Case Study Assignment Project Brief 1

Health Insurance Policy Design for Wholesome Insurance

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Introduction to Operations Research

Executive Summary

Wholesome Insurance is attempting to introduce a new health insurance policy to the market. To stand out from competition, the policy is planned to cost $20 per month. It covers seven individual claim categories which includes, "general dental," "major dental," "optical," "physiotherapy," "chiropractic," "osteopathy," and "alternative and natural therapies." These have set minimum claim limits to ensure public appeal. To increase above these minimum claim limits results in a proportional increase in customers, claims paid out and claims filled. Wholesome Insurance is looking for recommendations of claim limits to maximize profits for their proposed health insurance policy. Furthermore, Wholesome Insurance would like to be aware of the effects of addition constraints of a balanced policy on the profitability of the policy. Finally, they believe that the total claim limit (sum of claims of all categories) of $4000 is potentially erroneous and in fact could be up to $5000. They would like to establish any affects of increasing that claim limit up to $5000. To achieve this, we used a linear programming model to determine optimal claim limits to ensure maximal profits and conduct sensitivity analysis to determine both the stability of the model and the effects of the change in claim limits. It was found that there was a direct and linear relationship between increasing the claim limit and the profitability of the policy. It was determined that the maximum profit achievable with the health insurance policy is a range of $710,000 to $1,100,000 depending on the total claim limit. The alternative policy, which ensured a balanced policy, resulted in a maximum profit of $660,000 to $976,670. Finally, it was determined that the results provided are robust, given a potential small variance within the market research data provided.

Introduction

Wholesome Insurance is bringing a new health insurance policy to the market. The goal behind the policy Wholesome Insurance is introducing a new health insurance policy to the market with the objective of offering a more affordable option than competitors, thereby attracting new customers. The policy is planned to cost $20 per month. It covers seven claim categories: "general dental," "major dental," "optical," "physiotherapy," "chiropractic," "osteopathy," and "alternative and natural therapies." Each category has specific claim limits, allowing customers to receive reimbursements up to those limits during healthcare visits throughout the year.

Increasing the claim limits enhances the policy's appeal to the public but also leads to higher claim payouts as a result. Another cost associated with a growing customer base is the staffing required for claim processing. The estimated cost of processing a claim by Wholesome Insurance is $100. The company aims to optimize profitability by maximizing the number of customers while minimizing costs related to claim payouts and processing.

Market research has been conducted to assess the impact of changes in claim limits. It was found that claim limits below a certain threshold in each category rendered the policy unappealing to customers, resulting in no customers choosing the policy over competitors. These minimum claim limits are presented in table 1. Furthermore, the research indicated that an increase in claim limits above the established minimums corresponded to a proportional increase in the number of customers signing up. This relationship is demonstrated in table 1, which illustrates the effect of raising claim limits by $100.

However, the rise in claim limits attracts more customers but also leads to a higher volume of claims filed and increased claim payouts. The impact of this increase in claims and payouts was also investigated, revealing a linear relationship between raising claim limits by $100 and the corresponding increase in claims filed and total claim payouts. Table 1 provides analytical data of this effect.

Table 1: The resultant effect of increasing the claim limits above the minimum claim limit.

Insurance Category	Minimum claim limit	Increase in customers as claim limits increase by $100	Increase in total claim payouts as claim limits increase by $100	Increase in claims processed as claim limits increase by $100
General dental	$600	1000	$80,000	1200
Major dental	$300	300	$10,000	600
Optical	$300	400	$30,000	500
Physiotherapy	$400	500	$25,000	800
Chiropractic	$200	200	$5,000	400
Osteopathy	$200	100	$3,000	200
Alternative and natural therapies	$100	300	$40,000	500

Two additional critical requirements of the claim limits were discovered. Firstly, a category named “overall dental” which is the cumulative claim limits for general and major dental must be equal or exceed $1200 else the policy will not attract customers. Secondly, a category called, “overall physical wellness” which encompasses the claim limits of physiotherapy, chiropractic and osteopathy must be greater than or equal to $1000 else the policy will result with no customers. Market research suggests a total claim limit (which is comprised of the sum of the seven individual categories,) of $4000. A total claim limit exceeding $4000 is not expected to attract additional customers.

Wholesome Insurance company is primarily interested in finding the optimal claim limits to maximize yearly profits. Additionally, an evaluation of the impact of a deviation in the estimated overall claim limit of $4000 to $5000. Furthermore, there is an interest in advertising a balanced policy between overall dental and overall physical wellness. This balanced policy will have the additional requirement that the claim limit for overall dental cannot exceed twice the claim limit for overall physical wellness, and vice versa.

Methods

Given the direct relationship between claim limits and revenue and costs, the utilization of a linear programming model is justified to optimize the claim limits. With multiple constraints involved, such as minimum claim limits and requirements for specific categories, the linear programming model accommodates these multiple constraints to find optimal feasible solutions. The model can determine the sensitivity of the overall claim limit set at $4000, to determine the effect of increasing this limit to $5000.

To develop the linear program for Wholesome Insurance, a function of yearly profits must be identified. The associated profit of increasing the claim limits by $100 was calculated as seen in table 2. The assumption was made that customers will stay on the health insurance policy for the whole year. This assumption allows for the revenue per year to be calculated because of the rise in claim limits. Each customer attracted by the new health insurance policy pays $20 per month for 12 months, resulting in an assumed annual payment of $240. The costs incurred by increasing the claim limits by $100 include total claim payouts and claim processing expenses. Table 1 illustrates the relationship between claim limits, the associated costs of total claim payouts, and the number of claims processed, with each claim requiring $100 for processing. Table 2 shows the associated, revenue, costs and subsequently profit of raising the claim limits by $100.

Table 2: Calculated Revenue, Costs and Profit as a result of claim limits increasing by $100

	Calculated Data		
Insurance Category	Revenue due to increased claim limits by $100	Costs due to increasing claim limits by $100	Increase in Profit as claim limit increase by $100
General dental	$240,000.00	$200,000	$40,000.00
Major dental	$72,000.00	$70,000	$2,000.00
Optical	$96,000.00	$80,000	$16,000.00
Physiotherapy	$120,000.00	$105,000	$15,000.00
Chiropractic	$48,000.00	$45,000	$3,000.00
Osteopathy	$24,000.00	$23,000	$1,000.00
Alternative and natural therapies	$72,000.00	$90,000	-$18,000.00

To build the linear program model, the decision variables must be set. In this case the decision variables will be set to the increase in claim limits above the minimum values. Therefore the decision variables can be set;

Let Z = The amount of profit made from the health care policy in a year (in $).

Let $x_1 =$ The increase of claim limits above the minimum for general dental(in $).

Let $x_2 =$ The increase of claim limits above the minimum for major dental (in $).

Let $x_3 =$ The increase of claim limits above the minimum for optical (in $).

Let $x_4 =$ The increase of claim limits above the minimum for physiotherapy (in $).

Let $x_5 =$ The increase of claim limits above the minimum for chiropractic (in $).

Let $x_6 =$ The increase of claim limits above the minimum for osteopathy (in $).

Let $x_7 =$ The increase of claim limits above the minimum for Alternative and natural therapies (in $).

The objective function can be found. With an increase of 100 units, the profits experienced a corresponding increase in profits as seen in table 2. We want to identify maximum profits therefore the objective function is constructed as;

$$\max_{x_1,x_2,x_3,x_4,x_5,x_6} Z = \frac{x_1}{100} * 40000 + \frac{x_2}{100} * 2000 + \frac{x_3}{100} * 16000 + \frac{x_4}{100} * 15000 + \frac{x_5}{100} * 3000 + \frac{x_6}{100} * 1000 + \frac{x_7}{100} * -18000$$

The above objective function can be simplified assuming that claim limits are linearly proportional to the increase in profit from a claim limit increase of $1 to $100.

$$\max_{x_1,x_2,x_3,x_4,x_5,x_6} Z = \$(x_1 * 400 + x_2 * 20 + x_3 * 160 + x_4 * 150 + x_5 * 30 + x_6 * 10 + x_7 * -180)$$

Since the objective function is formulated, constraints on the model must be set. As identified previously, there are multiple constraints set on the claims in certain categories. Four constraints for all solutions identified include, firstly general and major dental must be equal or exceed $1200 else the policy will not attract customers. Therefore, the first constraint is;

Constraint 1:

$$\$600 + \$x_1 + \$300 + \$x_2 \geq \$1200$$

The above constraint shows the total claim limit for general dental which is equal to $(600 + x_1)$(minimum claim limit + increase in claim limit) and the total claim limit for major dental which is equal to $(300 + x_2)$. The second constraint is; the sum of claim limits of physiotherapy, chiropractic and osteopathy must be greater than or equal to $1000 else the policy will result with no customers.

Constraint 2:

$$\$400 + \$x_4 + \$200 + \$x_5 + \$200 + \$x_6 \geq \$1000$$

The final constraint common for all solutions is the total claim limit of $4000.

$$\$600 + \$300 + \$300 + \$400 + \$200 + \$200 + \$100 + \$x_1 + \$x_2 + \$x_3 + \$x_4 + \$x_5 + \$x_6 \leq \$4000$$

This constraint is simplified to;

Constraint 3:

$$\$x_1 + \$x_2 + \$x_3 + \$x_4 + \$x_5 + \$x_6 + \$2100 \leq \$4000$$

The final constraint is non-negativity, the increase in claim limits cannot be negative as this would result in claim limits set being below the minimum claim limit thus resulting in zero customers. Therefore;

Constraint 4:

$$\$x_1, \$x_2, \$x_3, \$x_4, \$x_5, \$x_6 \geq \$0$$

These three constraints remain true within the model. There are however two additional constraints for the alternative recommendation. The constraints formed by the requirement for the claim limit for overall dental cannot exceed twice the claim limit for overall physical wellness, and vice versa are;

Constraint 1 Alt:

$$\$600 + \$x_1 + \$300 + \$x_2 \leq 2 * (\$400 + \$x_4 + \$200 + \$x_5 + \$200 + \$x_6)$$

Constraint 2 Alt:

$$\$400 + \$x_4 + \$200 + \$x_5 + \$200 + \$x_6 \leq 2 * (\$600 + \$x_1 + \$300 + \$x_2)$$

With the objective function formulated and constraints set, the linear programming model is complete and can be analyzed using Excel Solver. Sensitivity analysis will be conducted to evaluate the effects of changing the total claim limit constraint from $4000 to potentially $5000, as requested by Wholesome Insurance.

Results

Analysis was conducted on Wholesome Insurance's health insurance policy, aimed at maximizing yearly profits. The findings were able to determine the claim limits required for maximizing yearly profits. Additionally, we were able to determine the effects of the inaccuracy of the overall $4000 claim limit, including the scenario whereby a $5000 claim limit is set. Lastly, an assessment of the alternative recommendation incorporating the addition alternate constraints was explored to determine the potential cost of promoting a balanced policy between overall dental and overall physical wellness.

Based on the analysis, the following claim limits resulted in maximal yearly profit:

- General dental set at an increase of $1700 resulting in a claim limit of $2300.
- Major dental set at an increase of $0 resulting in a claim limit of $300.
- Optical set at an increase of $0 resulting in a claim limit of $300.
- Physiotherapy set at an increase of $200 resulting in a claim limit of $600.
- Chiropractic set at an increase of $0 resulting in a claim limit of $200.
- Osteopathy set at an increase of $0 resulting in a claim limit of $200.
- Alternative and natural therapies set at an increase of $0 resulting in a claim limit of $100.

These claim limits result in a maximum yearly profit of $710,000. In the collection of these results, it was assumed that there was no variance within the data provided. Therefore, it is important for Wholesome Insurance to ensure that the optimum solution is robust for small variance within the data provided. Wholesome Insurance wants to determine the consequences of inaccuracies in the overall claim limit suggesting that an $5000 overall claim limit could be more accurate.

The sensitivity analysis suggests the optimum solution is robust unless there is large variance in Profit as claim limit increase by $100. This can be seen within the sensitive report of study 1, whereby the allowable range of the objective coefficient is significant. This suggests the optimum solution is reliable unless there is a substantial variability in the data supplied which was used to calculate profit as claim increase by $100.

Furthermore, sensitivity analysis was used to determine the effects of deviation in the $4000 overall claim limit. It can be seen within the sensitivity report study 1, that the shadow price of

the overall claim limit is $400 with an allowable increase of infinity. This suggests that increasing the overall claim by $1 results in an additional $400 profit. Therefore, if the $5000 overall claim limit is accurate, the insurance policy is expected to earn an additional $400,000 above the previously calculated optimal solution, resulting in a yearly income of $1,100,000.

Wholesome Insurance expressed interest in an alternative recommendation that promotes a balanced policy between overall dental and overall physical wellness categories. By introducing two additional conditions, the claim limit for overall dental cannot exceed double the claim limit for overall physical wellness, and vice versa. These addition constraints result in the optimum solution of:

- General dental set at an increase of $1500 resulting in a claim limit of $2100.
- Major dental set at an increase of $0 resulting in a claim limit of $300.
- Optical set at an increase of $0 resulting in a claim limit of $300.
- Physiotherapy set at an increase of $400 resulting in a claim limit of $800.
- Chiropractic set at an increase of $0 resulting in a claim limit of $200.
- Osteopathy set at an increase of $0 resulting in a claim limit of $200.
- Alternative and natural therapies set at an increase of $0 resulting in a claim limit of $100.

The proposed solution yields a total profit of $660,000, which is $50,000 lower than the unconstrained original solution. It is important to note that the alternative recommendation has a lower shadow price of $316.67 on the overall claim limit. This implies that if the overall claim limit is set at $5000, the total profit will amount to $976,670. Implementing this alternative solution would result in a profit reduction ranging from $50,000 to $123,330 compared to the original solution.

Conclusions

Wholesome Insurance is a company proposing a health insurance policy. Market research was conducted to collect critical data to predict maximum yearly profits. Based on the analysis conducted, the recommended claim limits that aim to maximize yearly profits for Wholesome Insurance are $2100, $300, $300, $800, $200, $200, $100 for general dental, major dental, optical, physiotherapy chiropractic, osteopathy, and alternative and natural therapies respectively. These claim limits are robust for potential variance within the collected data. These values result in a total profit of $710,000 to $1,100,000 depending on claim limit set at between $4000 to $5000. It is shown that an increase claim limit increases profit from the health insurance policy.

Wholesome Insurance also wanted to investigate the effect of two addition constraints to determine the cost of marketing a balanced policy. These constraints where, the claim limit for overall dental cannot exceed double the claim limit for overall physical wellness, and vice versa.

It has been determined that the alternative recommendation would reduce profit from $50,000 to $123,330 compared to the original solution.