TEAM SUM

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2021 Student Research Case Study Challenge

NEW·WORLD Parametric Insurance

SOCIETY OF ACTUARIES®

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Table of Contents

Executive Summary

Global health risks such as respiratory diseases and diabetes are often overlooked and underinsured. To address these concerns, factors leading to the specified diseases can be monitored and preemptive measures implemented to prevent their onset, rather than merely reimbursing their losses. NEW·WORLD's parametric solution would address economic losses related to such risks in Ambernïa and Palòmïnïa.

PAIRM is a cutting-edge invention that would redefine the existing functions of parametric insurance. It provides a payout if $PM_{2.5}$ levels hit a predetermined trigger. Benefits provided through vouchers on a lump sum or annuity basis to policyholders in an extensive network scheme to purchase measures to reduce the risk of specified diseases.

The key risks that **PAIRM** faces as well as strategies to mitigate these risks were identified before conducting a sensitivity analysis to determine the elements to which **PAIRM** is more sensitive and hence NEW·WORLD should monitor.

1. Objectives

1.1 Protection gaps in traditional CI/TPD

Traditional Total Permanent Disability (TPD) *(Kagan, 2020)* and Critical Illness (CI) *(Kumok, 2019)* policies provide a fixed sum assured payout upon diagnosis (Appendix A). They alleviate the exorbitant medical expenses borne by policyholders, enabling them to undergo necessary treatment. Many are inadequately protected financially for CI due to high premiums required, indicating a protection gap *(Heong, 2019).* Furthermore, the time lag between diagnosis and payout hinders its effectiveness as a protective measure.

1.2 Target Market

We believe that prevention is better than cure. Our parametric solution, **PAIRM**, complements traditional CI/TPD products and would be sold to individual policyholders' resident in Palȍmïnïa and Ambernïa with or intending to obtain CI coverage. By tying benefit payouts to $PM_{2.5}$ indices hitting a trigger, **PAIRM** enables policyholders to receive their payout faster, which allows them to take swift action in protecting themselves against the onset of specified diseases.

1.3 Insurability

PAIRM has been tailored to ensure economic feasibility by controlling the frequency and severity of payouts. The trigger level has been set such that any losses incurred are unlikely to be catastrophic and will be reviewed regularly to account for updated information. The level of payout has been set to defray the costs incurred by policyholders in mitigating the onset of specified diseases.

2. Design Considerations

2.1 Index Measure

We selected $PM_{2.5}$ over PM_{10} as the former measures the concentration of finer particles, which are deadlier as they penetrate deeply into the lungs, impairing their function. Studies have shown significant correlation between fine particle pollutants and respiratory morbidity and mortality *(Xing, Y. F, et al., 2016)*, and that $PM_{2.5}$ can induce oxidative stress in lungs, triggering insulin resistance and increasing the risk of developing type 2 diabetes mellitus *(O'Toole, 2017, Long et al., 2019)*. The prevalence of respiratory diseases and diabetes increases by 2.07% *(Xing, Y. F, et al., 2016)* and 1% *(Pearson et al., 2010)* respectively for every $10\mu g/m^3$ increase in $PM_{2.5}$.

Thus, it is evident that policyholders would benefit from **PAIRM**, which enables them to take actions that would prevent or delay the onset of respiratory diseases and diabetes (herein referred to as "specified conditions") when the $PM_{2.5}$ indices rises beyond a particular limit.

Metrics such as average blood pressure and blood glucose levels are not selected to be index measures as they reflect the effect of the trigger event (cardio-vascular disease and diabetes respectively) and cannot be used as an index to predict the probability of occurrence. Other metrics such as tobacco use and weight distribution are cohort-level trends which do not reflect global trends.

2.2 Triggering Event

To obtain a distribution for the $PM_{2.5}$ index, we used the Maximum Likelihood Estimation method (Appendix B) to fit the $PM_{2.5}$ indices for various countries *(The World Bank, 2017)* to Normal and Log-normal distributions. Log-normal distributions were considered, as had been done in prior research (*Lu HC, et al, 2002)*, due to the non-negative nature of $PM_{2.5}$.

As most countries' indices had a higher likelihood under a Normal model, we opted to model the $PM_{2.5}$ indices of Palòmïnïa and Ambernïa using a Normal model. This choice was validated using the Jarque–Bera test for normality (*Jarque and Bera, 1980;* Appendix C) from which we concluded, at a 5% significance level, that the indices for both countries followed a Normal distribution.

Assumption I: $PM_{2.5}$ levels follows a Normal Distribution

Under these distributions, the trigger levels were chosen by determining the $PM_{2.5}$ levels which would have a 5% probability of being exceeded: **28.19**µg/m^3 and **10.88**µg/m^3 for Palòmïnïa and Ambernïa respectively (Figure 1).

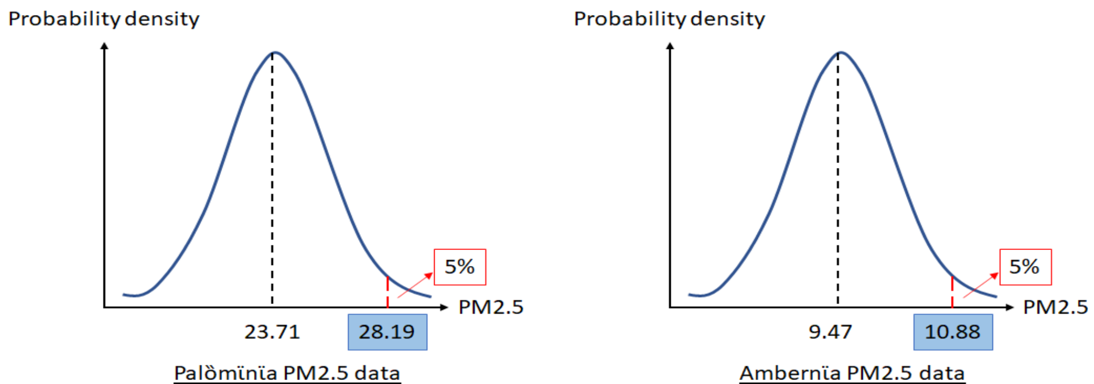


Figure 1: Determining the trigger levels

2.3 Product Design

PAIRM is a single-premium policy renewable annually, which ensures that NEW·WORLD has the option to revise the trigger level after at most one year.

Policyholders can choose between the two variations in the schedule of benefits (Figure 2): (1) lump sum upon $PM_{2.5}$ reaching the trigger level; and (2) annuity payable for each month during which $PM_{2.5}$ is above the trigger. Once the trigger is reached, benefits would be distributed to policyholders as vouchers for various items to reduce the risk of contracting the specified conditions (Appendix D).

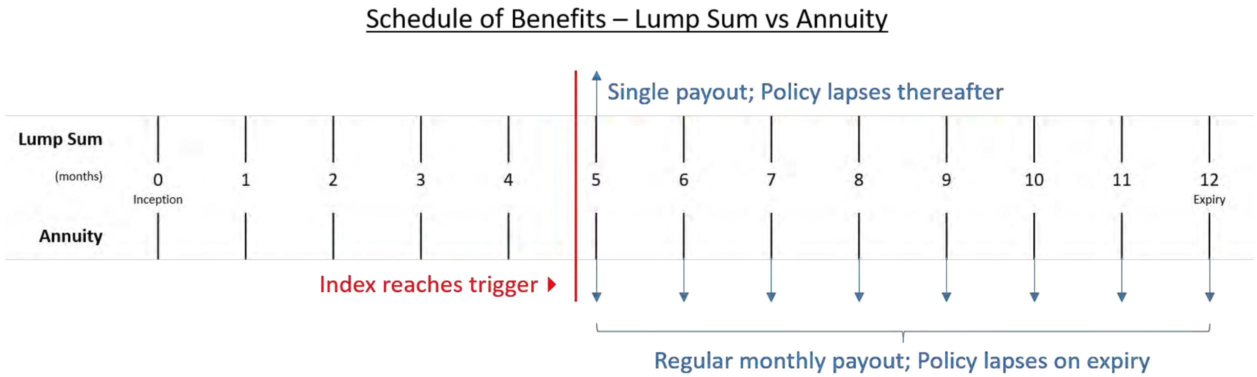


Figure 2: Schedule of Benefits - Lump Sum vs Annuity

Lump sum payouts can be used for one-off purchases of costlier equipment such as air purifiers and treadmills, while annuity payouts can be used to purchase inventory items like masks and low-sugar foods which need to be replenished periodically. Hence, **PAIRM** is able to cater to policyholders' needs and preferences.

The voucher scheme requires the establishment of an extensive network of third-party retailers and pharmacists from whom policyholders can choose the items they want to purchase should the trigger be reached. While developing this network, a temporary system of providing cash payouts can be implemented. The eventual transition from cash to vouchers can be justified through a well-connected network with a variety of appealing choices for policyholders.

3. Data Limitations and Assumptions

In designing **PAIRM**, we used the Economic (CPI, Healthcare Spending per Person, and 3-Month Interest Rates), Trigger (Air Pollution) and NEW·WORLD's Financial Statements data. The limitations of these data led to some key assumptions made, as summarised below.

	Data Limitation	Impact	Assumption (Appendix E)
I	Limited data timeframe for $PM_{2.5}$.	Having 11 data points stifled our ability to obtain an accurate distribution of $PM_{2.5}$, This would affect the setting of trigger level.	Worldwide $PM_{2.5}$ index data from the World Bank were used to approximate the distributions for Ambernïa and Palòmïnïa.
II	Lack of indication of movements on price index on forecasted data.	An accurate projection is required to encapsulate the relevant conditions during **PAIRM** launch in Q4 2021.	GNI per person was projected based on a yearly average; CPI taken at 2020 level as movement of inflation cannot be accurately determined.
III	Lack of updated data for discount rates, historical data accurate as at the end of 2020.	Difficulty in establishing the discount rate for the pricing of **PAIRM.**	Use of the Cox-Ingersoll-Ross model to project the annual short rate for 2021 and beyond.
IV	The data provided was generally on an annual basis.	Incompatible for the pricing of **PAIRM**, which can be triggered and repriced on a monthly basis.	Assumed an annual constant discount rate each year.

4. Implementation Plan

4.1 Pricing model

We performed a 5-year profit/loss projection for each policy. Our pricing model is a multi-decrement model consisting of three states, namely *NotTriggered*, *Triggered* and *Lapsed*. Using the assumption of a 5% probability of the index reaching the trigger level, the transition probabilities between the states are as reflected in Figures 3 and 4.

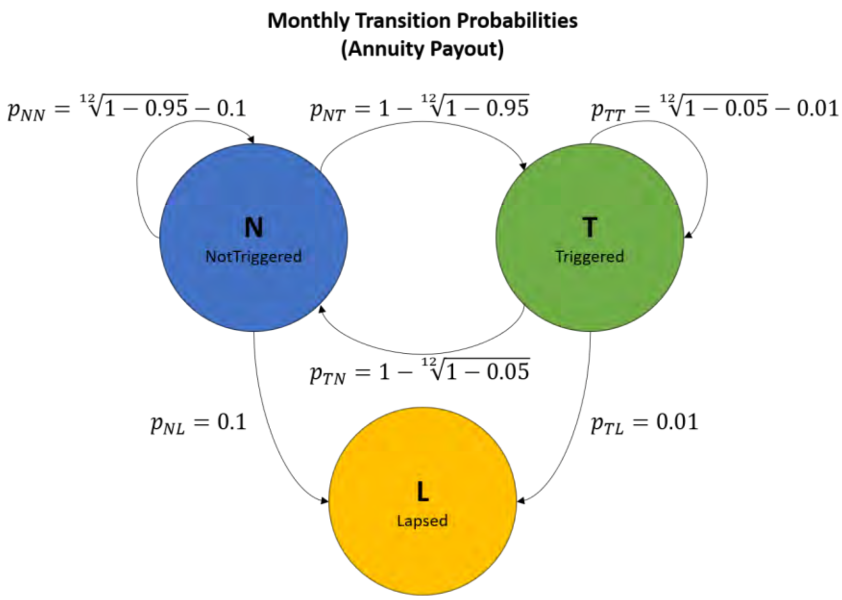


Figure 3: Monthly Transition Probabilities (Annuity Payout)

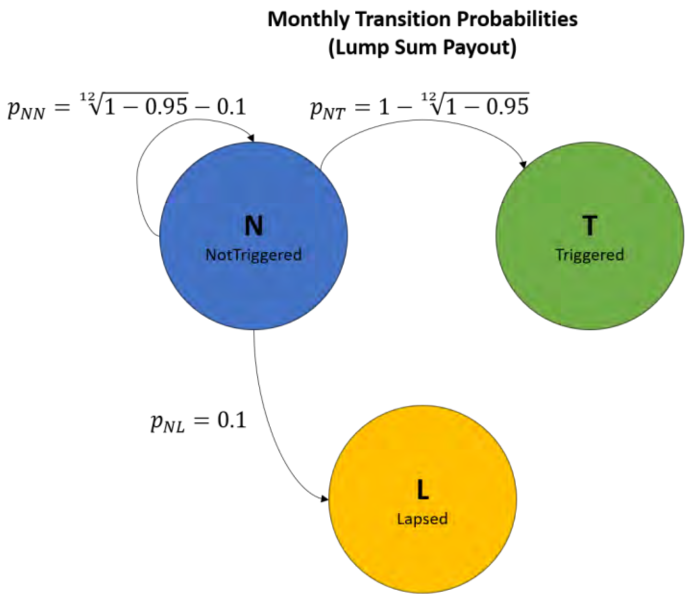


Figure 4: Monthly Transition Probabilities (Lump Sum Payout)

The 2021 healthcare spending per person was projected by using the inflation-adjusted year-on-year increase to determine the real healthcare spending. Thereafter, we determined the benefit amount (Figure 5) through multiplying the 2021 projected healthcare spending by the proportion of healthcare spending allocated to respiratory conditions in the US in 2013 *(Cox, 2017)*.

Payout type (mil)	Lump Sum (per trigger)	Annuity (per month triggered)
Ambernïa	8.33% * ψ6073.13 = ψ505.89	ψ505.89 / 12 = ψ42.16
Palòmïnïa	8.33% * ψ718.88 = ψ59.88	ψ50.56 / 12 = ψ4.99

Figure 5: Summary of benefits per policy type

Assumption II: Inflation rates for projection follow 2020 CPI levels

Expenses, valued at 10% of the single premium, were assumed to be uniformly distributed throughout the year and incurred at the start of every month.

The expected cash-flows per policy in-force were determined as follows:

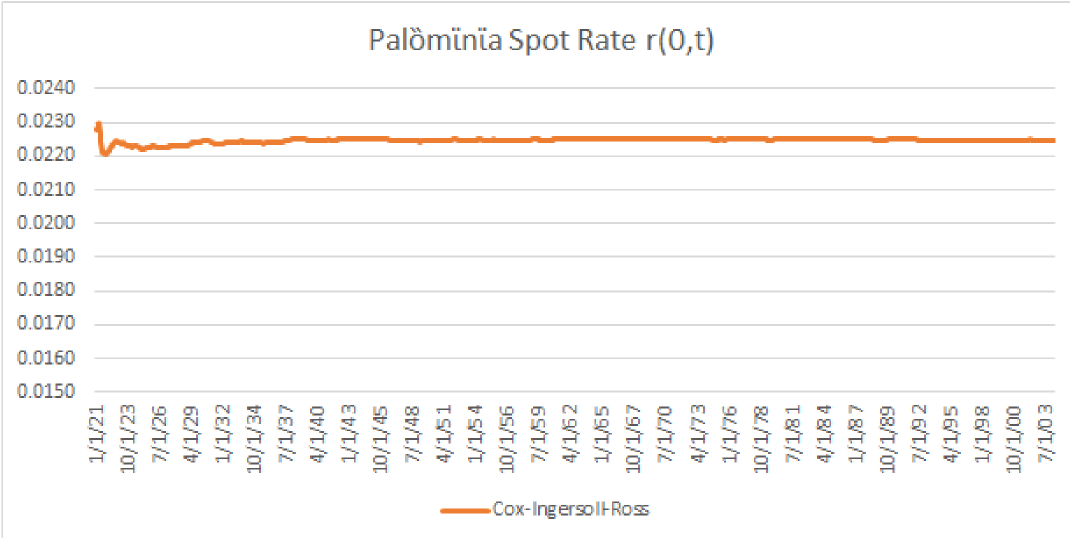
- Expenses = 10% * Premium * In-force policies [Pr(Triggered) + Pr(NotTriggered)]
- Benefits = 1000 * Pr(Triggered)

Fixing our profit margin ($\frac{\Sigma Net\ profit}{\Sigma Premiums}$) at 10%, we calculated the single premium by using the **principle of equivalence** (Profit = Premium - Expenses - Benefits).

The expected cash flows were discounted to calculate the present value. We determined the interest rate based on the Cox-Ingersoll-Ross (CIR) short rate model, with mean and variance based on the past 11 years' 3-month interest rate, which is the short rate provided with the closest duration to our yearly-renewable product. The CIR model is desirable due to the non-negativity constraint of the model. Although negative interest rates were observed in Ambernïa for the recent few years, we expect that the rates will eventually revert back to the positive mean interest rate level. By conducting 5 simulations, then taking the averages of the short rates, we determined the short rate to be between **1.59% - 2.15%** and **0.38% - 0.40%** for Palòmïnïa and Ambernïa respectively (Figure 6). Details of the CIR simulation are collected in Appendix F.

Assumption III: CIR model to determine short rate model

Assumption IV: Constant annual interest rate



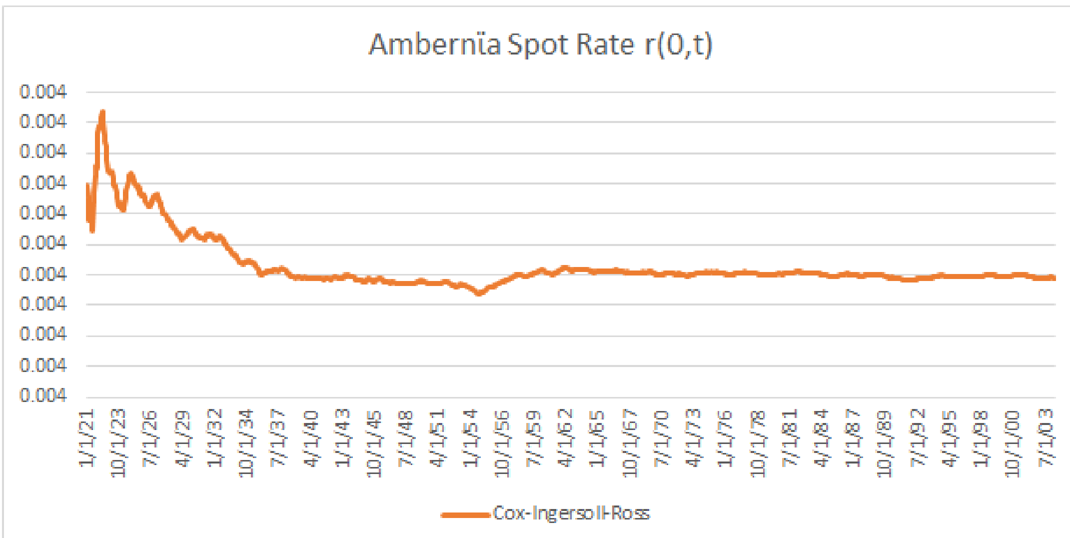


Figure 6: Forecasted interest spot rates

The single premium per ψ1000 payout for each policy type is summarized in Figure 7.

Country/Payout type (mil)	Lump Sum	Annuity
Ambernïa	ψ 61.742370	ψ 5.310899
Palòmïnïa	ψ 61.092097	ψ 5.254289

Figure 7: Summary of premium amount per policy type

The total expenses as a proportion of net assets of NEW·WORLD increased by 12.2%, from 0.2463 in 2019 to 0.2763 in 2020. The projected proportion of expenses/net assets in 2021 is 0.31. By the **principle of equivalence**,

Premiums = Reserves + [Expenses + Benefits + Profit]

Manipulating the equation to obtain the net assets,

Net Assets = Premiums - Reserves = [Expenses + Benefits + Profit]

Therefore,

Expenses / Net Assets = Expenses / [Expenses + Benefits + Profit]

All products have a proportion less than the projected proportion of 0.31 and will be suitable additions to NEW·WORLD's product mix (Figure 8).

Country/(Expense/NA)	Lump Sum	Annuity
Ambernïa	ψ 5.9985/ ψ 41.6599 ≈ 0.14	ψ 0.5226/ ψ 3.5582 ≈ 0.15
Palòmïnïa	ψ 5.9353/ ψ 42.1838 ≈ 0.14	ψ 0.4402/ ψ 3.6034 ≈ 0.12

Figure 8: Summary of proportion of total expenses/net assets

4.2 Marketing plan

PAIRM would be marketed together with an existing base plan, targeting existing and potential policyholders and alerting them to the potential health benefits of taking preventive measures. Key partnerships with the national meteorological centres and environmental agencies will enable NEW·WORLD to obtain real-time updates of $PM_{2.5}$ indices, allowing policyholders to be informed in a timely manner when the $PM_{2.5}$ level hits the trigger. NEW·WORLD can publish a catalogue of the products available for redemption through vouchers and their functions (Appendices D and G) through social media.

4.3 Implementation Timeline

The implementation timeline for **PAIRM** can be found in Appendix I.

5. Risk and Risk Mitigation Strategies

We summarized the risk analysis and the corresponding mitigation strategies in the table below.

Risk	**Description**	**Mitigation Strategies**
Basis Risk	Majority of Palòmïnïa and Ambernïa populations might have existing respiratory-related illnesses. Hence, **PAIRM** might not meet their medical needs, as the index focuses on prevention and not cure.	We can collect data on diseases typically suffered by Palòmïnïa and Ambernïa. Through this, we can understand the true healthcare needs of the population and create an index that reflects this better.
Claims Risk	Palòmïnïa and Ambernïa are subjected to catastrophic events such as hotspots in neighbouring countries, resulting in higher than expected claims.	As external risks are hard to predict, it is preferred to cede the catastrophic risk to a reinsurer. Even though these events are rare, it can have a severe impact on profitability.
Third Party Risk	Delays could be expected in establishing partnerships with pharmacies throughout Palòmïnïa and Ambernïa, resulting in the misuse of cash benefits by the policyholders, where they purchase items unrelated prevention, defeating the purpose of **PAIRM**.	To reduce the risk, we could present them with statistics on the effectiveness of masks and air purifiers in reducing the risk of contracting respiratory illnesses.

Market Risk	With the high level of PMI trigger, the public might not be incentivized to purchase **PAIRM** if they think payout is unlikely to occur. Moreover, a fall in demand for **PAIRM** could occur when the cash benefit is replaced with vouchers. This is due to the perceived decline in benefits from the public.	Marketing initiatives can inform people the benefits of our parametric insurance product, reducing the market risk.

Risk Likelihood	**Risk Severity**		
	Minor	**Moderate**	**Major**
Unlikely			Claims Risk
Possible		Basis Risk	Market Risk
Likely	Third Party Risk		

6. Sensitivity Analysis and Data Monitoring

We conducted sensitivity analysis on 4 main assumptions: Expense, Trigger Frequency, Lapse and Interest Rate (Appendix H).

PAIRM was found to be most sensitive to deviations in trigger frequency, with a 30% higher than expected trigger frequency resulting in the profit margin plummeting from 10% to -13.5% and -14.2% for Palòmïnïa and Ambernïa respectively. This is a major concern for NEW·WORLD as it increases the severity of insurance risk, the risk of greater-than-expected claims. NEW·WORLD should hence monitor this closely in the initial phases and adjust the frequency assumptions as required.

The profit margin of **PAIRM** is also sensitive to deviation in projected expenses, decreasing from 10% to 8.7% and 8.8% for Palòmïnïa and Ambernïa respectively if the expense ratio increases from 10% to 16%. To monitor this, NEW·WORLD should keep track of the number of policies sold in relation to projections, as well as the costs incurred per policy.

PAIRM is less sensitive to changes in lapse rates and interest rates. This is favourable for NEW·WORLD and implies that the profit margin is rather insulated from these factors.

As we obtain more data and experience, we will refine our pricing methodology. With a greater volume of granular data, we can more accurately fit a distribution to the $PM_{2.5}$ levels and conduct experience studies to analyse other parametric factors with high correlation with the specified conditions. Should the experience differ markedly from initial assumptions, revision would be necessary to maintain profitability and competitiveness, with priority placed on the more sensitive expense and trigger frequency elements.

7. Conclusion

PAIRM provides policyholders in Palòmïnïa and Ambernïa with a payout when $PM_{2.5}$ indices exceed the trigger. This provides them with the means to purchase preventive equipment such as masks and air purifiers to mitigate the risk of contracting the specified conditions.

We believe that, by focusing on prevention rather than cure, **PAIRM** is a novel product that fills an existing protection gap, and we hope that **PAIRM** will pave the way for the development of a series of health-centric parametric insurance products.

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Appendices

Appendix A: Table illustrating difference between traditional and parametric insurance

Predictor of/ Health Risk	**Traditional (Prescriptive)**		**Parametric (Preventive)**	
	Triggering event(s)	**Payout**	**Triggering event(s)**	**Payout**
Cardio-vascular disease. (eg. High blood pressure)	Hypertension (Systolic > 140 m Hg, diastolic > 90mm Hg)		Rise in hypertension prevalence	
Diabetes	Rise in blood sugar level (> 200 mg/DL)	Critical Illness plan provides lump sum pay-out on diagnosis	Rise in PM2.5 indices --- OR --- Increase in diabetes prevalence/ blood sugar levels	On a lump sum basis (small amount sufficient to provide for preventive measures)
End Stage Lung Disease/Chronic obstructive pulmonary disease	Diagnosis of End Stage Lung Disease (LIA, (2019))	A lump-sum payout of 100% of the sum assured will be made to the policyholder	PM2.5 indices reaching **28.19** and **10.88** (5% right-tail probability) for Palòmïnïa and Ambernïa respectively.	• PM2.5 indices in Palòmïnïa and Ambernïa obtained from population weighted concentration

				• On a lump sum basis (small amount sufficient to provide for preventive measures) eg. masks, air purifiers.
Lung cancer, ARI (Acute Respiratory Infections)	Future possible consideration: Proportion of smokers in age group	Lung cancer, ARI (Acute Respiratory Infections)		• Second hand smoke inhaled increases the chance of respiratory diseases • Triggered when high proportion of smokers in that age group which may indicate health risks

Appendix B: Derivation of Maximum Likelihood Estimators for Normal and Lognormal Models

Normal Model

$$X \sim N\left(\mu, \sigma^2\right)$$

$$f\left(x; \mu, \sigma^2\right) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right] = \exp\left[-\frac{1}{2}\ln\left(2\pi\sigma^2\right) - \frac{1}{2\sigma^2}\left(x-\mu\right)^2\right]$$

$$l\left(\underline{x}; \mu, \sigma^2\right) = -\frac{n}{2}\ln\left(2\pi\sigma^2\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{n}\left(x_i - \mu\right)^2$$

$$\begin{cases} \dfrac{\partial l}{\partial \mu} = \dfrac{1}{\sigma^2}\displaystyle\sum_{i=1}^{n}\left(x_i - \mu\right) = \dfrac{1}{\sigma^2}\left(\displaystyle\sum_{i=1}^{n} x_i - n\mu\right) \\ \dfrac{\partial l}{\partial \sigma^2} = -\dfrac{n}{2\sigma^2} + \dfrac{1}{2\sigma^4}\displaystyle\sum_{i=1}^{n}\left(x_i - \mu\right)^2 \end{cases} \Rightarrow \begin{cases} \hat{\mu}^{ML} = \dfrac{1}{n}\displaystyle\sum_{i=1}^{n} x_i \\ \widehat{\sigma^2}^{ML} = \dfrac{1}{n}\displaystyle\sum_{i=1}^{n}\left(x_i - \hat{\mu}^{ML}\right)^2 \end{cases} \Rightarrow \hat{l}^{ML} = -\frac{n}{2}\left[1 + \ln\left(2\pi\widehat{\sigma^2}^{ML}\right)\right]$$

Lognormal Model

$$X \sim LN\left(\mu, \sigma^2\right)$$

$$f\left(x; \mu, \sigma^2\right) = \frac{1}{\sigma\sqrt{2\pi}}\frac{1}{x} \exp\left[-\frac{1}{2}\left(\frac{\ln x-\mu}{\sigma}\right)^2\right] = \exp\left[-\frac{1}{2}\ln\left(2\pi\sigma^2\right) - \ln x - \frac{1}{2\sigma^2}\left(\ln x-\mu\right)^2\right]$$

$$l\left(\underline{x}; \mu, \sigma^2\right) = -\frac{n}{2}\ln\left(2\pi\sigma^2\right) - \sum_{i=1}^{n}\ln x_i - \frac{1}{2\sigma^2}\sum_{i=1}^{n}\left(\ln x_i - \mu\right)^2$$

$$\begin{cases} \dfrac{\partial l}{\partial \mu} = \dfrac{1}{\sigma^2}\displaystyle\sum_{i=1}^{n}\left(\ln x_i - \mu\right) = \dfrac{1}{\sigma^2}\left(\displaystyle\sum_{i=1}^{n}\ln x_i - n\mu\right) \\ \dfrac{\partial l}{\partial \sigma^2} = -\dfrac{n}{2\sigma^2} + \dfrac{1}{2\sigma^4}\displaystyle\sum_{i=1}^{n}\left(\ln x_i - \mu\right)^2 \end{cases} \Rightarrow \begin{cases} \hat{\mu}^{ML} = \dfrac{1}{n}\displaystyle\sum_{i=1}^{n}\ln x_i \\ \widehat{\sigma^2}^{ML} = \dfrac{1}{n}\displaystyle\sum_{i=1}^{n}\left(\ln x_i - \hat{\mu}^{ML}\right)^2 \end{cases} \Rightarrow \hat{l}^{ML} = -\frac{n}{2}\left[1 + \ln\left(2\pi\widehat{\sigma^2}^{ML}\right)\right] - \sum_{i=1}^{n}\ln x_i$$

Summary of Results

Model with higher log-likelihood	**Count**	**Percentage**
Normal	161	67.08%
Lognormal	79	32.92%
Total	**240**	**100.00%**

Appendix C: Jacque-Bera Test Statistic (Jacque and Bera, 1980)

$$S = \frac{\hat{\mu}_3}{\hat{\sigma}_3} = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^3}{\left[\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2\right]^{3/2}}$$

$$K = \frac{\hat{\mu}_4}{\hat{\sigma}_4} = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^4}{\left[\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2\right]^{2}}$$

$$JB = \frac{n}{6}\left[S^2 + \frac{1}{4}\left(K-3\right)^2\right]$$

The detailed calculations behind Appendices B and C can be found here: (MLE and JB analysis on PM2.5.xlsx)

Appendix D: Items in voucher network scheme (Non-exhaustive)

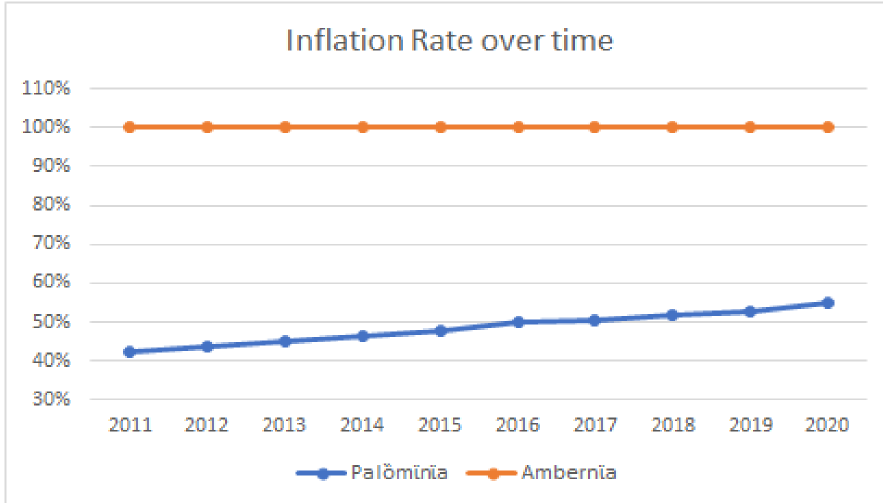
Preventive measure	**Respiratory Disease**	**Diabetes**
Monitor risk	● Radon test kit ● Arsenic water test kit ● Thermometer	● Weighing scale ● Step tracker ● Blood pressure monitor (Manual/Automatic) ● Weight-loss & diet planner
Reduce/eliminate risk	● Surgical Masks ● Air purifier and dehumidifier ● Hand sanitisers and wet wipes	● Healthy foods (eg. whole grains, high fiber foods like fruits and vegetables) ● Off the counter supplements (eg. vitamin D, probiotics) ● Exercise equipment (eg. treadmill, yoga mat, weights)

Appendix E: Assumptions in detail

Section	**Assumption with rationale and analysis**
2.2	Distribution of $PM_{2.5}$ data We assumed that Worldwide $PM_{2.5}$ data from various countries can be used as a proxy to determine a suitable distribution for Palömïnïa and Ambernïa. Yet a normal distribution allows for negative values of $PM_{2.5}$ which is not possible. The geography and landscape of these countries may also affect the distribution of $PM_{2.5}$, and is included as one of the risk factors we considered (Section 5). The tail end probability would affect the $PM_{2.5}$ limit since we set a 5% significance level, a low but not improbable event chance of happening. Setting a limit that's too low could result in higher losses as more than expected claims are made (ie probability is actually more than 5%), while a limit that's too high (ie probability is actually less than 5%) would lead to basis risk and dissatisfaction of policyholders. Furthermore, our sensitivity analysis showed that **PAIRM** was most sensitive to changes in trigger frequency, hence this variable needs to be monitored closely. A normal distribution was chosen after conducting the MLE estimation and that an overwhelming majority of countries' data follow a normal one. Any unexpected risks have to be mitigated as elaborated in Section 5.

4.1	<u>Profit margin</u> We deemed a 10% profit margin to be appropriate as a reasonable benchmark to determine how much to charge. This is to ensure sustainability of the product and that it is a profit making product that can be added to the product mix of the company. This profit margin was decided based on industry averages of about 9.6% for life insurance companies. <u>Trigger frequency</u> We assumed a 5% frequency of hitting the index. This tail end probability was deemed to be appropriate because of the severity of being able to cause significant respiratory issues and diabetes. It is estimated that 3% of cardiopulmonary and 5% of lung cancer deaths are attributable to $PM_{2.5}$ globally *(Xing, Y. F, et al., 2016)*, and further described in Section 2.1. Since the total impact can be estimated by frequency * severity, by factoring a 5% frequency rate could result in a proportionate decrease in the total impact caused by $PM_{2.5}$. <u>Lapse Rate</u> We assumed a 10% lapse rate from NonTriggered (NT) to Lapse (L) and 1% lapse rate from Triggered (T) to Lapse (L). This includes a) mortality (death), b) withdrawal from the policy and c) contracting an illness before the preventive measure is required. It is 10 times higher for NT to L than T to L as those in T state most likely wouldn't b) withdraw since they are already receiving benefits and c) is irrelevant because they are already receiving the benefits. 10% is deemed reasonable as due to changes in trigger levels and other unforeseen circumstances, we overestimate the lapse frequency, to provide a conservative estimate for the premiums.

	<u>Healthcare spending</u> The proportion of healthcare spending allocated to respiratory disease is an estimate of what people spend on products. There are perhaps others classified as ‘Others’ or ‘Miscellaneous’ but can be used as a good proxy. Some of these expenses would include medical expenses which are part of the payout which traditional insurance covers. However, we believe that these two effects cancel one another, as the over accounted medical bills approximately equals the unaccounted medical equipment. <u>Interest Rate</u> We assumed a long term mean reversion based on the past 11 years of data provided and a 0.33 drift term to model the interest rates based on 5 simulations. It is also affected by inflation rate, and it is accounted for by adjusting the nominal interest rates to real rates before the simulation. The lack of data could result in an inaccurate long-term mean, affecting interest rates. <u>Inflation</u> Inflation for both countries has a generally increasing trend, and we did not want to overcomplicate matters by projecting future inflation rates as shown in the figure below. It is influenced by factors such as the spare capacity of the economy and the relative value of its currency which we do not have the data for. We made a simple assumption to take the most recent (2020) inflation rate to account for all future cash flows within our pricing model, to account for the differences between real and nominal cash flow values.



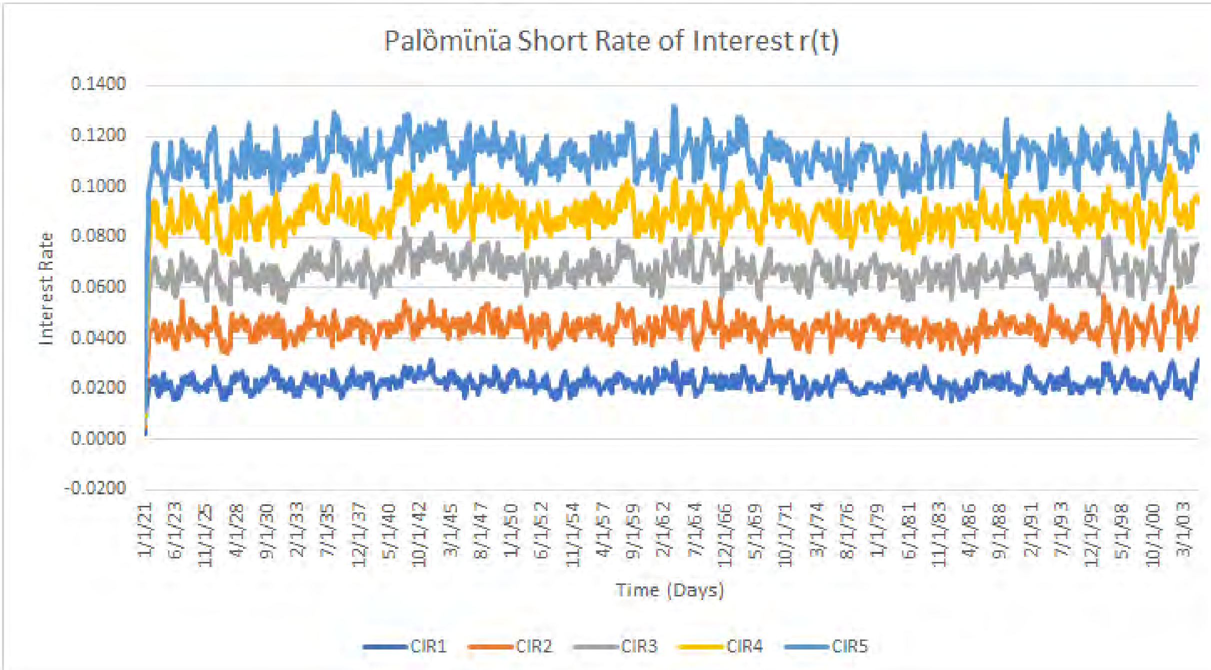
<u>Expenses</u>

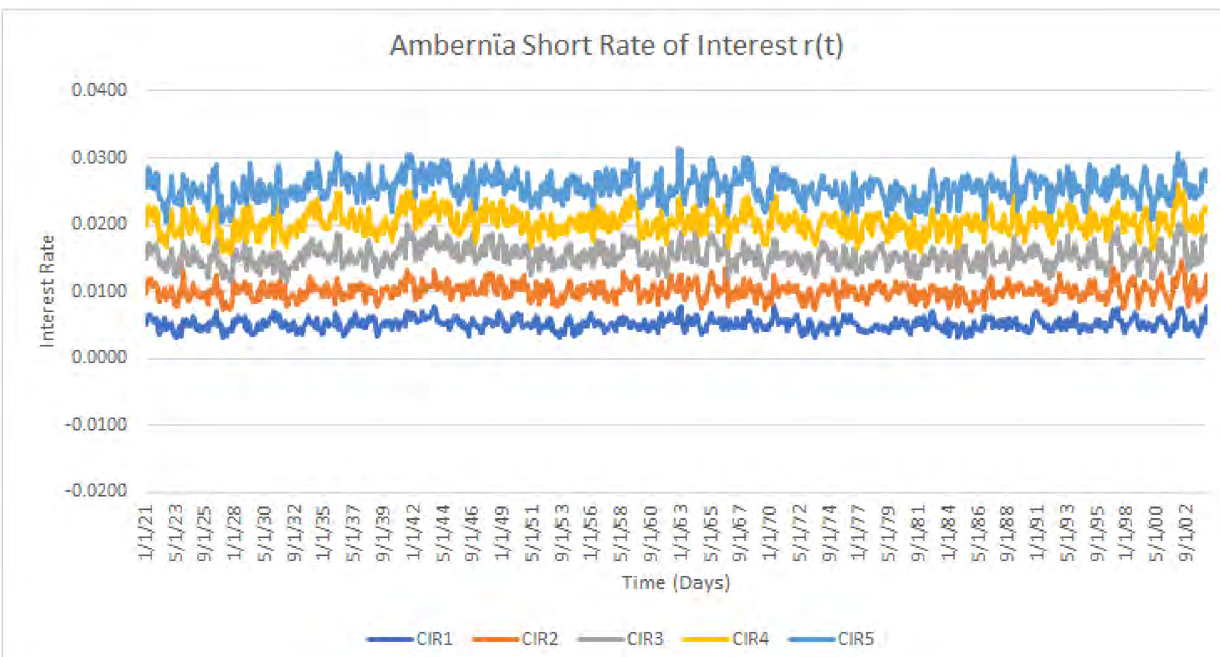
We assumed a 10% loading factor for expenses on the premiums. These are variable expenses which include commissions, distribution costs, agency fees, etc. These expenses vary based on the number of policies sold.

A detailed model with calculations for the pricing model can be found here: (Pricing Model with Sensitivity Analysis.xlsm)

Appendix F: Simulation of interest rate (CIR model)

$$dr(t) = \alpha\left[\mu - r(t)\right]dt + \sigma\sqrt{r(t)}dW(t)$$





Appendix G: Multinational corporations to collaborate with (Non-exhaustive)

Type	**Companies**
Pharmaceuticals	• Pfizer • Moderna
Medical Devices	• Johnson & Johnson • Abbott Laboratories
Supermarkets/Food retail	• Walmart • Nestle • Unilever • P&G
Electronics and fitness	• Fitbit • Carrot

+ Local health and wellness companies and pharmaceuticals

Appendix H: Sensitivity Analysis

Palòmïnïa

Expense	-3	-2	-1	0	1	2	3	Delta	2%
% prem SA	0.04	0.06	0.08	0.1	0.12	0.14	0.16		
Profit Margin	11.1439%	10.7419%	10.3400%	9.9380%	9.5360%	9.1341%	8.7321%		

Freq	-3	-2	-1	0	1	2	3	Delta	10%
NT to T	0.2986%	0.3412%	0.3839%	0.4265%	0.4692%	0.5118%	0.5545%		
T to T	0.6119%	0.6993%	0.7867%	0.8742%	0.9616%	1.0490%	1.1364%		
Profit Margin	33.6096%	25.6821%	17.7916%	9.9380%	2.1212%	-5.6590%	-13.4028%		

Lapse	-3	-2	-1	0	1	2	3	Delta	10%
NT to L	0.070%	0.080%	0.090%	0.100%	0.110%	0.120%	0.130%		
T to L	0.007%	0.008%	0.009%	0.010%	0.011%	0.012%	0.013%		
Profit Margin	9.7908%	9.8399%	9.8890%	9.9380%	9.9870%	10.0360%	10.0849%		

I/r	-3	-2	-1	0	1	2	3	Delta	10%
Factor	-30%	-20%	-10%	0%	10%	20%	30%		
Profit Margin	9.6268%	9.7309%	9.8347%	9.9380%	10.0410%	10.1435%	10.2458%		

Ambernïa

Expense	-3	-2	-1	0	1	2	3	Delta	2%
% prem sa	0.04	0.06	0.08	0.1	0.12	0.14	0.16		
Profit Margin	11.2020%	10.8017%	10.4013%	10.0010%	9.6007%	9.2003%	8.8000%		

Freq	-3	-2	-1	0	1	2	3	Delta	10%
NT to T	0.2986%	0.3412%	0.3839%	0.4265%	0.4692%	0.5118%	0.5545%		
T to T	0.6119%	0.6993%	0.7867%	0.8742%	0.9616%	1.0490%	1.1364%		
Profit Margin	34.0922%	26.0684%	18.0380%	10.0010%	1.9573%	-6.0931%	-14.1501%		

Lapse	-3	-2	-1	0	1	2	3	Delta	10%
NT to L	0.070%	0.080%	0.090%	0.100%	0.110%	0.120%	0.130%		
T to L	0.007%	0.008%	0.009%	0.010%	0.011%	0.012%	0.013%		
Profit Margin	9.8532%	9.9025%	9.9518%	10.0010%	10.0502%	10.0994%	10.1485%		

I/r	-3	-2	-1	0	1	2	3	Delta	10%
Factor	-30%	-20%	-10%	0%	10%	20%	30%		
Profit Margin	9.9427%	9.9621%	9.9816%	10.0010%	10.0204%	10.0398%	10.0592%		

Appendix I: Timeline of product launch

	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Phase	Date	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22
	Launch of product																	
	Liase with third party suppliers																	
	Marketing of product																	
	Partner with national meteorological centres																	
1	Monitor experience																	
	Start of voucher scheme																	
	Inclusion of other parametric factors																	
	Collaboration with third party suppliers for discounts																	
	Analysis of basis risk																	
2	Integrate with Insuretech																	