: implications for equity and efficiency. Quant Econ. 8 (3), 929–975.

Geruso, M., Layton, T., McCormack, G., Shepard, M., 2021. The two margin problem in insurance markets. Rev. Econ. Stat.

Glazer, J., McGuire, T.G., 2000. Optimal risk adjustment in markets with adverse selection: an application to managed care. Am. Econ. Rev. 90 (4), 1055–1071.

Handel, B., 2013. Adverse selection and inertia in health insurance markets: when nudging hurt. Am. Econ. Assoc. 103 (7), 2643–2648.

Handel, B.R., Kolstad, J.T., 2015. Health insurance for "humans": information frictions, plan choice, and consumer welfare. Am. Econ. Rev. 105 (8), 2449–2500.

Handel, B., Hendel, I., Whinston, M., 2015. Equilibria in health exchanges: adverse selection versus reclassification risk. Econometrica 83 (4), 1261–1313.

Handel, B., Kolstad, J., Spinnewijn, J., 2019. Information frictions and adverse selection: policy interventions in health insurance markets. Rev. Econ. Stat. 101 (2), 326–340.

Handel, B., Kolstad, J., Minten, T., & Spinnewijn, J. (2020). The social determinants of choice quality: evidence from health insurance in The Netherlands. *NBER Working Paper Series - Working Paper 27785*.

Henriquez, J., van Kleef, R., Matthews, A., McGuire, T., & Paolucci, F. (2023). Combining risk adjustment with risk sharing in health plan payment systems: private health insurance in Australia. *National Bureau of Economic Research (No. w31052)*.

Kettlewell, N., Zhang, Y., 2024. Financial incentives and private health insurance demand on the extensive and intensive margins. J. Health Econ. 94.

Klein, P., van Kleef, R., Henriquez, J., Paolucci, F., 2023. The interplay between risk adjustment and risk rating in voluntary health insurance. J. Risk Insur. 90 (1), 59–91.

Layton, T., 2017. Imperfect risk adjustment, risk preferences, and sorting in competitive health insurance markets. J. Health Econ. 56, 259–280.

Layton, T., Ellis, R., McGuire, T., van Kleef, R., 2017. Measuring efficiency of health plan payment systems in managed competition health insurance marketsMeasuring efficiency of health plan payment systems in managed competition health insurance markets. J. Health Econ. Dec (56), 237–255.

Layton, T., Montz, E., Shepard, M., 2018. Health plan payment in US marketplaces: regulated competition with a weak mandate. In: McGuire, T., van Kleef, R. (Eds.), Risk Adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets Theory and Practice. Academic Press, pp. 491–521.

Lorenz, N., 2017. Using quantile and asymmetric least squares regression for optimal risk adjustment. Health Econ. 26 (6), 724–742.

Manning, W.G., Newhouse, J.P., Duan, N., Keeler, E.B., Leibowitz, A., 1987. Health insurance and the demand for medical care: evidence from a randomized experiment. The Amer. econ. rev. 251–277.

Marone, V., Sabety, A., 2022. When should there Be vertical choice in health insurance markets? Am. Econ. Rev. 112 (1), 304–342.

Ministerio de Salud. (2019). Formula Indicación Sustitutiva al Proyecto de Ley que modifica el Sistema Privado de Salud, Incorporando un Plan Garantizado (Boletín N 8105-11).

Outreville, J., 2014. Risk aversion, Risk behavior, and demand for insurance: a survey. J. Insur. Issues 37 (2), 158–186.

Paolucci, F., Sequeira, A., Fouda, A., Matthews, A., 2018. Health plan payment in Australia. I. In: McGuire, T., van Kleef, R. (Eds.), Risk adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets. Academic Press, pp. 181–208.

Pardo, C., Schott, W., 2014. Health insurance selection in Chile: a cross-sectional and panel analysis. Health Policy Plan 29 (3), 302–312.

Powell, D., Goldman, D., 2021. Disentangling moral hazard and adverse selection in private health insurance. J. Econom. 222 (1, Part A), 141–160.

Rothschild, M., Stiglitz, J., 1978. Equilibrium in competitive insurance markets: an essay on the economics of imperfect information. Q. J. Econ. 90 (4), 629–649.

Saltzman, E., 2021. Managing adverse selection: underinsurance versus underenrollment. Rand J. Econ. 52 (2), 359–381.

Samek, A., & Sydnor, J. (2020). Impact of consequence information on insurance choice. *National Bureau of Economic Research, WORKING PAPER 28003*.

Schmid, C.P., Beck, K., Kauer, L., 2018a. Health plan payment in Switzerland. In: McGuire, T., Van Kleef, R. (Eds.), Risk adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets. Academic Press, pp. 453–489.

Superintendencia de Salud, 2024. *Planes de Salud*. Retrieved from Estadística Anual de Planes de Salud del Sistema Isapre a Enero 2024. https://www.superdesalud.gob.cl/app/uploads/2024/08/estadistica-anual-planes-de-salud-ano-2024-1.xlsx.

van Kleef, R.C., McGuire, T.G., van Vliet, R.C., van de Ven, W.P., 2017. Improving risk equalization with constrained regression. Eur. J. Health Econ. 18 (9), 1137–1156.

van Kleef, R., Eijkenaar, F., van Vliet, R., 2020. Selection incentives for health insurers in the presence of sophisticated risk adjustment. Med. Care Res. Rev. 77 (6), 584–595.

Van Kleef, R., Eijkenaar, F., van Vliet, R., van de Ven, W., 2018a. Chapter 14 - health plan payment in the Netherlands. In: McGuire, T., van Kleef, R. (Eds.), Risk Adjustment, Risk Sharing and Premium regulation in Health Insurance Markets. Academic Press, pp. 397–429.

Van Kleef, R., Hamstra, G., Pirktl, L., Holly, A., 2024. Selection in insurance markets with a strong mandate and contract space – A graphical framework and empirical application. In: Risk Adjustment Network Annual Meeting. Dublin.

Van Kleef, R., Schut, F., van de Ven, W., 2018c. Premium regulation, risk equalization, risk sharing, and subsidies: effects on affordability and efficiency. In: McGuire, T., van Kleef, R. (Eds.), Risk Adjustment, RIsk Sharing and Premium Regulation in Health Insurance Market. Theory and Practice. Academic Press, pp. 21–54.

Van Winssen, K., van Kleef, R., van de Ven, W., 2018. Can premium differentiation counteract adverse selection in the Dutch supplementary health insurance? A simulation study. Eur. J. Health Econ. 19, 757–768.

Velasco, C., Henríquez, J., Paolucci, F., 2018. Health plan payment in Chile. In: McGuire, T., Van Kleef, R. (Eds.), Risk adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets. Academic Press, pp. 235–261.

Wasem, J., Buchner, F., Lux, G., Schillo, S., 2018. Health plan payment in Germany. In: McGuire, T., Van Kleef, R. (Eds.), Risk adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets. Academic Press, pp. 295–329.

Withagen-Koster, A.A., van Kleef, R.C., Eijkenaar, F., 2024. High-risk pooling for mitigating risk selection incentives in health insurance markets with sophisticated risk equalization: an application based on health survey information. BMC Health v Res 24 (1).

Zweifel, P., Manning, W.G., 2000. Moral hazard and consumer incentives in health care. In: Handbook of Health Economics, 1. Elsevier, pp. 409–459.