PARAMETRIC INSURANCE

For the Countries, Ambernïa and Palòmïnïa

SUMMARY

We, from team Martingale would like to present our product based on Parametric Insurance for the health company, NEW WORLD.

Our Team

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EXECUTIVE SUMMARY

Our company, team Martingale, has been hired by NEW·WORLD, multinational insurance company located in the country of Ambernïa to develop a parametric insurance product that will focus on economic losses related to global health risks in Ambernïa and Palồmïnïa. The difference with the traditional health insurance is within the payout, which will be settle on the occurrence of one or more triggering events of measurable health conditions. This program promotes the need of “parametric insurance” for the risks that are underinsured or not insured by traditional health insurance on the market.

The product will be focused on covering one of the growing health concern risks, which is diabetes, and the “triggering event” will be obese and hypertension. The amount of benefit offered to customers is the amount outside of the annual out of pocket expense per person from each country. The amount of premium and benefit for costumers from Ambernïa and Palồmïnïa have been calculated based on health risks between each countries and gender.

Under the development of this product, we hope the product can lower the protection gaps existing in society today, by reducing out of pocket expense for healthcare spending on diabetes. The program is also projected to generate revenue of ψ38.639 million in 2025.

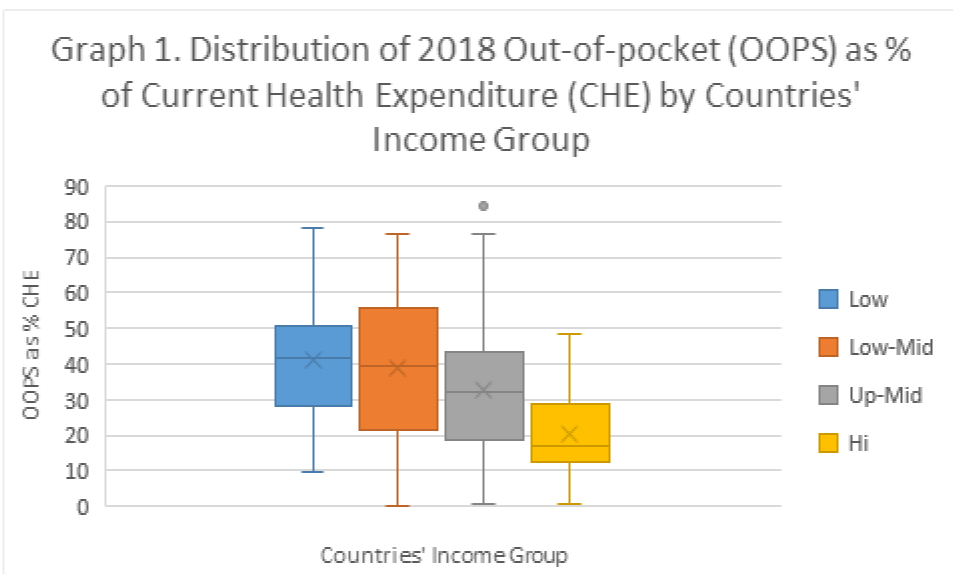
ANALYSIS METHODOLOGY

Purpose & Background

Parametric insurance exists to lower the protection gaps existing in society today. In various countries, a representative measure of protection gaps for healthcare insurance is out-of-pocket expenses (OOP expenses), i.e., the share of the expenses that the insured must pay directly to the healthcare provider, without reimbursement by a third-party such as an insurer or the government (Geneva Association, 2018).

Currently, total healthcare protection gaps in various countries with various economic profiles ranges from 1.8% - 2.4% of GDP. The lower the OOP expenses level, the greater the protection against catastrophic expenses provided to the poor. According to World Health Organization, OOP expenses are said to be catastrophic if those expenses have covered more than 40% of household subsistence expenses.

Figure 1. Distribution of 2018 Out-of-pocket as % of Current Health Expenditure by Countries' Income Group



Source: World Health Organization (2018)

PRODUCT ASSESSMENT

Product advantages and disadvantages

Advantages:

- **Moral hazard from loss perspective is minimized.**

  In parametric insurance, a payout to the insured is based on triggering event. In this case, health issues are the triggering event. So, based on loss perspective, the fraud of health insurance can be minimized because the payout in based on objective index.

- **Reduction of costs and human capital in the long term leads to lower premium.**

  In the long term, once the product structures have been standardized based on the evaluation of the product in the early stage and most administrative processes are reduced, the costs of the administrative and human capital will be reduced, which offers the potential of lower premiums.

- **Shorter timelines of payouts.**

  With traditional insurance product, an insurance company need to assess individual or group losses and check the proof of losses. In parametric insurance, the company don't need to assess the losses because the specific amount will be received by the insured based on triggering event and only check the proof of triggering event.

Disadvantages:

- **Basis risk can arise if an individual insured's loss experience does not correlate with the index payouts.**

  In this case, some individuals that experience loss from the serious health issue may not receive compensation, while some who suffer no loss receive insurance payouts based on the parameter of the products.

- **In the early years, a lot of financial and human capital is required before standardized products and systems can be developed.**

The parametric insurance products are technically complex and relatively new in health insurance sector. Insurance company need to evaluate the product within the early stage of the product launching, so the basis risk can be minimized in the long run. Promotion activities are also needed, so the products can be advertised to the target market in Ambernïa and Palồmïnïa.

Product audience for the target market

The product has been designed to be suitable for customers who wish to protect against the financial implications of diabetes beside the coverage of traditional health insurance and who require cover for a fixed term. The target market covers a broad range of customer segments, but customers will typically, be in the age of 25-65 age range. The primary targets for this products are covered by the following customer segments:

- Customers aged between 25 to 39, already have traditional insurance, fewer responsibilities, a job, or financial dependents.
- Customers aged between 40 to 55, already have traditional insurance, peaking responsibilities, a job, or financial dependents.
- Customers aged 55+, already have traditional insurance, reduced of responsibilities, a job or financial dependents.

Individuals who need parametric insurance cover tend to be of working age that already have a primary health insurance, with the core market likely to be between ages 25-65. For customers in this core market, if they did suffer type 2 diabetes, it could be impact on their financial resilience and the payout from this insurance policy will help them cover a fraction of their protection gaps.

Insurability

For an insurance product to be viable, the risk covered by it must be insurable. Based on a couple of criteria, we are able to measure the insurability of parametric insurance. Through our analysis shown in the appendix, we found almost no problematic criterion except one, information assymetry. Moral hazard and adverse selection can be a challenging problem for the company to maximize its revenue. Concerning this problem, we have recommended risk mitigation strategies for the company. Hence, we conclude that risk covered by our insurance product is insurable.

Data Limitations and Assumptions

The following are the data limitations and the assumptions to overcome them.

Table 1. Data Limitations and Assumptions

Data limitation	Assumption	Reason
Healthcare spending rates for Ambernïa and Palòmïnïa in 2011 are not available.	Data generated with a linear model.	Linear model is a model that is simple and representative enough to predict the value of the data.
2019 and 2020 out-of-pocket expenses from WHO data are not available.	Data generated with a linear model.	Linear model is a model that is simple and representative enough to predict the value of the data.
There is no information on the proportion of men and women in both Palòmïnïa and Ambernïa for each year.	Ambernïa's gender proportion follows the Finnish data, while Palòmïnïa follows the Moroccan data.	The demographic and economic characteristics of each pair of countries are quite similar.
For each triggering event, the information on the conditional probability of diabetes given the triggering event is very minimal.	Data generated using a grid search, utilizing diabetes probability data from Finland and Morocco *	The data is generated in such a way that the error between the grid search probability and the real probability is minimal so that the resulting data is quite credible.

* This assumption has the most significant impact

Methodology

Based on literature studies and data availability, the level of obesity and blood pressure were determined to be two independent triggering events that were effective enough to be used for diabetes incidence. A person is categorized as hypertensive if the systolic pressure exceeds 130 or the diastolic pressure exceeds 80. Both hypertension and obesity must occur simultaneously for a claim to be processed.

By utilizing data on the proportion of people with diabetes to the total population, as well as the independent relationship between the two triggering events, a grid search was carried out to determine the following four proportions per year during 2011-2020: diabetics given obesity, diabetics given hypertension, diabetics given both event, and diabetics given not both. The set of proportions was generated for the two genders separately in each country by Python.

The set of proportions is used as a sample point to determine the type of conditional probability distribution of diabetes given each triggering event, separated by country and gender. This stage is done with the help of EasyFit. A summary of events and their corresponding distributions and parameters is given in the table provided in the Appendix.

Premiums throughout 2011-2020 are determined by the principle of equivalence by utilizing the benefit set data - which will be discussed in the loss coverage section - and conditional probability distribution data of diabetes events given each triggering event.

Premiums, benefits, and other profitability-related amounts are predicted for the year after 2020 by utilizing related data throughout 2011-2020. Ultimately, these predicted quantities are used to project future earnings.

PROGRAM DESIGN

Loss Coverage

The number of benefits offered to customers is the amount outside of the annual OOP expense per person from each country. The percentage of healthcare spending used in determining these benefits is the same as the average percentage of healthcare spending from all countries with the appropriate economic type based on data from WHO. Ambernïa as a country with a developed economy uses the average data from a high-income country, while Palòmïnïa with a developing economy uses data from a low-income country.

From the following table, it should be noted that the percentage of healthcare spending (OOP_CHE) numbers listed in 2019 and later are obtained with a linear model that has been fitted based on the previous year's data, namely: OOP_CHE = 164.98522 - 0.07159 * YEAR (for Ambernïa) and OOP_CHE = 1012.75587 - 0.48171 * YEAR (for Palòmïnïa).

Table 2. Out of pocket expense data as a percentage of healthcare spending (OOP_CHE) for Ambernïa and Palòmïnïa for each year

Year	Ambernïa			Palòmïnïa		
	OOP_CHE	CHE (ψ)	Benefit (ψ)	OOP_CHE	CHE (ψ)	Benefit (ψ)
2011	21.03	4,668.34	3,686.52	43.43	314.44	177.87
2012	20.96	4,845.23	3,829.90	44.39	354.33	197.06
2013	20.79	4,997.79	3,958.79	43.47	374.62	211.76
2014	20.71	5,051.00	4,005.11	42.16	482.88	279.31
2015	20.81	5,152.58	4,080.53	41.99	504.45	292.64
2016	20.87	5,414.80	4,284.53	41.56	529.91	309.69
2017	20.55	5,573.14	4,427.78	40.71	557.70	330.67
2018	20.41	5,767.14	4,590.04	41.12	617.42	363.52
2019	20.45	5,814.01	4,625.34	40.18	666.68	398.79
2020	20.37	5,994.29	4,773.05	39.70	706.55	426.04

Payment Provisions

The premium price will be averaged for four groups, which are categorized by Ambernïa Male, Ambernïa Female, Palòmïnïa Male, and Palòmïnïa Female. We used an assumption for the gender ratio in each country.

Table 3. Assumption for the gender ratio in Ambernïa and Palòmïnïa

	Male	**Female**
Ambernïa	0,493157628	0,506842372
Palòmïnïa	0,492385787	0,507614213

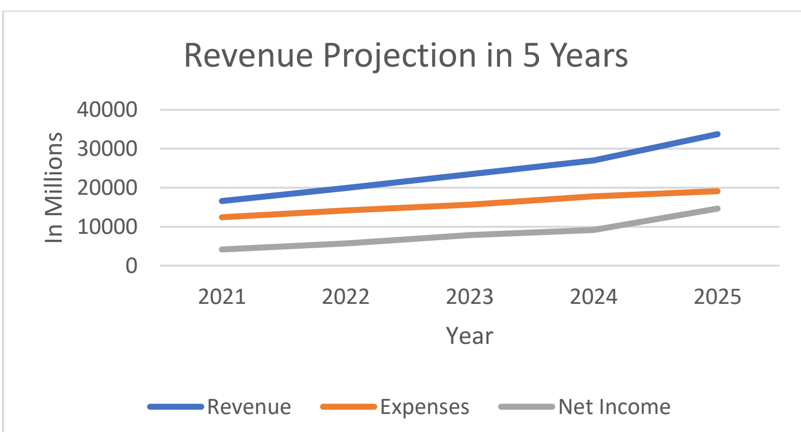
The average premium price and gross premiums written is illustrated in Table 1.1 Gross Premium Estimates from Parametric Insurance Product in Appendix.

The claim will be received if it fulfills that the insured experiences the triggering events for the parametric insurance. Those triggering events are obesity and hypertension. Here we define obesity as if ones having BMI > 30 and hypertension as if ones having systolic blood pressure more than 130 or diastolic more than 80.

Revenue and Expenses Projection

Through a projection of the revenue, we project a revenue of ψ38.639 million and a net income of ψ14.645 million in 2025, is as follows:

Figure 2. Revenue Projection in 5 years



We conclude that expenses will be higher in the first two years, and will be more stable in 2023, with a higher net income.

The revenue will be used for the new product, and for existing expenses such as claims, commissions and more. Expenses for the product will be as follows:

1. Cost of Product Development

   This would be the cost of developing the new product. For instance, keeping updated on the conditions of the health risks that are covered in the parametric insurance product. This would also include research and development to improve the product's features.

2. Cost of Marketing New Product

   Since this would be the first parametric insurance released by the company, the market is not aware of the product, such as what it covers and its features and benefits. Hence, the company would need to allocate certain budgets to market the new product.

3. Cost of Program Implementation and Regulation

   The company would have to allocate funds to government costs and management of the product. Aside from that, the company would also have to fund the programs for operational processes.

Marketing Plan

Our marketing plan to promote sales of the new product will be conducted in three stages, which constitutes as follows:

1. **Awareness**

   In this stage, the company will raise awareness on the risks of health diseases that are not insured by traditional insurance, the probability of having that risk, and promote why it's safer and a great investment for your future, especially with the current rising health concerns. The media for this promotional stage will be through a marketing campaign in channels such as social media, events, TV, and YouTube advertisements.

2. **Interest**

The company will need to hook its target market to take interest in purchasing this product by letting them know the special features that the product offers and a demonstration of the benefits of investing in this product, through product comparisons, targeted email newsletters, classes, etc.

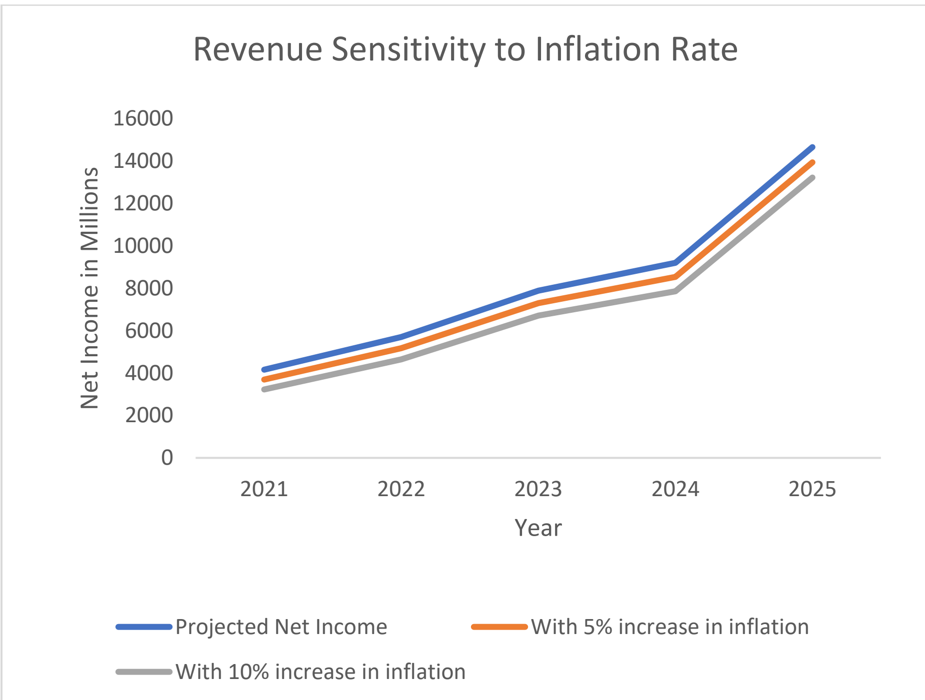
3. **Action**

In this stage, the target market is aware of the product and need the final push to purchase it. The company can promote trying the product first and introduce special promotional offers or referral promotions so family members can get a cheaper price when they register as a group.

Sensitivity Analysis

Assumptions used in the analysis before are selected through careful research and thorough data analysis. Despite this, these assumptions may not meet the reality. To mitigate the risks of these varying values, we performed a sensitivity analysis to see its impact on company's cashflow.

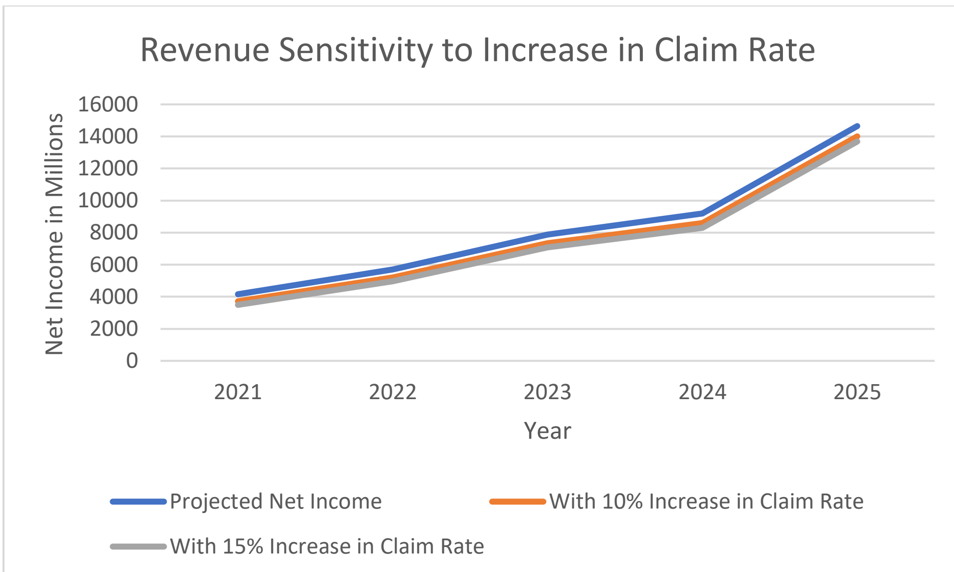
Figure 3. Revenue Sensitivity to Inflation Rate



We will look at net income in this case. We consider focusing on net income because inflation rate may affect expenses significantly.

We will test the revenue sensitivity towards the inflation rate. The inflation rate will affect higher expenses for costs of developing the new product and managing operational and existing products. By projecting a 5% and 10% increase in inflation, we observe that the company will still have a stable but decreased net income.

Figure 4. Revenue Sensitivity to Increase in Claim Rate



We are also considering the risk of having unmatching actuarial model that may result in higher-than-expected claim rate. In this scenario, we test our model to have 10% and 15% increment in claim rate. By applying this scenario, we can expect the company to still generate positive net income despite lower than our projected net income under our assumptions.

RISK MANAGEMENT

We have seen in the sensitivity analysis section that the parametric insurance product we are offering is quite safe towards several market risks. Yet, there are several other risks beyond market risks that should be concerned by the company. These are possible risks that we consider might affect the business and our recommendation to mitigate it.

1. Policy holders may fake their BMI and blood pressure to submit false claim. To minimize this risk, we recommend the implementation of artificial intelligence and partnership with tech vendors. New World could implement AI-based BMI inference from facial or full-body images to eliminate claims with false information related to body height and weight. New World could also establish a partnership with tech vendors to give policy holders a smartwatch with ability to measure blood pressure. We expect that partnership program would not be too costly for the company since it would bring more brand awareness and revenue for the partner company (tech vendors). Hence, risks of having false blood pressure measurement should be decreased.
2. Data limitations and dynamic reality may inhibit us from having a model that perfectly captures the reality. To minimize the risk of having underpriced model or higher probability of loss, we recommend New World to evaluate and remodel the product based on up-to-date data once a year.
3. Default risk may arise when the company offers underpriced products and having higher-than-expected claims. Investment portfolio also has a part in rising this risk since bad investment portfolio may bring the company into insolvency. Like our recommendation in the second point, we recommend New World to evaluate every aspect of the product and investing strategy.

CONCLUSIONS

- Under the program outlined above, we expect New World to see potential annual revenue of ψ38.639 million and ψ 14.645 million net income, and as much as ψ13.211 million net income even in the worst case of inflation rate and ψ13.683 million net income in the worst case of claim rate in five years.
- There are several other non-market risks that should be concerned by the company in order to secure its business. Risks like insurance claim fraud and actuarial risk arising from unmatched model to the reality should be mitigated carefully.
- We recommend New World to launch this parametric insurance product by Q2 2021 in order to benefit from first-mover advantages. New World can establish itself as a reputable insurance company and experience high-sales volume throughout the year, making it harder for the competitors to keep up.

APPENDIX

APPENDIX A: PROGRAM DESIGN

Table 1. Gross Premium Estimates from Parametric Insurance Product

	Male/Palòmïnïa	Female/Palòmïnïa	Male/Ambernïa	Female/Ambernïa	
	(in millions)	(in millions)	(in millions)	(in millions)	
2021					
Premium Estimates	101,7907459	183,3335169	803,1715375	782,1500639	
TAM Percentage	0,8181761	0,93854026	0,95104525	0,98547334	
TAM Market Size	9.118.950	10.783.984	2.428.324	2.586.054	
Frequency of Purchase per Year	1823790,046	2156796,77	485664,8659	517210,753	
Gross Premiums Written	185644949	395413137	390072197,1	404536423,6	1.375.666.707
2022					
Premium Estimates	181,6252891	163,537089	1609,584976	1776,868289	
TAM Percentage	0,7701296	0,992860293	0,95977334	0,9563257	
TAM Market Size	8.628.334	11.467.784	2.472.881	2.532.372	
Frequency of Purchase per Year	2588500,09	3440335,339	741864,2673	759711,6003	
Gross Premiums Written	470137077,2	562622426,4	1194093579	1349907452	3.576.760.534
2023					
Premium Estimates	49,55279202	67,37293742	829,8102217	2563,433643	
TAM Percentage	0,94497112	0,98768685	0,94976449	0,995658417	
TAM Market Size	10.642.287	11.467.373	2.469.132	2.660.271	
Frequency of Purchase per Year	4256914,687	4586949,382	987652,6085	1064108,265	
Gross Premiums Written	210942008,1	309036253,7	819564230	2727770925	4.067.313.417
2024					
Premium Estimates	231,3200373	106,553468	734,3459099	318,561903	
TAM Percentage	0,8760849	0,93940671	0,98780282	0,97439966	
TAM Market Size	9.917.547	10.963.268	2.590.942	2.626.708	
Frequency of Purchase per Year	6446405,871	7126123,98	1684112,474	1707360,047	
Gross Premiums Written	1491182846	759313223,8	1236721107	543899865,5	4.031.117.043
2025					
Premium Estimates	83,19752967	181,1904518	1776,51974	1948,806002	
TAM Percentage	0,8450374	0,94759393	0,8109577	0,94759393	
TAM Market Size	9.615.330	11.115.751	2.145.907	2.577.046	
Frequency of Purchase per Year	6730730,906	7781025,396	1502134,786	1803931,871	
Gross Premiums Written	559980184,2	1409847507	2668572100	3515513258	8.153.913.049

Table 2. Insurability Criteria of Parametric Insurance

Insurability Criteria	**Main findings**	**Assessment**
1. Randomness of Loss occurrence	• There is correlation among some triggering events both in Ambernïa and Palòmïnïa. • Correlation among triggering events might lead to challenges in building a reliable estimation of loss probabilities.	*Not problematic*
2. Maximum possible loss	• Maximum possible loss for health risk should be lower than death risk, which is an insurable risk. • Insurers have decided to cover certain amount of loss in parametric insurance case, so losses can be well covered	*Not problematic*
3. Average loss per event	• Average loss depends on disease and healthcare quality. Average loss in Palòmïnïa is expected to be lower than in Ambernïa. • By 2020, healthcare spending in Palòmïnïa and Ambernïa make up 7% and 9% of their GDP respectively. This is much lower than healthcare spending of the US which makes up around 17.7% of their GDP.	*Not problematic*
4. Loss exposure	• Citizens in Palomonia are more likely to catch diseases. This is justified by higher tobacco use, higher alcohol use, higher air pollution, and many other worse metrics had by Palòmïnïa compared to Ambernïa's one. • Risk of catching diseases in both countries are projected to be slightly decreasing in the following years.	*Not problematic*
5. Information asymmetry	• Moral hazard. Some triggering events defined by the company are prone to moral hazard because of bad lifestyle such as lack of physical activity or tobacco use.	*Problematic*

	• Adverse selection, that is, people with bad lifestyle are expected to be more encouraged to buy parametric health insurance as the coverage may seem beneficial for them.	
6. Insurance premium	• Low number of competitors; expected to increase. • Palòmïnïa will have higher risks which leads to higher premiums; expected to decrease. • Additional costs	*Increasingly less problematic*
7. Cover limits	• Policies have a set amount of benefit given to cover a loss.	*Not problematic*
8. Public policy	• Insurance fraud might be incentivized, since triggering events can be triggered intentionally. • Due to moral hazard incentives, exposure to health risks might increase.	*Less problematic*
9. Legal restrictions	• Risk of change of restrictions due to parametric insurance being a relatively new product. • Health insurance is mandated to be given to employees by businesses in many countries.	*Not problematic*

Table 3. Events and their Corresponding Distributions

Event	**Ambernïa - Male**	**Ambernïa - Female**	**Palòmïnïa - Male**	**Palòmïnïa - Female**
Diabetes | obese	Johnson SB (γ = -0.1749, δ = 0.7089, λ = 0.3178, ξ = -0.01563)	Gen. Extreme Value (k = 0.03864, σ = 0.11586, μ = 0.08353)	Dagum (k = 1.0342, α = 1.8044, β = 0.10361, γ = 0)	Johnson SB (γ = 1.2807, δ = 0.7378, λ = 1.3532, ξ = -0.04761)
Diabetes | hypertension	Uniform (a = -0.02472, b = 0.06472	Johnson SB (γ = 0.5475, δ = 0.3892, λ = 0.0930, ξ = -0.00273)	Error (k = 100, σ = 0.02648, μ = 0.0325)	Error (k = 100, σ = 0.04417, μ = 0.0575)
Diabetes | both trigger	Gen. Pareto (k = -0.0127, σ =	Johnson SB (γ = 1.5952, δ = 0.8172, λ =	Gen. Pareto (k = -0.7003, σ =	Johnson SB (γ = 1.8458, δ = 0. 6449, λ =

	0.27251, μ = -0.04101)	1.8374, ξ = -0.04371)	0.59049, μ = -0.00479)	1.7418, ξ = -0.01429)
Diabetes | no trigger	Gumbel Max (σ = 0.04953, μ = 0.02891)	Gumbel Max (σ = 0.01883, μ = 0.00413)	Johnson SB (γ = 0.57358, δ = 0.69278, λ = 0.39336, ξ = -0.01452)	Gumbel Max (σ = 0.03984, μ = 0.022)

A1. Modeling Probability of Risk

We have decided previously that risk we are considering in this program is diabetes with obesity and hypertension as its triggering events. In modeling the risk, we use the concept of prior and posterior probability. We firstly define the triggering events as prior events and diabetes as posterior event. Using data given in the case study challenge, we can construct probabilities of those triggering events and as seen on the following figures.

	Ambernia				
Year	Male	Female	Average	Male Comp	Female Comp
2011	0.063	0.0403	0.05165	0.609874153	0.390125847
2012	0.0631	0.0401	0.0516	0.611434109	0.388565891
2013	0.0632	0.0398	0.0515	0.613592233	0.386407767
2014	0.0633	0.0396	0.05145	0.61516035	0.38483965
2015	0.0632	0.0394	0.0513	0.615984405	0.384015595
2016	0.0633	0.0392	0.05125	0.617560976	0.382439024
2017	0.0633	0.0391	0.0512	0.618164063	0.381835938
2018	0.0634	0.0389	0.05115	0.619745846	0.380254154
2019	0.0636	0.0388	0.0512	0.62109375	0.37890625
2020	0.0638	0.0388	0.0513	0.621832359	0.378167641
			AVERAGE COMP	*0.616444224*	*0.383555776*

Figure A1.1: Diabetes proportion in Ambernïa

Age Band	Underweight	Normal	Pre-Obese	Obese	Proportion Age Band	Proportion Obese
15–19	0.0985	0.7248	0.1318	0.0449	0.0575	0.00258175
20–24	0.0415	0.6388	0.2273	0.0924	0.065	0.006006
25–34	0.0265	0.5562	0.2948	0.1225	0.129	0.0158025
35–44	0.0128	0.4617	0.3617	0.1638	0.128	0.0209664
45–54	0.0088	0.408	0.3952	0.188	0.1295	0.024346
55–64	0.011	0.3812	0.4095	0.1983	0.1225	0.02429175
65–74	0.0133	0.383	0.4185	0.1852	0.103	0.0190756
75+	0.0265	0.4407	0.3793	0.1535	0.095	0.0145825
					Total	**0.1276525**

Figure A1.2: Obesity proportion in Ambernïa

Using those two figures, we are willing to know the proportion of obesity of male and female in Ambernïa. We assume that proportion of male and female obesity follows the proportion of diabetes. By this assumption, we use the following formula to get male obesity proportion and similar formula for female obesity proportion.

$$\text{Male Proportion of Obesity} = \frac{\text{Male Proportion of Diabetes}}{\text{Male Proportion in Population}} \times \text{Diabetes proportion}$$

Thus, we get our male and female obesity proportion in Ambernïa for 2020. To get this proportion for the year 2011 – 2019, we assume that it follows the same trend as Finland since this country shares many similarities with Ambernïa.

We repeat this same methodology for Palòmïnïa Male and Female using following figures.

Diabetes	Palòmïnïa				
Year	Male	Female	Average	Male Comp	Female Comp
2011	0.0715	0.07	0.0712	0.505300353	0.494699647
2012	0.073	0.0709	0.0724	0.507296734	0.492703266
2013	0.0746	0.0718	0.07365	0.509562842	0.490437158
2014	0.0761	0.0727	0.0748	0.511424731	0.488575269
2015	0.0776	0.0735	0.076	0.513567174	0.486432826
2016	0.0791	0.0744	0.0772	0.515309446	0.484690554
2017	0.0806	0.0753	0.0784	0.516998076	0.483001924
2018	0.0821	0.0762	0.0796	0.518635502	0.481364498
2019	0.0837	0.0771	0.08085	0.520522388	0.479477612
2020	0.0853	0.078	0.0853	0.5223515	0.4776485
				0.514096875	0.485903125

Figure A1.3: Diabetes proportion in Palòmïnïa

Age Band	Underweight	Normal	Pre-Obese	Obese	Proportion Age Band	Proportion Obese
15–19	0.1273	0.7425	0.112	0.0182	0.0625	0.0011375
20–24	0.0623	0.699	0.2013	0.0374	0.132	0.0049368
25–34	0.0338	0.5705	0.3185	0.0772	0.1505	0.0116186
35–44	0.0165	0.4308	0.412	0.1407	0.153	0.0215271
45–54	0.0075	0.3238	0.4635	0.2052	0.13	0.026676
55–64	0.0093	0.287	0.4605	0.2432	0.1065	0.0259008
65–74	0.0085	0.2925	0.461	0.238	0.073	0.017374
75+	0.0203	0.3878	0.4208	0.1711	0.0465	0.00795615
					Total	0.11712695

Figure A1.4: Obesity proportion in Palòmïnïa

For the second triggering event, hypertension, we estimate the probabilities using multivariate normal distributions. The following figures are systolic and diastolic data for each gender in both countries.

Year	Male Systolic	Male Diastolic	Female Systolic	Female Diastolic
2011	130.4	78.7	121.3	74.6
2012	130.2	78.5	121.0	74.5
2013	129.9	78.4	120.6	74.3
2014	129.6	78.3	120.3	74.2
2015	129.3	78.2	120.0	74.1
2016	129.0	78.0	119.6	74.0
2017	128.7	77.9	119.3	73.9
2018	128.4	77.8	119.0	73.8
2019	128.1	77.7	118.6	73.7
2020	127.7	77.5	118.3	73.6

Year	Male Systolic	Male Diastolic	Female Systolic	Female Diastolic
2011	132.2	81.7	126.5	79.2
2012	132.3	81.7	126.3	79.1
2013	132.4	81.6	126.2	79.0
2014	132.4	81.6	126.0	79.0
2015	132.5	81.6	125.8	78.9
2016	132.6	81.5	125.6	78.8
2017	132.7	81.5	125.4	78.8
2018	132.8	81.5	125.2	78.7
2019	132.9	81.4	125.0	78.6
2020	132.9	81.4	124.7	78.6

Figure A1.5: Systolic and diastolic data for Ambernïa (left) and Palòmïnïa (right)

We estimate the probabilities by assuming that systolic and diastolic distribution for each year and gender follow normal multivariate distribution with mean given in the table and standard deviations of 20 for systolic and 9 for diastolic. We also assume that correlation coefficient of systolic and diastolic is 0.74. These assumptions are following global distribution of systolic and diastolic. We estimate probabilities of hypertension using the following formula. (X: systolic, Y: diastolic)

$$\Pr(X > 130) + \Pr(Y > 80) - \Pr(X > 130 \text{ } and \text{ } Y > 80)$$

By appending the probability of those two triggering events each year, we can construct the following table for each country and gender. Probability of both triggering events are calculated using the assumption of independency.

	AMBERNIA MALE			
	Pr(obesed)	Pr(hpt)	Pr(obese&hpt)	Pr(neither)
2011	0.118308717	0.5933	0.070192562	0.21819872
2012	0.122892737	0.5877	0.072224062	0.217183201
2013	0.127476757	0.5821	0.074204221	0.216219022
2014	0.132060777	0.5773	0.076238687	0.214400536
2015	0.136644797	0.5717	0.078119831	0.213535372
2016	0.141228817	0.563	0.079511824	0.216259358
2017	0.145812837	0.5578	0.081334401	0.215052762
2018	0.150396857	0.5516	0.082958907	0.215044236
2019	0.154980877	0.5461	0.084635057	0.214284065
2020	0.159564897	0.539	0.08600548	0.215429623

	AMBERNIA FEMALE			
	Pr(obesed)	Pr(hpt)	Pr(obese&hpt)	Pr(neither)
2011	0.072346737	0.4048	0.029285959	0.493567303
2012	0.075041737	0.4003	0.030039207	0.494619055
2013	0.077736737	0.392	0.030472801	0.499790462
2014	0.080431737	0.3868	0.031110996	0.501657267
2015	0.083126737	0.3817	0.031729476	0.503443787
2016	0.085821737	0.3753	0.032208898	0.506669365
2017	0.088516737	0.3686	0.032627269	0.510255993
2018	0.091211737	0.3649	0.033283163	0.5106051
2019	0.093906737	0.3577	0.03359044	0.514802823
2020	0.096601737	0.3524	0.034042452	0.51695581

	PALOMINIA MALE			
	Pr(obesed)	Pr(hpt)	Pr(obese&hpt)	Pr(neither)
2011	0.068291505	0.675	0.046096766	0.210611729
2012	0.074291505	0.6764	0.050250774	0.199057721
2013	0.080291505	0.6731	0.054044212	0.192564283
2014	0.086291505	0.6731	0.058082812	0.182525683
2015	0.092291505	0.6738	0.062186016	0.171722479
2016	0.098291505	0.6746	0.066307449	0.160801046
2017	0.104291505	0.6744	0.070334191	0.150974304
2018	0.110291505	0.675	0.074446766	0.140261729
2019	0.116291505	0.6738	0.078357216	0.131551279
2020	0.122291505	0.6738	0.082400016	0.121508479

	PALOMINIA FEMALE			
	Pr(obesed)	Pr(hpt)	Pr(obese&hpt)	Pr(neither)
2011	0.053837652	0.5641	0.030369819	0.351692529
2012	0.060313172	0.5584	0.033678875	0.347607953
2013	0.066788692	0.5548	0.037054366	0.341356942
2014	0.073264212	0.5543	0.040610352	0.331825436
2015	0.079739732	0.5484	0.043729269	0.328131
2016	0.086215252	0.5444	0.046935583	0.322449165
2017	0.092690772	0.5418	0.05021986	0.315289368
2018	0.099166292	0.5386	0.053410965	0.308822744
2019	0.105641812	0.5334	0.056349342	0.304608846
2020	0.112117332	0.5312	0.059556727	0.297125942

Figure A1.6: Compact tables for probability of each triggering events in both countries

Using the data, we can estimate the probability of diabetes given each prior event, which are obesity, hypertension, both triggering events, and neither of two. We build a brute force algorithm using Python to get best values of conditional probabilities. which best fit the following formula.

$$\begin{aligned}\Pr(\text{Diabetes}) = {} & \Pr(\text{Obesity}) . \Pr(\text{Diabetes}|\text{Obesity}) \\ & + \Pr(\text{Hypertension}) . \Pr(\text{Diabetes}|\text{Hypertension}) \\ & + \Pr(\text{Both}) . \Pr(\text{Diabetes}|\text{Both}) + \Pr(\text{Neither}) . \Pr\,(\text{Diabetetes}|\text{Neither})\end{aligned}$$

The following figures are the results of our simulation.

Year	Pr(diab|obesed)	Pr(diab|hypertension)	Pr(diab|both)	Pr(diab|neither)
2011	0.025	0	0.7	0.05
2012	0.175	0	0.2	0.125
2013	0.075	0	0.65	0.025
2014	0.225	0	0.3	0.05
2015	0.15	0	0	0.2
2016	0.25	0.025	0.175	0
2017	0.2	0.025	0.05	0.075
2018	0.075	0.075	0	0.05
2019	0.125	0.05	0.2	0
2020	0.275	0.025	0.075	0

Year	Pr(diab|obesed)	Pr(diab|hypertension)	Pr(diab|both)	Pr(diab|neither)
2011	0.375	0	0.45	0
2012	0	0	0.1	0.075
2013	0.075	0.075	0.15	0
2014	0.125	0	0.95	0
2015	0.35	0	0.325	0
2016	0.2	0.025	0	0.025
2017	0	0.025	0.525	0.025
2018	0.05	0.05	0.1	0.025
2019	0.3	0.025	0.05	0
2020	0.075	0.075	0.15	0

Year	Pr(diab|obesed)	(diab|hypertensio	Pr(diab|both)	Pr(diab|neither)
2011	0.025	0.05	0.325	0.1
2012	0.275	0	0.65	0.1
2013	0.075	0	0.2	0.3
2014	0.1	0.05	0.425	0.05
2015	0.025	0.05	0.6	0.025
2016	0.4	0	0.6	0
2017	0.1	0.025	0.275	0.225
2018	0.35	0.025	0.075	0.15
2019	0.125	0.05	0.075	0.225
2020	0.075	0.075	0.2	0.075

Year	Pr(diab|obesed)	(diab|hypertensio	Pr(diab|both)	Pr(diab|neither)
2011	0.075	0.1	0.025	0.025
2012	0.8	0.025	0	0.025
2013	0.175	0.1	0.125	0
2014	0.075	0	0.225	0.175
2015	0.475	0.05	0	0.025
2016	0	0.075	0.2	0.075
2017	0.225	0.075	0.275	0
2018	0.45	0.025	0.05	0.05
2019	0	0.125	0.05	0.025
2020	0.125	0	0.825	0.05

Figure A1.7: Conditional probabilities for Ambernïa Male (upper left), Ambernïa Female (upper right), Palòmïnïa Male (lower left), Palòmïnïa Female (lower right)

A2. Premium Forecasts

For the years 2021-2025, we can build forecasts on what our premiums will be. These forecasts are built on the previous years using regression.

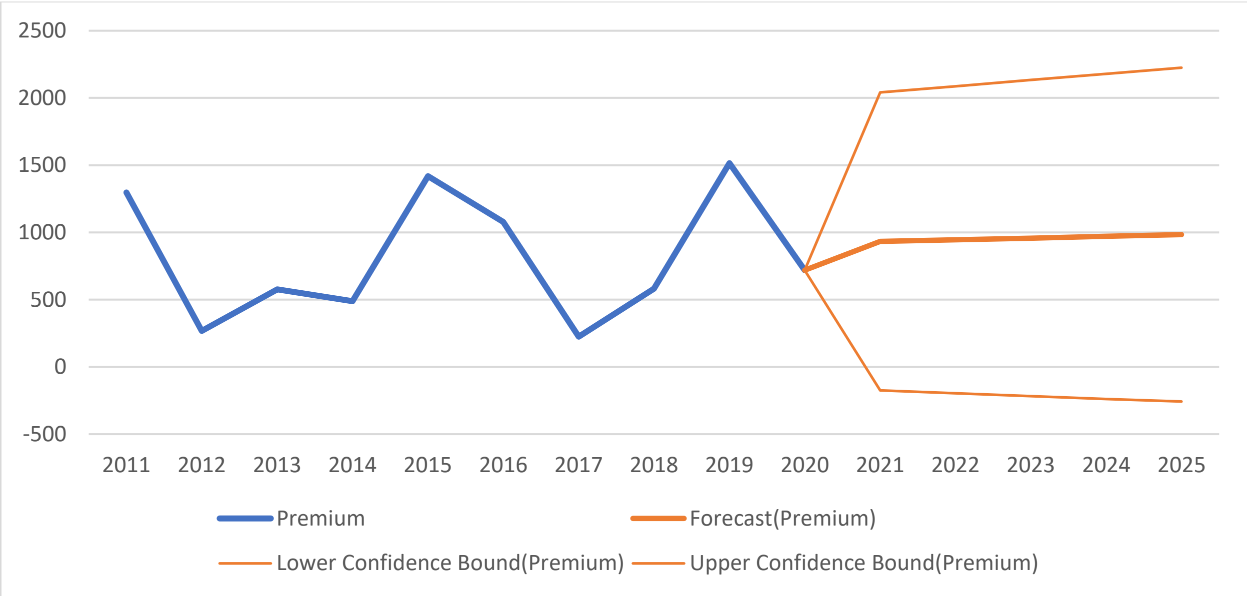


Figure A2.1. Ambernïa Female Premium Forecast

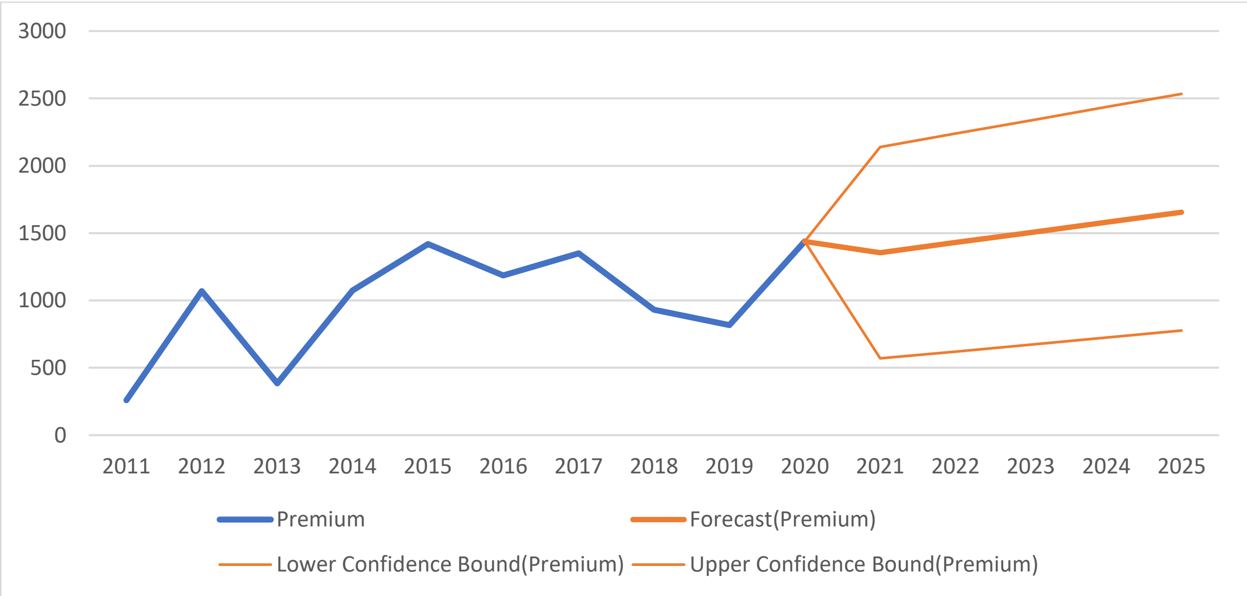


Figure A2.2. Ambernïa Male Premium Forecast

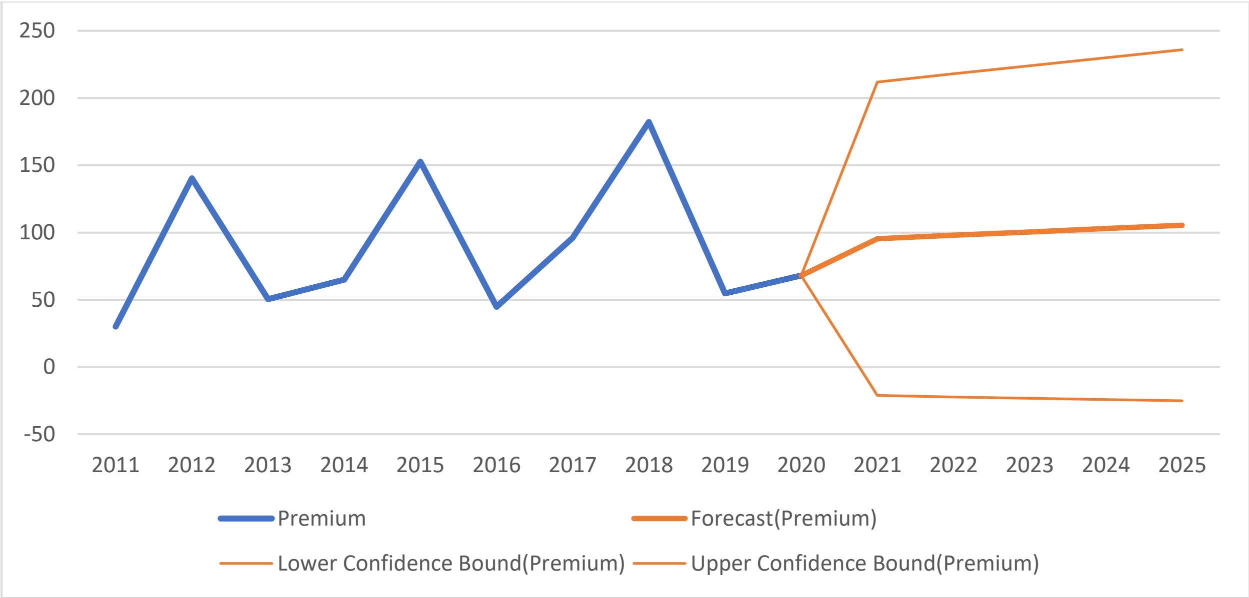


Figure A2.3. Palòmïnïa Female Premium Forecast

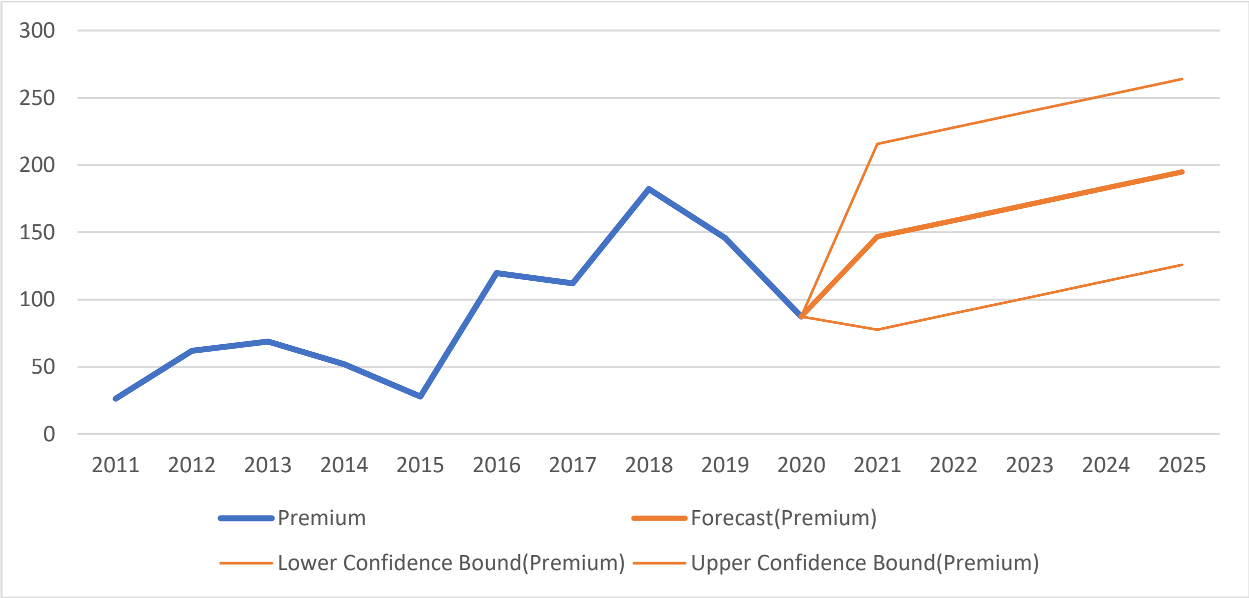


Figure A2.4. Palòmïnïa Male Premium Forecast

A3. Income Statement

Income Statement

For the Year-Ended December 31

(ψ in millions)

	2019	2020	2021	2022	2023	2024	2025
Revenue							
Gross premiums written	ψ 14.022	ψ 14.565	ψ 15.940	ψ 19.516	ψ 23.583	ψ 27.650	ψ 35.803
Less reinsurance ceded	1.633	1.475	1535	1635	1859	2203	2305
Net premiums written	ψ 12.389	ψ 13.090	ψ 14.405	ψ 17.881	ψ 21.724	ψ 25.447	ψ 33.498
Increase in reserve for unearned premiums	(407)	(448)	-503	-603	-712	-795	-835
Net premiums earned	ψ 11.982	ψ 12.642	ψ 13.902	ψ 17.278	ψ 21.012	ψ 24.652	ψ 32.663
Claims and Operating Expenses			ψ 6.774	ψ 7.536	ψ 8.298	ψ 9.061	ψ 9.823
Net claims incurred	ψ 4.564	ψ 5.227	ψ 5.890	ψ 6.553	ψ 7.216	ψ 7.879	ψ 8.542
Net adjusting expense	956	1.495	1.645	1.921	2.312	2.720	3.005
Commissions	1.237	1.318	1.399	1.480	1.561	1.642	1.723
Salaries and fees	1.076	1.511	1.846	2.381	2.816	3.251	3.686
Amortization of property and equipment	41	145	242	254	298	314	335
Amortization of intangible assets	83	62	41	53	48	70	90
Other expenses	1.000	1.183	1.366	1.549	1.366	1.915	1.732
	8.957	10.941	ψ 12.429	ψ 14.191	ψ 15.617	ψ 17.791	ψ 19.113
Net Underwriting Income	ψ 3.025	ψ 1.701	ψ 1.473	ψ 3.087	ψ 5.395	ψ 6.861	ψ 13.550
Other Income							
Investment income	2.778	3.272	3.766	4.260	4.754	5.248	5.742
Miscellaneous	7	155	303	257	362	146	234
	ψ 2.785	ψ 3.427	4.069	4.517	5.116	5.394	5.976
Income Before Income Tax Expense	ψ 5.810	ψ 5.128	ψ 5.542	ψ 7.604	ψ 10.511	ψ 12.255	ψ 19.526
Income Tax Expense	(1.488)	(1.313)	ψ (1.386)	ψ (1.901)	ψ (2.628)	ψ (3.064)	ψ (4.882)
Net Income for the Year	ψ 4.322	ψ 3.815	ψ 4.157	ψ 5.703	ψ 7.883	ψ 9.191	ψ 14.645

Income Statement

For the Year-Ended December 31

(ψ in millions)

	2019	2020	2021	2022	2023	2024	2025
Revenue							
Gross premiums written	ψ 14.022	ψ 14.565	ψ 15.940	ψ 19.516	ψ 23.583	ψ 27.650	ψ 35.803
Less reinsurance ceded	1.633	1.475	1535	1635	1859	2203	2305
Net premiums written	ψ 12.389	ψ 13.090	ψ 14.405	ψ 17.881	ψ 21.724	ψ 25.447	ψ 33.498
Increase in reserve for unearned premiums	(407)	(448)	-503	-603	-712	-795	-835

Net premiums earned	ψ 11.982	ψ 12.642	ψ 13.902	ψ 17.278	ψ 21.012	ψ 24.652	ψ 32.663
Claims and Operating Expenses			ψ 6.774	ψ 7.536	ψ 8.298	ψ 9.061	ψ 9.823
Net claims incurred	ψ 4.564	ψ 5.227	ψ 5.890	ψ 6.553	ψ 7.216	ψ 7.879	ψ 8.542
Net adjusting expense	956	1.495	1.645	1.921	2.312	2.720	3.005
Commissions	1.237	1.318	1.399	1.480	1.561	1.642	1.723
Salaries and fees	1.076	1.511	1.846	2.381	2.816	3.251	3.686
Amortization of property and equipment	41	145	242	254	298	314	335
Amortization of intangible assets	83	62	41	53	48	70	90
Other expenses	1.000	1.183	1.366	1.549	1.366	1.915	1.732
	8.957	10.941	ψ 12.429	ψ 14.191	ψ 15.617	ψ 17.791	ψ 19.113
Net Underwriting Income	ψ 3.025	ψ 1.701	ψ 1.473	ψ 3.087	ψ 5.395	ψ 6.861	ψ 13.550
Other Income							
Investment income	2.778	3.272	3.766	4.260	4.754	5.248	5.742
Miscellaneous	7	155	303	257	362	146	234
	ψ 2.785	ψ 3.427	4.069	4.517	5.116	5.394	5.976
Income Before Income Tax Expense	ψ 5.810	ψ 5.128	ψ 5.542	ψ 7.604	ψ 10.511	ψ 12.255	ψ 19.526
Income Tax Expense	(1.488)	(1.313)	ψ (1.386)	ψ (1.901)	ψ (2.628)	ψ (3.064)	ψ (4.882)
Net Income for the Year	ψ 4.322	ψ 3.815	ψ 4.157	ψ 5.703	ψ 7.883	ψ 9.191	ψ 14.645

Figure A3. Income Statement for 5 Years Projection

APPENDIX B: GRID SEARCH PYTHON CODE (GOOGLE COLLAB)

Ambernïa Male Distribution

```
pip install XlsxWriter
from google.colab import files
import pandas as pd
import numpy as np
uploaded = files.upload()
data=pd.read_excel('Ambernia - Male.xlsx')
writer = pd.ExcelWriter('Ambernia Male Dist.xlsx', engine='xlsxwriter')
list1=[]
for i in range(0,10):
  error1 = 1
  for prdiabobesed in np.arange(0,1,0.025):
    for prdiabhpt in np.arange(0,1,0.025):
      for prdiabboth in np.arange(0,1,0.025):
        for prdiabneither in np.arange(0,1,0.025):
          result = prdiabobesed*data.iloc[i,0] + prdiabhpt*data.iloc[i,1]
+ prdiabboth*data.iloc[i,2] + prdiabneither*data.iloc[i,3]
          error = abs(result-data.iloc[i,4])
          if error < error1:
            error1 = error
            temp = [str(2011+i),prdiabobesed,prdiabhpt,prdiabboth,prdiabne
ither]
  list1.append(temp)
df=pd.DataFrame(list1)
df.columns=['Year','Pr(diab|obesed)','Pr(diab|hypertension)','Pr(diab|both
)','Pr(diab|neither)']
df.to_excel(writer)
writer.save()
finalresult = files.download('Ambernia Male Dist.xlsx')
```

Ambernïa Female Distribution

```
uploaded2 = files.upload()
data2=pd.read_excel('Ambernia - Female.xlsx')
writer2 = pd.ExcelWriter('Ambernia Female Dist.xlsx', engine='xlsxwriter')
list1=[]
for i in range(0,10):
  error1 = 1
  for prdiabobesed in np.arange(0,1,0.025):
    for prdiabhpt in np.arange(0,1,0.025):
      for prdiabboth in np.arange(0,1,0.025):
```

```
        for prdiabneither in np.arange(0,1,0.025):
          result = prdiabobesed*data2.iloc[i,0] + prdiabhpt*data2.iloc[i,1
] + prdiabboth*data2.iloc[i,2] + prdiabneither*data2.iloc[i,3]
          error = abs(result-data2.iloc[i,4])
          if error < error1:
            error1 = error
            temp = [str(2011+i),prdiabobesed,prdiabhpt,prdiabboth,prdiabne
ither]
  list1.append(temp)
df=pd.DataFrame(list1)
df.columns=['Year','Pr(diab|obesed)','Pr(diab|hypertension)','Pr(diab|both
)','Pr(diab|neither)']
df.to_excel(writer2)
writer2.save()
finalresult2 = files.download('Ambernia Female Dist.xlsx')
```

Palòmïnïa Male Distribution

```
uploaded3 = files.upload()
data3=pd.read_excel('Palominia - Male.xlsx')
writer3 = pd.ExcelWriter('Palominia Male Dist.xlsx', engine='xlsxwriter')
list1=[]
for i in range(0,10):
  error1 = 1
  for prdiabobesed in np.arange(0,1,0.025):
    for prdiabhpt in np.arange(0,1,0.025):
      for prdiabboth in np.arange(0,1,0.025):
        for prdiabneither in np.arange(0,1,0.025):
          result = prdiabobesed*data3.iloc[i,0] + prdiabhpt*data3.iloc[i,1
] + prdiabboth*data3.iloc[i,2] + prdiabneither*data3.iloc[i,3]
          error = abs(result-data3.iloc[i,4])
          if error < error1:
            error1 = error
            temp = [str(2011+i),prdiabobesed,prdiabhpt,prdiabboth,prdiabne
ither]
  list1.append(temp)
df=pd.DataFrame(list1)
df.columns=['Year','Pr(diab|obesed)','Pr(diab|hypertension)','Pr(diab|both
)','Pr(diab|neither)']
df.to_excel(writer3)
writer3.save()
finalresult3 = files.download('Palominia Male Dist.xlsx')
```

Palòmïnïa Female Distribution

```
uploaded4 = files.upload()
data4=pd.read_excel('Palominia - Female.xlsx')
writer4 = pd.ExcelWriter('Palominia Female Dist.xlsx', engine='xlsxwriter'
)
list1 = []
for i in range(0,10):
  error1 = 1
  for prdiabobesed in np.arange(0,1,0.025):
    for prdiabhpt in np.arange(0,1,0.025):
      for prdiabboth in np.arange(0,1,0.025):
        for prdiabneither in np.arange(0,1,0.025):
          result = prdiabobesed*data4.iloc[i,0] + prdiabhpt*data4.iloc[i,1
] + prdiabboth*data4.iloc[i,2] + prdiabneither*data4.iloc[i,3]
          error = abs(result-data4.iloc[i,4])
          if error < error1:
            error1 = error
            temp = [str(2011+i),prdiabobesed,prdiabhpt,prdiabboth,prdiabne
ither]
  list1.append(temp)
df=pd.DataFrame(list1)
df.columns=['Year','Pr(diab|obesed)','Pr(diab|hypertension)','Pr(diab|both
)','Pr(diab|neither)']
df.to_excel(writer4)
writer4.save()
finalresult4 = files.download('Palominia Female Dist.xlsx')
```

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