Ninth Annual Actuarial Case Competition

Final Report

March 10th, 2018

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Health

The essential function of health insurance is to ensure the financial security of the policyholder in the event of illness by providing for health services mandated by the Affordable Care Act (ACA). Like other forms of insurance, a health insurance plan will include some form of deductible and annual limit.

The deductible, copayment, and out-of-pocket maximum are all amounts of money which the policyholder may be obligated to furnish for medical services before costs are covered by insurance. Expected premium thus varies inversely with each of these quantities. The deductible is the annual amount of money which the insured is responsible for paying for their health care, while copayment is the amount payable by the insured per individual treatment, after the deductible is met. The out-of-pocket maximum caps the amount of money which the insured may be required to pay for medical services during a given time period, typically a year.

Conversely, the annual limit of a health insurance plan caps the amount of money which the insurer is responsible for providing on behalf of the policyholder over the course of a year. A higher annual limit will result in a higher premium as a greater potential obligation for the insurer must be met with greater contribution from the policyholder.

The "metal-tier" plans are differentiated from each other by their respective levels of coinsurance and actuarial value. Coinsurance is the percentage of medical costs which the policyholder pays, whereas actuarial value is the percentage of medical costs which the insurer pays. On average, Bronze plan has an actuarial value of 60%, Silver has 70%, Gold has 80%, and Platinum has 90%. As the actuarial value of a plan increases, so to does the premium as more coverage increases the severity of loss to the insurer, hence increasing the pure premium.

Assuming an 85% loss ratio coupled with a 10% annual trend, we arrive at the following PEPM rates for 2018 per the ACA metal-tiers:

	Bronze	**Silver**	**Gold**	**Platinum**
PEPM Rates	$470.97	$631.30	$775.39	$963.19
Deductible	$6650	$4000	$2650	$1350
Coinsurance	0.4	0.3	0.2	0.1
Out-of-pocket max	$7350	$7350	$7350	$7350

If clients are allowed to choose between these coverage plans instead of being offered a single standalone plan, then these rates are not suitable to maintain an 85% loss ratio. The previously stated PEPM rates were computed assuming the entire book of business was under the same type of plan. If these same rates were offered in a multi-choice setting, then claims being filed by policyholders of plans with higher actuarial value could not be adequately covered by the total pool of premium dollars. The fact that some clients would be paying lower premium for plans with

lower actuarial value would make the total sum of annual premium insufficient to cover losses to the point where they only account for 85% of these cash inflows.

Ideally, we would like to lower deductibles for the bronze and silver plans in order to bring the premium up, given the ideal plan situation is based off of historical claims data. For high risk individuals who move to the bronze category, because of a low premium (Cutler, 8), we want to keep their deductible the same so that they essentially bring up the premium of the plan that they are choosing by a predetermined optimal margin. To completely mitigate adverse selection, we want to have the premiums of the four plans to be the same as the standalone rates. From the consumer's point of view, the best plan choice would be the plan with the lowest premium but also the most coverage. In the case that adverse selection is completely mitigated, consumers would likely go for the plans that have rates that are the same as the standalone rates. We constructed plans to mitigate adverse selection below.

	Bronze	**Silver**	**Gold**	**Platinum**
*PEPM rates (claim data deductible, max adverse selection)***	$647.31	$709.16	$776.82	$871.61
Deductible	**5000,claim dependent (cd.)	**4000,(cd.)	**3000,(cd.)	**2000,(cd.)
Coinsurance	0.4	0.3	0.2	0.1
Out-of-pocket max	$7350	$7350	$7350	$7350

Given the directive to minimize rates without allowing for adverse selection, we would make edits to the original plan designs similar to what we did previously. This would discourage people from switching to plans that would negatively affect the insurer. By having the rates similar to the standalone rates, we are able to eliminate the effects of adverse selection, while regulating premiums in a way that benefits the insurer and the insured by providing the appropriate amount of coverage based off of their claims.

Property and Casualty

AllProvince's base rate in effect since January 1st, 2017 has been $800. In order to properly assess the adequacy of premiums with respect to historical loss ratios, it is necessary to consider all exposures from both 2016 and 2017 at the current rate level. This is so that our data will be viewed in the most recent experience period's frame of reference (Werner and Modlin, 71). Thankfully, doing so in the scenario presented is straightforward. Given that only the base rate was changed on January 1st, 2017, we need only assign a base rate of $800 to each policy written in 2016 and proceed to price them with the same class factors as those stipulated by the 2017 rating algorithm.

Written premium for a given time period is the sum of the earned and unearned premium for policies which take effect during that time period, typically a calendar year (Werner and Modlin, 68). Earned premium is the amount of premium paid for coverage which the policy provides during the year it takes effect, whereas unearned premium is the amount of premium paid for coverage provided during the subsequent year, if any. For example, a policy written on January 1st, 2018 and a policy written on July 1st, 2018 both have the same written premium, but the first policy has earned premium account for 100% of its written premium, whereas the second has earned premium account for only 50% of its written premium.

Incurred losses are the sum of paid losses and case reserves for all claims in a company's book of businesses. The primary loss ratios used in an insurance context are incurred to earned, paid to written, and incurred to written (Hopper et al., 418). Our data includes both paid losses and case reserves, thus we have knowledge of the incurred losses at our disposal. Given this information, we will do a loss ratio analysis using the incurred to earned method as this provides the best match between total losses on policies effective that year and premium earned on those policies for that year.

We compute the 2016 loss ratio as 49% and the 2017 loss ratio as 67%. By convention, premium is the product of the base rate and all class factors. In order to increase premium by 10% effective on January 1st 2019, it is possible to scale both the base rate and various class factors by less than 10% such that their product still results in a 10% greater premium for 2019. Because we only have two years worth of data, it is unlikely that we can reliably predict how much AllProvince's book of business will grow from 2017 to 2018 and then from 2018 to 2019. We can however make useful deductions pertaining to the rating algorithm by examining loss ratios for different segments of AllProvince's mix-of-business.

Class factors vary directly with Coverage A and Age of Home as is sensible, thus there is no pressing reason to change them relative to each other. Credit Group class factors on the other hand were computed with a faulty assumption of seeing a 50%-35%-15% distribution between "High", "Medium" and "Low". This is not reflected by reality; for both 2016 and 2017, there is a nearly equal split between the three credit tiers among the policyholders. Because the class factors for credit group were computed under falls assumptions, large disparities in loss ratio between the tiers is apparent for both years.

The Loss Ratio Relativity Method, one of the two primary tools for adjusting class factors based on historical data, (Donlan & Ternacioglu, Slide 10) was used to propose a rating algorithm for 2019. We used this method to adjust class factors for Territory and Credit Group, and also introduce Smoke Detector as a rating variable after determining the weighted average between 2016 and 2017 of the class factors yielded by this method. In order to avoid excessively dramatic changes in the class factors effective 2019, we scaled the weighted class factors in equal proportion mutual to each other. The resultant figures were as follows.

Territory	1	2	3	4	5
Factor	1.013	1.060	1.058	1.006	0.981

Credit Group	High	Medium	Low
Factor	0.88	1	1.23

Smoke Detector	Yes	No
Factor	1	1.015

Smoke detectors are a standard component of homes, and the risk represented by a lack of one should be accounted for by a class factor exceeding 1. Territory and Credit Group factors were adjusted per the historical loss data, and then had their distances from 1 scaled down in hopes of minimizing policy-level premium dislocation. After these factors were put in place and applied to the policies put in effect during 2017, the base rate necessary to achieve a 10% increase in written premium (from $16,605,534 in 2017 to $18,266,087 in 2017) was computed to be $863, representing a 7.9% increase in base rate. For the many cases which we examined, achieving low policy-level premium dislocation proved extremely difficult. The final rating program proposed saw an average premium dislocation for 2019 of $184.28 compared to a mean of $166.44 for 2017. However, 2019 exhibited a much higher standard deviation and maximum of premium dislocation than 2017, which will likely result in considerable loss of business.

In order to retain old business and attract new business outside of rate adjustment, it would be advisable for AllProvince to market their insurance product as one that is appropriate for homeowners with high credit ratings, as they would receive a discount with respect to the base rate. Per historical data, this would also reduce loss ratio. Unlike the 2017 rate change, the 2019 rate change did result in some premiums being reduced, mostly for policyholders in the high-rated credit group, which will ideally attract new business from that segment.

Retirement

We assume a 6% contribution to the 401(k) will be made in order to access the maximum amount of contribution from the company. Under this assumption, we computed the Age 65 lump sum values as below. We further assume the employee remains at the same company for his entire career.

Company 1	**Company 2**	**Company 3**
$1,503,941	$1,403,662	$3,103,765

While the value assigned to Company 3 exceeds the values assigned to Companies 1 and 2, note that this is due to the assumption that the employee would choose to contribute 6% annually to the fund. The potential for considerable variability in the lump sum value of Company 3's retirement plan will be further discussed later. Although Companies 1 and 2 yield substantial retirement money with no contribution from the employee, we believe Company 3 should be

chosen because it has the maximum optimal return of the three. We concluded for our group that sacrificing some spending today is worth sacrificing for a secure and leisurely retirement.

Given that everyone in our group was male, we chose to assign the average American male life expectancy of 79 years (rounded up to the nearest year) to our hypothetical employee in the initial computations. Company 1 would furnish $105,867 annually per the provisions of the Final Average Pay Plan, while Company 2 would pay $127,772 annually by distributing the lump sum over 14 years as a level annuity-due. Only Company 3 would deliver annual payments which are higher than the final salary of $249,516, namely $282,529. For both Company 2 and 3, we used the Treasury rate to discount the annuity payments, as this represents the return of a risk-free investment. Only Company 3's 401(k) plan would allow for a similar lifestyle post-retirement to the one enjoyed during the final years of employment based on annual salary per the reputable study.

For the Final Average Pay Plan's Age 65 lump sum to reach 11 times the final year's salary, the factor by which the averaged salary would need to be multiplied would be approximately 0.0266 (or 2.66%). The Cash Balance Plan would need to progress from 9%-14% in 5-year increments rather than 3%-8% in order to reach the same goal. To reach the same result purely from personal contribution, the employee would be required to contribute about 10.35% of his salary each year.

When calculating the lump sum of the employee's retirement plan, potential changes to the variables must also be considered through sensitivity analysis. The first variable considered would be the age in which the employee first starts putting money towards their retirement. Intuitively, the earlier an employee begins saving for retirement, the more money they will have saved (See graph).

Similarly, the later the employee retires, the more money he can save for retirement. However, this is less important as a metric as compared to current age because employees are trying to improve their retirement by having maximal savings for it, so planning on retiring later in order to have enough saved is not ideal as it will shorten retirement.

We must also account for potential changes in current pay. This sensitivity analysis models the effects of an increase or decrease in starting salary. As is obvious, the more money the employee's current pay is, the greater their retirement fund (See Graph).

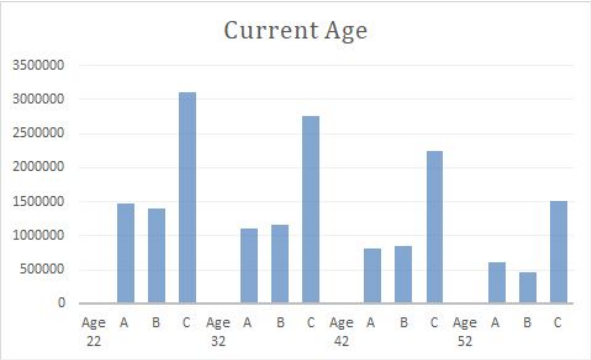
For initial computations, we used the American male life expectancy to calculate how long the employee will need to fund their retirement, but since men only make up half of the United States population, we must take into the American female life expectancy of 81. Clearly, expected age of mortality varies directly with necessary retirement savings, so female employees of these companies will likely have less adequate pension funds compared to their male colleagues.

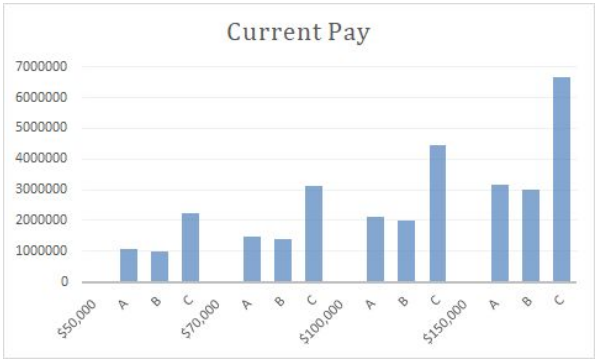
The housing cost which an employee incurs are not included in the formulas for lump sum factors and annual benefits. However, housing costs will have a major effect on the employee's saving for retirement. Mortgages are substantial expenses that take decades to pay off. Additionally, the employee will have to pay annual taxes on their house. So, the more expensive the house, the less money the employee will have saved for retirement. This reduces their potential contributions to the 401(k) plan offered by Company 3.

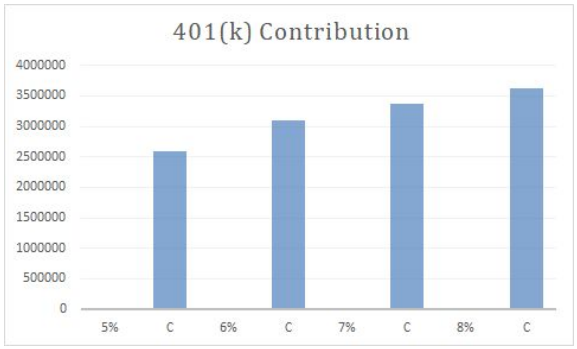
Similar to housing costs, family size is not accounted for in the lump sum factor and annual benefits formulas, but it is a major expense that will impact retirement savings. The more children

an employee has, the less they will be able to contribute annually towards their retirement. Like greater housing costs, greater family size reduces potential 401(k) contributions.

Changes in the investment rate will also have effects on retirement adequacy. Since the Final Average Pay Plan does not involve investing, the investment rate has no effect on the lump sum factor and annual benefit of that plan. However, Company 2 and 3's plans do involve a compounding pension fund and for these plans, pension fund value varies directly with investment rate.







Another potential change is variation in the employee's spending habits. Again, this only has an effect on the 401k plan. A higher propensity for discretionary spending lowers the percentage of the employee's income going towards their 401(k), which means less is contributed by their employer. If they lower their spending and puts more money into their 401(k) past 6%, the employer will not match it, but continue contributing only 6% (See Graph).

There are numerous ways for an employee to improve their retirement adequacy. The purchase of positive-return, low-risk securities (e.g. gold, mutual funds, real-estate) provides a source of stable, non-household earned income. For any retirement plan that would benefit from member contribution, this would increase the defined lump sum received during the member's active retirement years. Depending on starting salary, the amount of yearly income invested in low-risk securities can benefit from investment returns, returned on rates up until market interest rates are taken into account.

Additionally, if an employee is part of a household with a combined income higher than the median American household income, so-called 'shock events' result in less of an pressure on the retired individual to rely on Social Security monthly benefits to cover costs (Bajtelsmit et. al, 3). A

multi-income household increases the potential growth of assets into retirement as well, as there is opportunity to maximize wealth via household asset portfolio diversification, increasing non-household income going into retirement.

One other option to improve retirement adequacy would be to work part-time through retirement. While this is a more challenging approach to improving financial stability in case of a shock event, a less demanding approach would be to reduce potential medical costs by living a healthy lifestyle. This would apply independent of the retirement plan chosen.

From the perspective of employers, it may be advisable to improve vesting benefits, or financial incentives, for all plan members as well as maintain the real value of retained benefits through to retirement. Improving vested benefits will likely allow employees to accumulate more benefits over time with the company. Additionally, having employers managing the real value of retained benefits through to retirement will result in a greater gain for employees.

Furthermore, having employers reduce pre-retirement leakage of pension funds by limiting access to funds prior to retirement will eliminate any kind of premature usage of such funds. In essence, the goal of this would be to have employees put in and have more in the meantime, so that they can derive more future value.

Another possibility would be for the employers to introduce a requirement where part of the retirement benefits must be taken as an income stream, in other words, taken from part of the money the company generates on a regular basis. Depending on the amount of money a certain company generates, money drawn from the income stream will vary.

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