Parametric Insurance Coverage for Palȍmȉnȉa and Ambernȉa

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Executive Summary

NEW·WORLD's actuarial team has partnered with Quap LeGoibs Consulting Inc. in order to design a practical and profitable parametric insurance policy for economic losses related to health risks in Palȍmïnïa and Ambernïa. The product outlined in this report provides payouts for five health metrics that were identified as risks for major economic losses: smoking rates, diabetes rates, blood pressure levels, air pollution levels, and cholesterol levels. The product will pay independent payouts if any of these metrics reach specified trigger levels. The yearly probability of each individual payout will be fixed at 2%.

This will serve as a low-cost, attractive parametric reinsurance product for insurers in Palȍmïnïa and Ambernïa to cover the risk of major losses as a result of a large downturn in overall health of the covered population. Under the design outlined in this report, this product is also expected to provide steady profits over the next ten years for NEW·WORLD with an adaptable and marketable program in Palȍmïnïa and Ambernïa. Revenue and Profit for the first year and ten-year totals are shown in the table below.

	Revenue (Ψ)	Profit (Ψ)
First Year	20.94 mil	6.20 mil
Ten Year Totals	271.69 mil	105.05 mil

Table 1: *Expected first year and ten-year present value total revenues and profits.*

Quap LeGoibs Consulting Inc. is recommending that this plan be brought to market as soon as possible. Based on analysis, the plan was shown to have continual yearly revenue growth and profitability. A quicker move to market would provide the benefit of being first to market with this type of parametric insurance for health markets, yielding the possibility of a higher market share.

Objectives

The target market for this insurance will be the governments operating a federally managed health insurance policy, with the capability to market to interested large insurers and large group markets such as managed care organizations. The parametric insurance policy will provide repayment for health insurance programs that protect against higher costs associated with the covered triggers. The parametric insurance plan will offer a low-cost alternative relative to traditional insurance, allowing for a large population to be protected from large losses at a cheaper rate. This product should exclusively cover large markets because of the moral and morale hazards associated with parametric insurance, and the lack of individual-specific data for triggers.

Parametric insurance can fill many of the gaps left by traditional insurance and can benefit both the insured and the insurer. NEW·WORLD's policy will provide protection against abnormally high utilization and costs resulting from the triggers listed in the Design Considerations section below. The lack of variability for NEW·WORLD would allow for a lower cost reinsurance program, which governments and group markets could use to insure more individuals.

Design Considerations

Quap LeGoibs recommends that NEW·WORLD observes the following triggers and metrics for use in a parametric insurance plan:

Metrics	Measures
Smoking	Percentage of Current Smokers

Diabetes	Percentage of Population Affected
Blood Pressure	Average Systolic Blood Pressure
Air Pollution	Fine and Fine and Coarse Pop. Weighted Concentration
Cholesterol	HDL and non-HDL mmol/l by Gender

Table 2: *Trigger Names and Metrics. Metrics and rationale in metrics are expanded on in Appendix B*

These triggers were chosen due to their cost to the health system and ability to accurately be measured by health plans functioning within Ambernïa and Palòmïnïa. For each trigger, a distribution was estimated using the existing data and the data taken from the comparable countries, and a trigger point was found by choosing a threshold value for the trigger with a 2% chance of being surpassed. The plan will protect against any large amounts of claims that would occur as a result of these health metrics rising above the 98% percentile threshold. The methodology used to determine this percentile is shown in Appendix C. These thresholds, as well as the payouts and premiums, will be different in Palòmïnïa and Ambernïa.

The payouts will be a one-time payment if a trigger threshold has been crossed, separately tracked for each trigger. Health statistics for each population will be tracked quarterly and reported by the insurer, and therefore, the payouts will be distributed at the beginning of the quarter following a triggering event. For each insurer to qualify for future payouts with that trigger, they must correct their respective metrics to below the current trigger percentage by the next year. Triggers will only be paid once per calendar year.

The respective thresholds, as well as the per-member payout and premium, for both countries are listed in Table 3 below:

Palòmïnïa:	Threshold	Payout (per Member)	Gross Premium (per Member)
Smoking	26.58%	Ψ 12.41	Ψ 0.45
Diabetes	8.29%	Ψ 25.16	Ψ 0.91
Blood Pressure	129.47 mmHg	Ψ 0.50	Ψ 0.02
Air Pollution	25.96 (Fine)	Ψ 15.71	Ψ 0.69
	39.01 (Fine and Coarse)		
Cholesterol	4.93 mmol/L	Ψ 51.14	Ψ 1.84
Total		Ψ 104.91	Ψ 3.91

Ambernïa:	Threshold	Payout (per Member)	Gross Premium (per Member)
Smoking	20.39%	Ψ 40.67	Ψ 1.47
Diabetes	5.14%	Ψ 11.52	Ψ 0.42
Blood Pressure	122.80 mmHg	Ψ 0.80	Ψ 0.03
Air Pollution	9.54 (Fine)	Ψ 29.34	Ψ 1.30
	17.17 (Fine and Coarse)		
Cholesterol	3.27 mmol/L	Ψ 0.88	Ψ 0.03
Total		Ψ 83.23	Ψ 3.24

Table 3: *The payouts and premiums per member for each country and trigger*

Expenses were estimated through an analysis of labor and administrative costs for implementation of the plan. Table 4 shows the overall expenses estimated per year of the plan, with higher expenses estimated in earlier years due to costs involving implementation of the plans and decreasing over time. Further analysis on the possible fluctuations of these expenses is considered in the Sensitivity Analysis section.

	Year 1	Year 2	Years 3+
Expenses Estimated:	Ψ 3,036,130	Ψ 2,277,097	Ψ 1,138,548

Table 4: *Expenses estimated over the years of implementation*

In total, the amount of premium for each member included is, in total, ψ3.91 (in Palо̀mïnïa) or ψ3.24 (in Ambernïa). This assumes that, for the first year, 55.5% of the premium is expected to be spent on claims, 15.5% is spent on expenses, and the remaining 30% is profit. This total amount of premium for both claims and expenses was adjusted to have a planned profit of 30%, comparable to NEW·WORLD's current pre-tax profit of 25%, which will increase slightly in the future as less premium is spent on expenses.

The initial implementation of this product should be thought of as a negotiation with the governments, as different plans will have different necessities. While this analysis primarily focuses on government-ran programs, this product can also be offered to large insurers and other large group markets as a tool for mitigating the health risk. These groups would be required to provide sufficient information on their insured populations for underwriting purposes.

In order to ensure health statistics are being tracked accurately, it is recommended that NEW·WORLD utilize a third party to audit the reports from each country. This will also serve as a buffer to minimize moral hazard in this reporting process.

Data and Data Limitations

The historical data for Palòmïnïa and Ambernïa cover many of the triggers for NEW·WORLD's policy, but there are gaps left by the data that must be filled in order to price the policy correctly. To fill in these gaps, Quap LeGoibs elected to use data from similar nations regarding GDP per capita, GNI per capita, population, and population density to approximate the prevalence and medical costs for the triggers. Using these factors, New Zealand was selected as a comparable nation to Ambernïa, and Malaysia was selected as a comparable nation to Palòmïnïa. These limitations may have led to less accurate predictions of the costs. This will be considered in our sensitivity analysis and should be covered by the relatively high profit margins included in this plan.

NEW·WORLD should request to receive quarterly reports giving the metrics needed for the triggers listed in Table 2 of the Design Considerations section, across both the countries as well as within the insured population. Any outside data used for this analysis can be found in the Works Cited section below.

Assumptions

The analysis performed relies on some key assumptions:

- There is proportional healthcare spending, and age distributions between New **Zealand and Ambernïa as well as** Malaysia and Palȍmïnïa. Correspondingly, some auxiliary data from these two countries will be used in the analysis (See Data Limitation Section.)
    - These countries were chosen due to having similar GDP, GNI, and Population (see Table 5), which signals that they may have proportional costs to their counterparts.

	Ambernïa	New Zealand
GDP (Per Capita)	64,865.73	42,080
GNI (Per Capita)	44,210.48	42,670
Population	5,132,634	4,848,435

	Palòmïnïa	Malaysia
GDP (Per Capita)	9705.48	11,410
GNI (Per Capita)	20,138.90	11,230
Population	22,533,810	32,365,999

Table 5: *Statistical Comparisons Between Relative Countries. The similarities between Ambernïa and New Zealand and Palòmïnïa and Malaysia are similar enough to justify comparison*

- The cost associated with our metrics, change proportionally with the percentage of the population affected.
  - As the proportion of population changes for each trigger, the overall health costs associated with that trigger will also change at an equivalent proportionate amount. This allows for an estimated health cost, given a shift in the affected proportion of overall population.
- Current trends in health metrics continue in the future.
  - There is trend in many of the metrics given to NEW·WORLD, these trends can be seen in Appendix C. Quap LeGoibs expects this trend to continue forward into the future.
- Residuals of the trigger distributions are normal distributed.

- This assumption is widely used in health metrics. It was used in the calculation of our upper limits that establish trigger points.

- The distribution of losses (i.e., total payments for triggering events) closely follows a gamma distribution.
    - This assumption was used for premium and revenue analysis and is expanded on in Appendix F.

Other Assumptions:

- Nominal interest rates will stay constant at -0.05% over a ten-year period and possible values could range from -2.05% to 1.95%.
- The currency's exchange rate resembles the euro's.
- The available data reflects the entire population for the country. This will be adjusted accordingly with further communication regarding the populations covered.
- Both countries will show an active interest in purchase and renewal of this product given that it is priced appropriately.
- Variations in tobacco use are equivalent in Ambernïa and New Zealand as well as Palòmïnïa and Malaysia.

- In both countries, the kids under the age of 14 do not smoke.
- Amberniïa and Palòmïniïa have an equal distribution of men and women.
- Correlations between trigger metrics are assumed, and can be seen in Appendix D.
- Expenses will decrease in future years. See Table 4.

More detailed explanations and reasonings of these assumptions can be found in Appendix A.

Implementation Plan

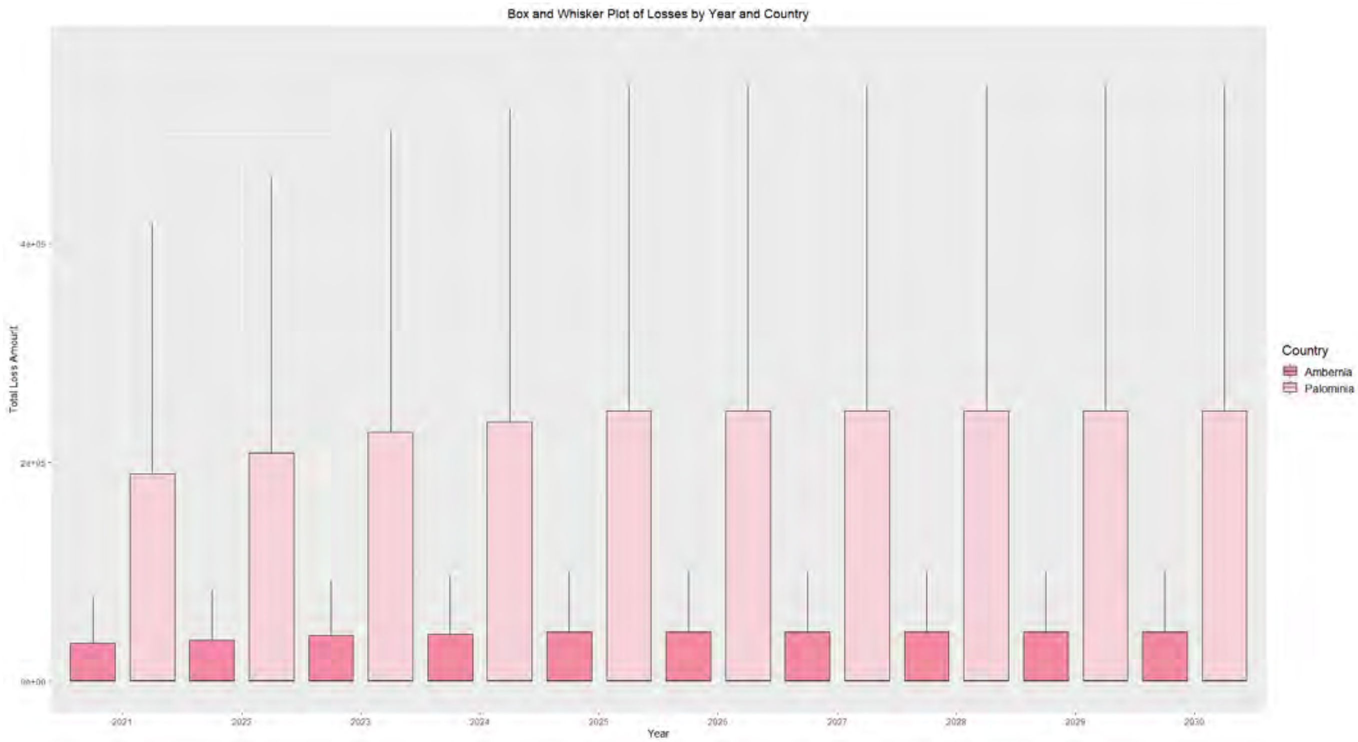
MARKETING PLAN

Quap LeGoibs Consulting Inc. is recommending that NEW·WORLD begin implementing this policy with target market share of 20% from government-run programs. It may be necessary to make consolation and compromises with the government to implement this program as soon as possible to reach the targeted market share. Due to the nature of similar government-run health plans, Quap LeGoibs Consulting Inc. has broken down gross premiums to a per member level. This implies a variable gross premium, depending on each country's yearly enrollment.

In order to expand the market share, NEW·WORLD should expand from government run plans into large group markets, such as the managed care market. To attract these companies, the initial success of the product in Palòmïnïa and Ambernïa can be used as a proof-of-concept for the rest of the insurance landscape. Our projections have modest growth for market share increase, which provides realistic analysis for the success of the product design.

REVENUE AND PROFIT PROJECTIONS

For this policy, Quap LeGoibs Consulting Inc. decided to use two gamma distributions for the loss distributions (i.e., the total payments for triggering events) of Palòmïnïa and Ambernïa, respectively. The expected value and variance of losses were calculated using the assumed correlation factors in Appendix D for both countries, and were used to create the model for each country and the process for finding these values can be found in Appendix E. With these values, the models were determined using maximum likelihood estimation (MLE) and can be seen in Appendix F. The graph for this distribution can be seen in Graph 1 below.



Graph 1: Yearly *Loss Box Plots for Ambernïa and Palòmïnïa*

Losses and expenses were analyzed by using simulations, with expenses distributed uniformly as a percent of assets. This was then combined with the loss distribution to find percentiles of losses and expenses as seen in Table 6 below.

	Expected Value	Std. Deviation	5th Percentile	50th Percentile	95th Percentile
Losses	Ψ 151.57 mil	Ψ 464.97 mil	Ψ 0.00	Ψ 288,207.50	Ψ 60.20 mil
Expenses	Ψ 15.0 mil	Ψ 4.99 mil	Ψ 7.21 mil	Ψ 15.00 mil	Ψ 22.85 mil
Losses and Expenses	Ψ 166.57 mil	Ψ 465.00 mil	Ψ 7.21 mil	Ψ 15.29 mil	Ψ 83.05 mil

Table 6: Losses and Expenses Percentile Analysis

The gross premiums on a per member level was calculated as ψ 3.91 for Ambernïa and ψ 3.24 for Palŏmïnïa. It is estimated that the expense cost of drafting plans for Palŏmïnïa and Ambernïa will have a combined total of ψ 3,036,130.00 in the first year, calculated based on an estimation of the manpower and administration costs. Over the course of ten years, the estimated administrative costs amount to 0.02 % of NEW ·WORLD's current assets. Furthermore, gross premiums are currently being set to target an initial 30% profit margin. Below is a realistic ten-year breakdown of expenses, revenue, and profit. The projections assume a real interest rate of -1.04% due to NEW ·WORLD's central location of Ambernïa combined with expected inflation.

Year	Market Share	Admin Costs	Expected Losses	Revenue	Profit
2021	20%	Ψ 3.04 mil	Ψ 11.62 mil	Ψ 20.94 mil	Ψ 6.20 mil
2022	22%	Ψ 2.28 mil	Ψ 12.78 mil	Ψ 23.03 mil	Ψ 7.89 mil
2023	24%	Ψ 1.14 mil	Ψ 13.94 mil	Ψ 25.12 mil	Ψ 9.96 mil
2024	25%	Ψ 1.14 mil	Ψ 14.53 mil	Ψ 26.17 mil	Ψ 10.43 mil
2025	26%	Ψ 1.14 mil	Ψ 15.12 mil	Ψ 27.22 mil	Ψ 10.89 mil
2026	26%	Ψ 1.14 mil	Ψ 15.12 mil	Ψ 27.22 mil	Ψ 10.89 mil
2027	26%	Ψ 1.14 mil	Ψ 15.12 mil	Ψ 27.22 mil	Ψ 10.89 mil
2028	26%	Ψ 1.14 mil	Ψ 15.12 mil	Ψ 27.22 mil	Ψ 10.89 mil
2029	26%	Ψ 1.14 mil	Ψ 15.12 mil	Ψ 27.22 mil	Ψ 10.89 mil
2030	26%	Ψ 1.14 mil	Ψ 15.12 mil	Ψ 27.22 mil	Ψ 10.89 mil
			Total PV	Ψ 271.69 mil	Ψ 105.05 mil

Table 7: *Ten-year projections for expenses, revenue, and profit*

Sensitivity Analysis & Scenario Analysis

SENSITIVITY ANALYSIS

Sensitivity analysis was done to test the effect a change in certain key variables would have on yearly profit and revenue. The variables tested were interest rate, inflation rate, market share, payout amounts, and administrative expense drop-off. The projections were calculated using all assumptions detailed in the implementation plan, except for the tested variable. The realistic case was compared with ten-year projections of profit and revenue for a rise and fall in the selected variable. The graphs below show the expected present values of profit and revenue throughout the course of ten years.

For interest rate testing, the nominal interest rate of -0.05% was tested against rise to 1.95% and a fall to -2.05% as can be seen in Graph 2 below.

Graph 2: *Yearly expected revenue and profit for an increase and decrease in interest rate.*

For market share testing, the estimated market share at each year was tested against lower and higher projections shown in Table 8:

Year	Realistic	Optimistic	Worst Case
2021	20%	20%	20%
2022	22%	24%	21%
2023	24%	27%	22%
2024	25%	29%	23%
2025	26%	30%	23%
2026+	26%	31%	23%

Table 8: *Market Share Scenarios by Year*

Graph 3: *Trigger Names and Metrics. Metrics and rationale in metrics are expanded on in Appendix B*

Payout amount testing was done to show the most optimistic scenario, where no triggers occur. For the worst case it includes a one in three-hundred-year event for overall losses, using changes in correlation as shown in Appendix D. These were both again compared against the realistic case described above. The medical losses for this catastrophic year were dispersed across the ten-year period to better represent the continual effect on yearly profit.

Graph 4: *Profit testing given a 2% payout occurs in Ambernïa and Palòmïnïa compared with no losses occurring*

The shown sensitivities were found to have the largest impact on profit and revenue. This analysis shows that the most impactful factor for profit is the probability of payout. If there are bad experiences, we can raise premiums in the future to cover losses. For revenue, the most impactful factor is market share because it is directly affected by the population covered. To improve the market share of this product, profit margins can be lowered in order to make this policy more attractive to insurers. The sensitivity analyses for inflation rate and administrative costs do not have a large impact and can be seen in Appendix G.

SCENARIO ANALYSIS

Quap LeGoibs Inc. also performed a scenario analysis to calculate the effect if all changes in the sensitivity analysis were to happen simultaneously. Some of the changes can be seen in Tables 9, 10, and 11 below.

Scenario	1st Year Admin Costs	2nd Year Admin Costs	3+ Year Admin Costs
Optimistic Case	Ψ 3.04 mil	Ψ 1.82 mil	Ψ 0.728 mil
Realistic Case	Ψ 3.04 mil	Ψ 2.28 mil	Ψ 1.14 mil
Worst Case	Ψ 3.04 mil	Ψ 2.66 mil	Ψ 1.99 mil

Table 9: *Expenses Over Implementation Years for Each Scenario*

Scenario	Interest Rates	Inflation Rates	Payout Amount
Optimistic Case	-2.05%	3%	Ψ 0
Realistic Case	-0.05%	1%	Ψ 143.51 mil
Worst Case	1.95%	0%	Ψ 309.27 mil

Table 10: *Assumed Interest Rates, Inflation Rates, and Payout Amounts for Each Scenario*

Scenario	1st Year	2nd Year	3rd Year	4th Year	5th Year	6+ Year
Optimistic Case	20%	24%	27%	29%	30%	31%
Realistic Case	20%	22%	24%	25%	26%	26%
Worst Case	20%	21%	22%	23%	23%	23%

Table 10: *Assumed Inflation Rates for Each Scenario*

Optimistic Scenario: Assuming no change to the premium, distribution, or cost to medical groups due to the triggering morbidities in the future, the probability of having no triggers for 10 full years is approximately 46.9%. In this particular case, there would be no claims paid out, and thus NEW·WORLD would receive all profit not paid towards expenses (totaling ψ11.1 million) received over 10 years, a present value of approximately ψ302.4

million. Market share is assumed to grow from 20% to 31% of the population over 5 years as this product begins to cover more of the governmental plans, as well as additional large insurers.

Realistic Scenario: Using the expected value of a payout for each year, calculated via the probability of a particular morbidity being the one that triggers a payout, NEW·WORLD is projected to pay out approximately ψ166.6 million in expenses and medical costs on average over 10 years, leading to a present value of estimated profit of ψ105 million. The assumed market share for this scenario is a growth from 20% to 26%.

Possible Worst Case Scenario: It was found, using the worst case loss distributions from Appendix F, that if a 98th percentile loss or a one in 50-year loss happens in both Ambernïa and Palòmïnïa then the payout would be ψ179.1 million, which has a 0.0335 probability of occurring throughout the course of a 10-year period assuming the highest levels of variation. The ψ179.1 million loss was set to occur in the tenth year to yield the highest present value for this loss due to Ambernïa's negative interest rate. Assuming static gross premiums, the ten-year present value of revenue was ψ258.4 million with the present value of expected losses and expenses being ψ367.8 million. This ultimately yields a net present value of ψ(109.4) million in losses, with a 3.35% chance as mentioned.

Graph 5: *Graphical Representation of Ten-Year Profitability for Each Scenario*

Scenario	Revenue	Expense and Loss	Profit
Optimistic Case	Ψ 313.5 mil	Ψ 11.1 mil	Ψ 302.4 mil
Realistic Case	Ψ 271.7 mil	Ψ 166.6 mil	Ψ 105.0 mil
Worst Case	Ψ 258.4 mil	Ψ 367.8 mil	Ψ (109.4) mil

Table 12: *Present Value of Revenue, Expense and Loss, and Profit for Each Scenario*

Risks & Risk Mitigation Strategies

Quap LeGoibs Consulting Inc. realizes that when insuring populations, there are many risks that ensue. Although many of these risks have been identified and calculated for, some cannot be reasonably quantified, and these risks are described below.

Although current premiums were developed with experienced data, there is the unforeseen possibility that the overall population of Ambernïa and/or Palòmïnïa becomes significantly less healthy. This may lead to catastrophic losses if all trigger metrics are met. If a loss like this occurs, premiums would be adjusted to account for the worsened health, with each country bearing the burden of improving their population's health until at a reasonable proportion for each trigger to qualify for future payouts. Since premiums are readjusted yearly, insurers are encouraged to promote positive health efforts which would create a healthier population and reduce premiums.

Another risk is the possibility that a wildfire could occur, which would shift air pollution levels in the respective country. Higher levels of air pollution have been shown to negatively affect overall health for affected populations. This could lead to, not only air pollution, but multiple trigger thresholds being met as well. While not much can be done in the form of mitigation measures for this risk, outside tools such as catastrophe bonds or weather derivatives could be used. NEW·WORLD may be able to apply an additional risk factor to the premiums if these countries are shown to be more at risk for wildfires, given available data.

Government run healthcare programs are typically crafted to provide care for lower income populations. It is important to note that lower income populations can be at a higher risk than wealthier populations for some of the specified trigger metrics. This may be an area of concern for NEW·WORLD to take into account when issuing this insurance policy and would need further data on who exactly is being covered for underwriting purposes.

Appendix:

APPENDIX A: EXPLANATION OF NON-KEY ASSUMPTIONS

Assumptions	Rationale
The silon's exchange rate resembles the euro's	The euro is a world currency that holds for many economies and would likely work with most countries, and thus can be assumed to be comparable to the silon. This was assumed to help comparison with real-world data, given in real-world currencies, to the data given in silon.
The available data reflects the entire population for the government run programs. This will be adjusted accordingly with further communication regarding the populations covered.	This information was given by the country, so we believe that it is reliable. We assume that more complete data can be requested in the future.
Both countries will show an active interest in purchase and renewal of this product given that it is priced appropriately.	We assume that there is an existing market or an interest in new markets for this insurance product in both the government and large-group private sector.
Variations in tobacco use are equivalent in Ambernïa and New Zealand as well as Palòmïnïa and Malaysia.	All the countries show declining rates in smoking, and the smoking populations are at similar levels between countries.

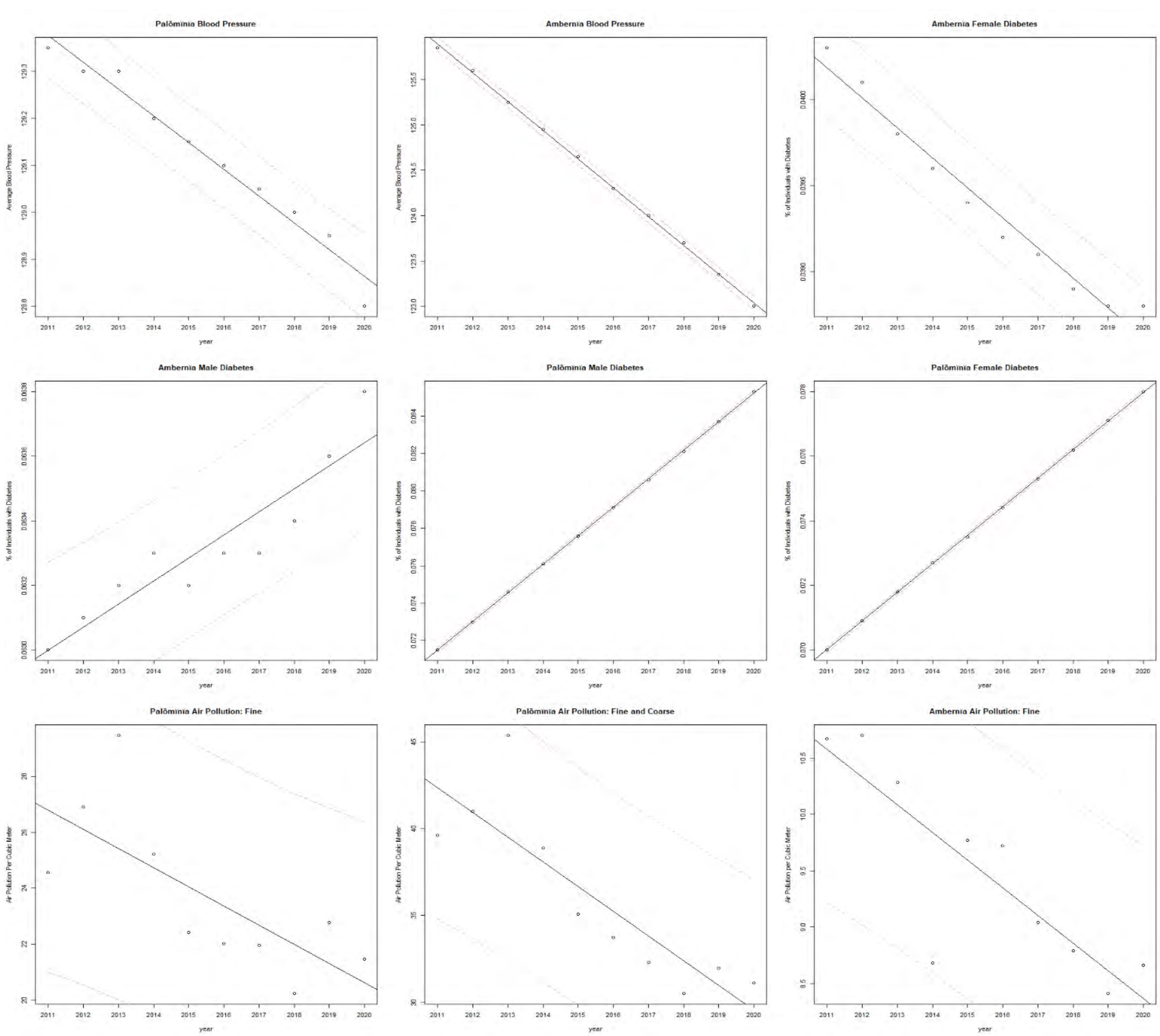
In both countries, the kids under the age of 14 do not smoke.	These age bands were removed when considering the proportion of the population currently smoking.
Ambernïa and Palòmïnïa have an equal distribution of men and women.	This is a standard assumption made for calculating some of the trigger costs and is likely based on global distribution.
Correlations between trigger metrics are assumed.	There was not enough data to calculate exact correlation statistics between each trigger metric. Therefore, assumed correlation statistics were used based on research.
Expenses will decrease in future years	Expenses in future years will decrease due to fewer costs related with implementation.
Interest rates will stay constant over a ten-year period.	A sensitivity analysis was performed to consider the effect of different interest rates.

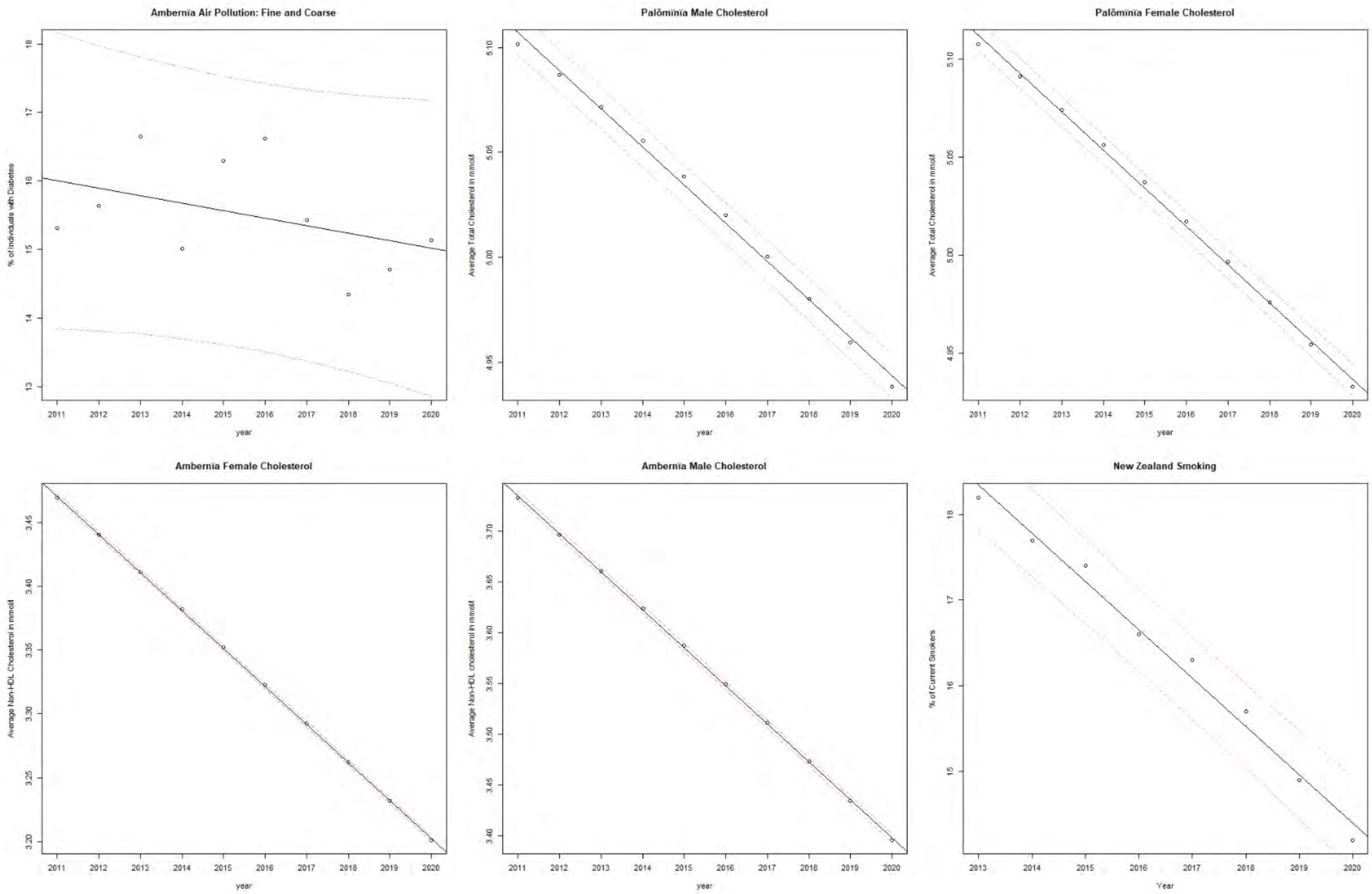
APPENDIX B: TRIGGERS AND METRICS

Triggers	Definitions
Smoking	If the percent of current smokers, defined as someone who has smoked in the last 12 months, rises above the threshold, a payout is delivered. Smoking was chosen as a trigger due to the risk of lung and cardiovascular medical issues, as well as the ease of reporting.
Diabetes	If the percent of those diagnosed with diabetes rises above the threshold, a payout is delivered. Diabetes was chosen due to the cost of its care as well as being a common ailment.
Blood Pressure	If mean systolic blood pressure, measured in mmHg, rises above the threshold, a payout is delivered. Blood pressure was chosen due to its relation to dangerous morbidities such as obesity and heart issues.
Air Pollution	If either air pollution metric rises above the threshold, a payout is delivered. Air pollution was chosen due to the ill effect it can have on lungs and other respiratory organs that may lead to all health claims increasing.
Cholesterol	If the mean cholesterol level increases above a certain threshold, a payout is delivered. Cholesterol was chosen due to its relation to dangerous morbidities such as obesity and heart issues.

APPENDIX C: METRIC TREND CALCULATIONS AND EXPLANATIONS

All health trends in this report were calculated based upon a linear regression analysis using yearly percentile or average data to predict future expected values. These regressions were used as well for the prediction intervals in order to come to our 98% upper limit estimates. The graphs and equations for the linear regressions are below:





APPENDIX D: CORRELATIONS OF TRIGGERS

The correlation coefficients found below, were based upon the combination of research and actuarial judgment. For each correlation value there is an upper and lower estimate, chosen based on the level of confidence for the given correlation. Upper and lower estimates were used for the sensitivity of the payout amount.

Expected Correlations

	Smoking	Blood Pressure	Diabetes	Cholesterol	Air Pollution
Smoking	1	0.6	0.35	0.2	0.1
Blood Pressure	0.6	1	0.65	0.7	0.05
Diabetes	0.35	0.65	1	0.4	0.14
Cholesterol	0.2	0.7	0.4	1	0
Air Pollution	0.1	0.05	0.14	0	1

Upper Value Correlations

	Smoking	Blood Pressure	Diabetes	Cholesterol	Air Pollution
Smoking	1	0.7	0.4	0.3	0.2
Blood Pressure	0.7	1	0.8	0.8	0.15
Diabetes	0.4	0.8	1	0.5	0.16
Cholesterol	0.3	0.8	0.5	1	0.1
Air Pollution	0.2	0.15	0.16	0.1	1

Lower Value Correlations

	Smoking	Blood Pressure	Diabetes	Cholesterol	Air Pollution
Smoking	1	0.5	0.3	0.1	0
Blood Pressure	0.5	1	0.5	0.6	0
Diabetes	0.3	0.5	1	0.3	0.12
Cholesterol	0.1	0.6	0.3	1	0
Air Pollution	0	0	0.12	0	1

APPENDIX E: CALCULATION OF EXPECTED LOSS AND LOSS VARIANCE

Loss random variable is defined as the total payments for the triggering events.

$$Ambernïa\ Expected\ Value = \sum_{i=1}^{5} P(risk_i) * Payout_i$$

$$Ambernïa\ Variance = \sum_{i=1}^{5} \sum_{j=1}^{5} Cor_{i,j} P(risk_j) * P(risk_i) * Payout_i * Payout_j$$

$$Palòmïnïa\ Expected\ Value = \sum_{i=1}^{5} P(risk_i) * Payout_i$$

$$Palòmïnïa\ Variance = \sum_{i=1}^{5} \sum_{j=1}^{5} Cor_{i,j} P(risk_j) * P(risk_i) * Payout_i * Payout_j$$

APPENDIX F: LOSS DISTRIBUTION

Distribution	α	θ
Expected	0.044200301	221,164,221.42
Upper Correlation Case	0.039377167	201,335,894.14
Lower Correlation Case	0.048553315	248,253,642.00

Appendix F Table 1: Palomino's Gamma Distributions for Loss Model Found by Maximum Likelihood Estimator

Distribution	α	θ
Expected	0.045599085	40,450,440.74

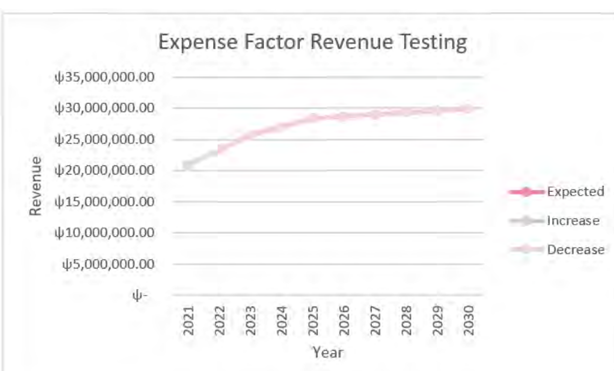
Upper Correlation Case	0.041518414	44,426,144.50
Lower Correlation Case	0.050440269	36,568,065.53

Appendix F Table 2: Amberniïa's Gamma Distributions for Loss Model Found by Maximum Likelihood Estimator

APPENDIX G: SENSITIVITY ANALYSIS EXPANDED

The graph below, shows the sensitivity to inflation for our product.

The graph below, shows this plan's sensitivity to expenses.



APPENDIX H: R-CODE

```
# First create the linear approximations for each of the triggers.
# Blood Pressure

pmbp = c(  132.2,  132.3,  132.4,  132.4,  132.5,  132.6,  132.7,  132.8,  132.9,  132.9)
pfbp = c(  126.5,  126.3,  126.2,  126,  125.8,  125.6,  125.4,  125.2,  125,  124.7)
x = (pfbp+pmbp)/2
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
par(  mfrow = c(3,3) )
plot(z, ylab = "Average Blood Pressure", xaxt = "n", main = "Palòmïnïa Blood Pressure")
#Ambernïa Palòmïnïa
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
t = data.frame(year=c(11:20))
PBPpred = predict.lm(r,t, interval = "predict", level = 0.96)
PBPpred

ambp = c(  130.4,  130.2,  129.9,  129.6,  129.3,  129.0,  128.7,  128.4,  128.1,  127.7)
afbp = c(  121.3,  121.0,  120.6,  120.3,  120.0,119.6,  119.3,  119.0,  118.6,  118.3)
x = (afbp+ambp)/2
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "Average Blood Pressure", xaxt = "n",
    main = "Ambernïa Blood Pressure")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
t = data.frame(year=c(11:20))
APBPpred = predict.lm(r,t, interval = "predict", level = 0.96)
APBPpred

########################################
# Diabetes

afd = c(  0.0403,  0.0401,  0.0398,  0.0396,  0.0394,  0.0392,  0.0391,  0.0389,  0.0388,  0.0388  )
x = afd
year = c(1,2,3,4,5,6,7,8,9,10)
```

```
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
r
plot(z, ylab = "% of Individuals with Diabetes", xaxt = "n", main = "Ambernïa Female Diabetes")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
t = data.frame(year=c(11:20))
ADFpred = predict.lm(r,t, interval = "predict", level = 0.96)
ADFpred

amd = c(  0.063,  0.0631,  0.0632,  0.0633,  0.0632,0.0633,  0.0633,  0.0634,  0.0636,  0.0638)
x = amd
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "% of Individuals with Diabetes", xaxt = "n", main = "Ambernïa Male Diabetes")
#Ambernïa Palòmïnïa
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
ADMpred = predict.lm(r,t, interval = "predict", level = 0.96)
ADMpred

pmd = c(  0.0715,  0.073,  0.0746,  0.0761,  0.0776,  0.0791,  0.0806,  0.0821,  0.0837,  0.0853)
x = pmd
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "% of Individuals with Diabetes", xaxt = "n", main = "Palòmïnïa Male Diabetes")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
PDMpred = predict.lm(r,t, interval = "predict", level = 0.96)
PDMpred

pfd = c(  0.07,  0.0709,  0.0718,  0.0727,  0.0735,  0.0744,  0.0753,  0.0762,  0.0771,  0.078)
x = pfd
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
```

```
r=lm(x~year,z)
plot(z, ylab = "% of Individuals with Diabetes", xaxt = "n", main = "Palòmïnïa Female Diabetes")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
PDFpred = predict.lm(r,t, interval = "predict", level = 0.96)
PDFpred

################################
# Air Pollution

papf = c(  24.57,  26.90,  29.47,  25.23,  22.43,  22.03,  21.97,  20.23,  22.77,  21.47)
x = papf
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "Air Pollution Per Cubic Meter", xaxt = "n", main = "Palòmïnïa Air Pollution: Fine")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
PAPFpred = predict.lm(r,t, interval = "predict", level = 0.96)
PAPFpred

papc = c(  39.63,  41.00,45.37,  38.87,  35.07,  33.73,  32.30,  30.50,  31.97,  31.13)
x = papc
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "Air Pollution Per Cubic Meter", xaxt = "n", main = "Palòmïnïa Air Pollution: Fine and Coarse")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
PAPCpred = predict.lm(r,t, interval = "predict", level = 0.96)
PAPCpred

aapf = c(  10.67,  10.70,  10.28,  8.68,  9.77,  9.72,  9.04,8.79,  8.41,  8.66)
x = aapf
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
```

```
plot(z, ylab = "Air Pollution per Cubic Meter", xaxt = "n", main = "Ambernïa Air Pollution: Fine")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
AAPFpred = predict.lm(r,t, interval = "predict", level = 0.96)
AAPFpred

par(mfrow = c(2,3))
aapc = c( 15.31, 15.64, 16.65, 15.01, 16.30, 16.62, 15.43, 14.34, 14.71, 15.14)
x = aapc
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "% of Individuals with Diabetes", xaxt = "n", main = "Ambernïa Air Pollution: Fine and Coarse")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
AAPCpred = predict.lm(r,t, interval = "predict", level = 0.96)
AAPCpred

################################
# Cholesterol

pmc = c( 3.8331040, 3.8191670, 3.8047788, 3.7894993, 3.7731003, 3.7555895, 3.7368807, 3.7173425,
3.6972668, 3.6769312)
pmc = pmc + c( 1.2685612, 1.2677311, 1.2669251, 1.2661168, 1.2653253,1.2645030, 1.2636339, 1.2628018,
1.2621059, 1.2615089)
x = pmc
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "Average Total Cholesterol in mmol/l", xaxt = "n", main = "Palòmïnïa Male Cholesterol")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
PCMpred = predict.lm(r,t, interval = "predict", level = 0.96)
PCMpred

pfc = c( 3.6361546, 3.6163203, 3.5959286, 3.5747260, 3.5526492, 3.5298034, 3.5063904, 3.4823322,3.4578999,
3.4331173)
```

```
pfc = pfc + c(  1.4715248,  1.4748480,  1.4781146,  1.4813261,  1.4844522,  1.4875329,  1.4905270,  1.4935745,
1.4967436,  1.5000203)
x = pfc
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "Average Total Cholesterol in mmol/l", xaxt = "n", main = "Palòmïnïa Female Cholesterol")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
PCFpred = predict.lm(r,t, interval = "predict", level = 0.96)
PCFpred

afc = c(  3.4696812,  3.4401813,  3.4110621,  3.3818798,  3.3523132,  3.3224722,  3.2922774,  3.2620084,  3.2317230,
3.2012620)
x = afc
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "Average Non-HDL Cholesterol in mmol/l", xaxt = "n", main = "Ambernïa Female Cholesterol")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
ACFpred = predict.lm(r,t, interval = "predict", level = 0.96)
ACFpred

amc = c(  3.7332371,  3.6964064,  3.6602844,  3.6239947,  3.5870695,  3.5495036,  3.5112494,  3.4729301,
3.4345008,3.3958455)
x = amc
year = c(1,2,3,4,5,6,7,8,9,10)
z=as.data.frame(cbind(year,x))
r=lm(x~year,z)
plot(z, ylab = "Average Non-HDL cholesterol in mmol/l", xaxt = "n", main = "Ambernïa Male Cholesterol")
axis (1, at = 1:10, labels = 2011:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
PCMpred = predict.lm(r,t, interval = "predict", level = 0.96)
PCMpred

####################################
```

```
# Smoking

nzs = c(  18.2,  17.7,  17.4,  16.6,  16.3,  15.7,14.9,  14.2)
x = nzs
Year = c(1:8)
z=as.data.frame(cbind(year,x))
r=lm(x~Year,z)
plot(z, ylab = "% of Current Smokers", xaxt = "n", main = "New Zealand Smoking")
axis (1, at = 1:8, labels = 2013:2020)
abline(r)
pred_interval <- predict(r, newdata=data.frame(c(1:10)), interval="prediction",level = 0.96)
lines(Year, pred_interval[,2], col="#f18ba0", lty=2)
lines(Year, pred_interval[,3], col="#f18ba0", lty=2)
summary(r)
t = data.frame(year = c(9:18))
NZSpred = predict.lm(r,t, interval = "predict", level = 0.96)
NZSpred

# Find the standard error of the prediction for the New Zealand Prediction
crit <- qt(p= 0.02, df = summary(r)$df[2], lower.tail = FALSE)
(NZSpred[,"upr"] - NZSpred[,"fit"])/crit
# Take trend and critical value from this and apply it to mean for Ambernïa

# Find the estimated 2% loss for both Ambernïa and Palòmïnïa
qgamma(.98,shape = 0.04420030056,scale = 221164221.42)
qgamma(.98,shape = 0.03937716676,scale = 248253642.00)

# Plot the density functions for both Ambernïa and Palòmïnïa
x = seq(0,500000000, by = 100000)
par(mfrow  = c(1,2))
plot(x, dgamma(x, scale = 40450440.74, shape =      0.04559908459),
    ylab = "Probability of Loss", xlab = "Loss Amount", main =  "Ambernïa's Loss Distribution Function")
plot(x, dgamma(x, scale = 221164221.42, shape =     0.04420030056),
    ylab = "Probability of Loss", xlab = "Loss Amount", main =  "Palòmïnïa's Loss Distribution Function")
x = seq(0,1, by = .01)
par(mfrow  = c(1,1))
plot(x, dgamma(x, scale = 40450440.74, shape =      0.04559908459),
    ylab = "Probability of Loss", xlab = "Loss Amount", main =  "Ambernïa's Loss Distribution Function")

q1 = qgamma(x, scale = 221164221.4, shape =         0.04559908459)
q2 = qgamma(x, scale = 243280643.6, shape =         0.04559908459)
q3 = qgamma(x, scale = 265397065.7, shape =         0.04559908459)
q4 = qgamma(x, scale = 276455276.8, shape =         0.04559908459)
q5 = qgamma(x, scale = 287513487.8, shape =         0.04559908459)
q6 = qgamma(x, scale = 287513487.8, shape =         0.04559908459)
q7 = qgamma(x, scale = 287513487.8, shape =         0.04559908459)
q8 = qgamma(x, scale = 287513487.8, shape =         0.04559908459)
q9 = qgamma(x, scale = 287513487.8, shape =         0.04559908459)
q10 = qgamma(x, scale = 287513487.8, shape =        0.04559908459)
```

```
q = cbind(q1,q2,q3,q4,q5,q6,q7,q8,q9,q10)[-101,]
boxplot(q, main = "Box and Whisker Plot of Losses by Year", xaxt = "n", ylab = "Loss Amount", xlab = "Year"
        , outline = FALSE)
axis (1, at = 1:10, labels = 2021:2030)
q <- rbind(cbind(q1,rep(2021,101))[-101,],cbind(q2,rep(2022,101))[-101,],cbind(q3,rep(2023,101))[-101,],
     cbind(q4,rep(2024,101))[-101,],cbind(q5,rep(2025,101))[-101,],cbind(q6,rep(2026,101))[-
101,],cbind(q7,rep(2027,101))[-101,],
     cbind(q8,rep(2028,101))[-101,],cbind(q9,rep(2029,101))[-101,],cbind(q10,rep(2030,101))[-101,])
q = as.data.frame(q)
q =cbind(q,"Palòmïnïa")
names(q) = c("Loss", "Year", "Country")

w <- rbind(cbind(w1,rep(2021,101))[-101,],cbind(w2,rep(2022,101))[-101,],cbind(w3,rep(2023,101))[-101,],
          cbind(w4,rep(2024,101))[-101,],cbind(w5,rep(2025,101))[-101,],cbind(w6,rep(2026,101))[-
101,],cbind(w7,rep(2027,101))[-101,],
          cbind(w8,rep(2028,101))[-101,],cbind(w9,rep(2029,101))[-101,],cbind(w10,rep(2030,101))[-101,])
w = as.data.frame(w)
w =cbind(w,"Ambernïa")
names(w) = c("Loss", "Year", "Country")
t = rbind(q,w)
t$Year = as.factor(t$Year)

# Change the position
p<-ggplot(t, aes(x=Year, y=Loss, fill = Country)) +
  geom_boxplot(position=position_dodge(1), outlier.shape = NA)+ coord_cartesian(ylim = c(0,570000))+
  labs(title="Box and Whisker Plot of Losses by Year and Country",x="Year", y = "Total Loss Amount")+
  theme(plot.title = element_text(hjust = 0.5),legend.title = element_text(size = 14),
        legend.text = element_text(size = 12))
p+scale_fill_manual(values=c("#f18ba0", "#f5d3da"))
#Expense Distribution and percentile calculations

p = rgamma(100000, scale = 40450440.74, shape =   0.04559908459)
q = rgamma(100000, scale = 221164221.4, shape =   0.04559908459)
e = runif(100000, 6342837,23631503.03)
e = e/10
h = p+q+e
quantile(h, c(.05,.5,.95))
j = p+q
quantile(j, c(.05,.5,.95))
```

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