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Safelife Report

Autonomous Vehicles Insurance Policy

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1 Executive Summary

In the near future autonomous vehicles will pose great challenges and opportunities for insurers. This analysis shows how Safelife could benefit from entering Carbia's autonomous vehicle insurance market. It was found that Safelife can increase their pure premium revenues by 25.3% in 2030, compared to the scenario where Safelife does not not enter the market, mainly due to an increase in exposure. Moreover, as a first-mover, Safelife can set a higher profit margin on their new insurance products.

It is recommended for Safelife to launch a single autonomous vehicle policy in the first quarter of 2020. The new policy will cover for the standard risks faced by traditional vehicles and also for new risks specific to autonomous vehicles: Cyber Risk, Malfunction Risk and Infrastructure Risk. In the long-run premiums will be shared between the owner and manufacturer.

Finally, as liability shifts from the driver to the manufacturer, a prerequisite for successfully implementing the proposed new policy is a data-sharing arrangement with vehicle manufacturers, drivers and insurers.

2 Purpose & Background

2.1 Safelife: the Leading Insurance Company in Carbia

Safelife has been growing in the automobile insurance market, presently leading the market in Carbia with a 34% share. Figure 1 illustrates Safelife's upward exposure trend throughout the years of 2009—2019.

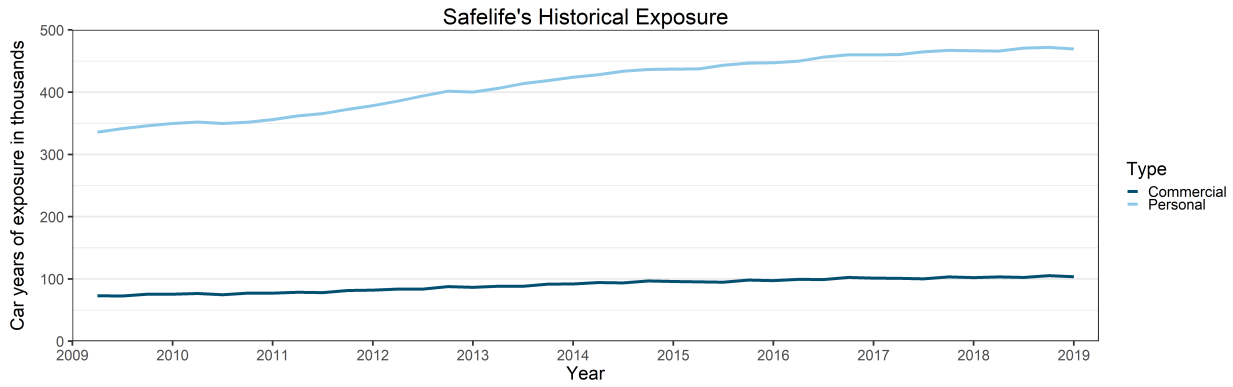

Figure 1: Safelife's historical exposure.

The data in Figure 2 displays a generally steady progression of growth in the total amount of claims for all five coverages, except for a significant spike in comprehensive claim amount in the third quarter of 2010 due to a natural disaster.

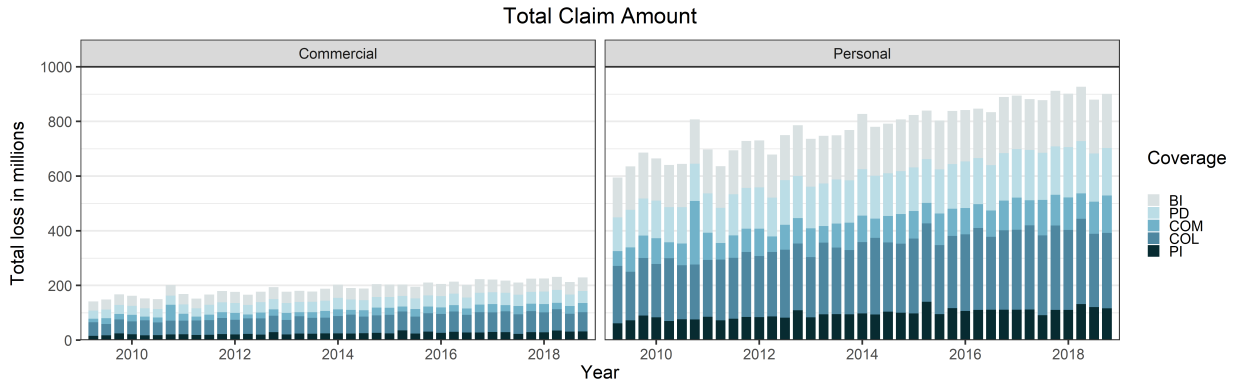

Figure 2: Historical total loss for all coverage (BI - Bodily Injury Liability, PD - Property Damage, COM - Comprehensive, COL - Collision and PI - Personal Injury).

Note that all monetary values throughout this analysis are presented in 2019 prices, assuming an annual inflation rate of 2.2% over the period 2009—2030 (see Appendix A.3).

2.2 The Revolution of Autonomous Vehicles

The introduction of AVs[1] will create preeminent changes not only in the auto insurance industry but in society as a whole. To assess the impact of AVs on Safelife's insurance business, first an insurance policy for AVs will be designed and additionally future pure premiums for the new products combined with traditional policies will be estimated, given a suggested launch date and other market assumptions. A sensitivity analysis will assess the impact of the assumptions on premiums by presenting different scenarios.

3 Methodology

3.1 Assumptions

The market for AVs will be divided into three levels of autonomy [1]:

Level	Class	Description
A0	Traditional	Fully operated by the driver.
A1	Semi-autonomous	Transitional vehicle operated by an individual but with autonomous driving features.
A2	Full-autonomous	Completely self-driving vehicle, with no need for human input.

Table 1: Autonomy Levels

[1] Autonomous Vehicles

3.1.1 Carbia

It is foreseen that AVs will be more attractive for commercial purposes, since international firms like Uber or Lyft have a higher ability and a greater interest in investing in such long-term options. Additionally, controlling for dispersion, regional implementation problems and ensuring standard levels of service and maintenance [5] is easier if the vehicles are sold for taxi-service purposes, rather than for individual use. Overall, the commercial and personal market are expected to grow at a rate of 4% and 0.5% per year, respectively [6]. Combining both effects and using KPMG's predictions [9], it is possible to draw a trend for the proportion of exposure per autonomy level, represented in Figure 3.

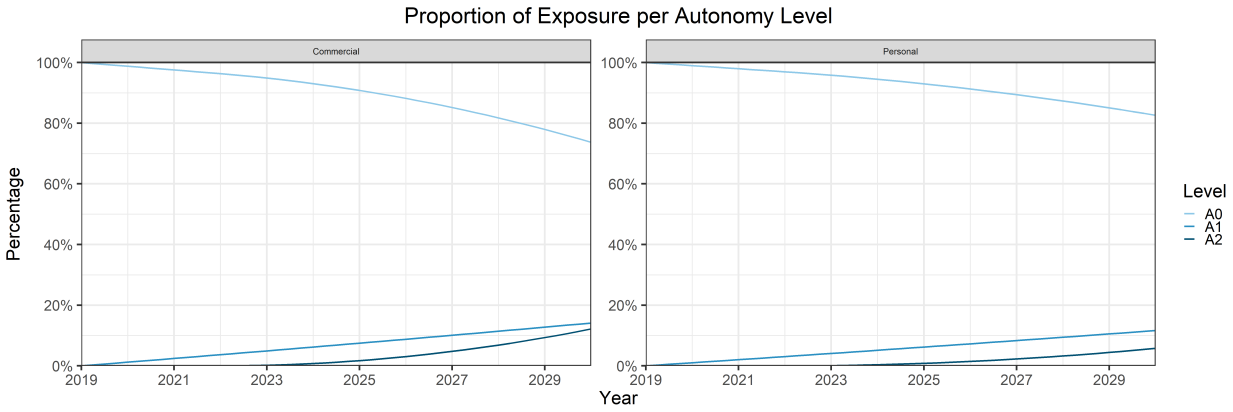

Figure 3: Share of AVs in the personal and commercial market. Full-autonomous vehicles are not expected to have a significant presence in the market before 2022 [1].

Finally, total exposure per autonomy level can be derived from the combination of assumptions on exposure and proportion of AVs.

3.1.2 Safelife

- Entering AVs Insurance Market: The Perfect Timing

The main risk of entering the insurance market for AVs prior to competitors is the lack of historical claim data, which could lead to estimation errors in premium calculations. Other issues could be unexpected legislation and contractual difficulties [1]. On the other hand,

Safelife would secure the "first-mover effect", gaining a competitive advantage for example by working in partnership with the OEMs[2] and collecting proprietary driver data from AVs and capturing potential revenues [1]. This would also improve Safelife's market reputation now linked with progressive technological solutions. Therefore, despite the potential issues, it is recommended and thus assumed for the purpose of our study that Safelife enters the market in the first quarter of 2020.

- Market Share for Different Levels of Autonomy

Figure 4 illustrates Safelife's market share per autonomy level over time. Based on recent years' trend, it is presumed that Safelife will steadily increase their market share in the traditional car market by 0.5% per year over the next 10 years.

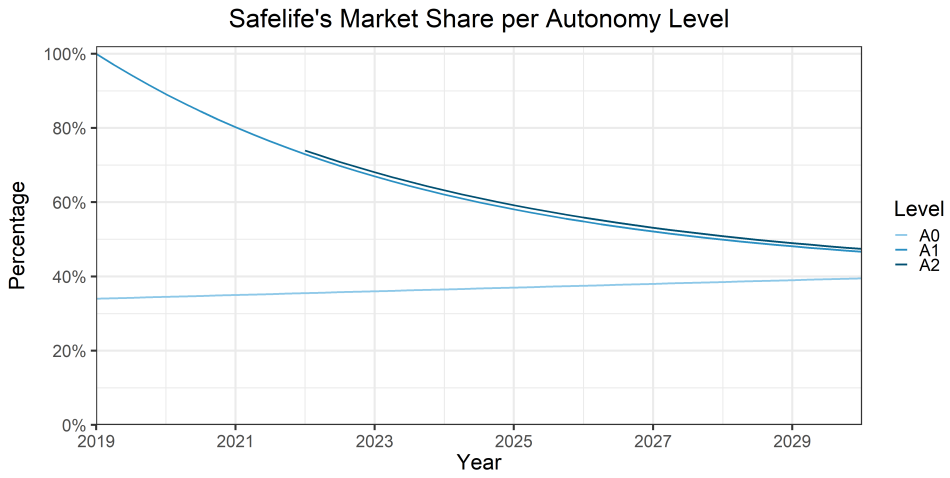

Figure 4: As a first-mover, Safelife will initially capture all the exposure from the semi-autonomous car market, until its competitors decide to enter. Since full-autonomous cars are only expected to be introduced by 2022, it is assumed that by this time other insurers in Carbia have already entered this market.

Combining all the previous assumptions, the predictions for Safelife's total exposure in different markets follow according to Figure 5.

[2]Original Equipment Manufacturers

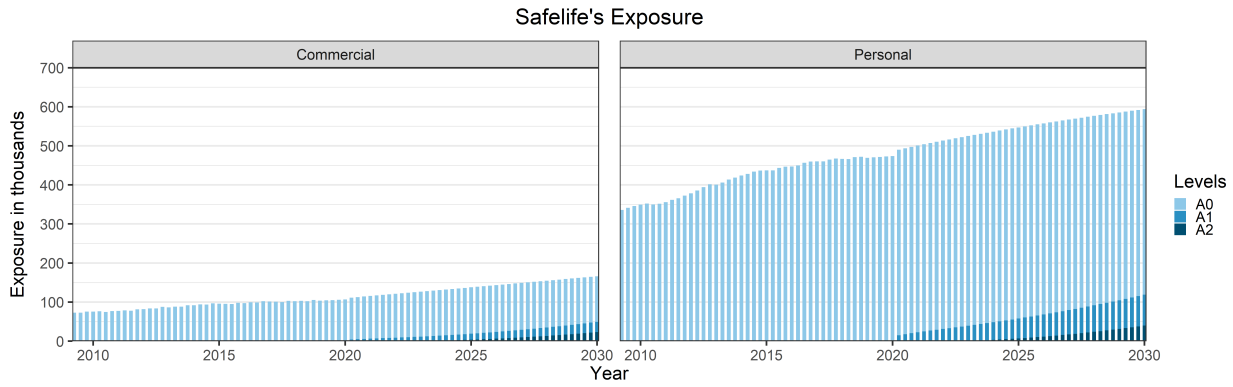

Figure 5: Safelife's total estimated exposure.

3.2 What to Expect from Legislation

Since 2017, most states in the United States have begun to allow the use of an automated driving system if the system is in compliance with the federal law in place [8]. The same development is assumed in Carbia as it has similar laws and regulations.

3.2.1 The Liability System

For traditional insurance, the liability sits with the driver, but as cars become more autonomous there will be a shift in liability to the OEM. Ideally, the liability system should encourage OEMs to develop safer technology, regulate accountability and responsibility, compensate fairly and quickly for claims and reduce frictional costs [2]. How premiums will be shared between the AV owner and the manufacturer will be discussed in more detail in section 5.1.2.

3.2.2 Data-Sharing Legislation

The existence of data-sharing legislation is crucial to achieve fair and quick compensation in case of an accident. Indeed, such arrangement would help finding the cause of an incident and the driver's interaction with the technology. Nevertheless, today's strict data-protective environment could delay this process and thus the implementation of AVs [2].

3.3 Designing a New Policy for Safelife

3.3.1 New Coverage for AVs

Safelife will offer three new coverage for AVs. Risk classes will remain the same as before for A0 and A1 vehicles, but risk classes for A2 policies now only depend on vehicle size and type. Detailed information can be found in Appendix C.

- Coverage 1: Cyber Risk

Criminal or terrorist hijacking of vehicle controls through hacking, identity theft, privacy invasion and theft of personal information.

- Coverage 2: Malfunction Risk

Communication or connection failure and/or potential failure of software and hardware.

- Coverage 3: Infrastructure Risk

Issues with infrastructure controlling for vehicle movements and traffic flow.

Note that dependent risks might cause numerous claims at the same time due to similar technological errors. Hence, and also to cover for third party risks, Safelife must establish a maximum amount of $\hat{C}300{,}000$ payable per accident for these new coverages - keeping the sum insured under control. Finally, all policyholders are obliged to have a legal and updated version of the AV software to avoid covering for defective technology.

3.4 Estimating Policy Premiums

3.4.1 Pure Premium for Traditional Vehicles

Generalized linear modelling [7] is used to estimate the frequency and severity of claims for traditional vehicles based on Safelife's historical data, in order to calculate the expected loss

per unit of exposure (Appendix A.1). The following formula is used to estimate the expected total loss for a standard coverage at time t:

$$E[TC_{trad,st}(t)] = \sum_{i} \sum_{rc} E[AAC_{trad,i,rc}(t)] \times E[NC_{trad,i,rc}(t)] \quad \text{for } i \in \{BI, PD, COM, COL, PI\}$$

where TC is defined as the total claim amount, AAC as the amount per claim, NC as the total number of claims, rc as the risk class and i as the coverage. Note that frequency and severity are assumed to be independent.

3.4.2 Pure Premium for AVs

As both standard and new coverages apply to AVs, two different formulas are required. The total loss for standard coverages at time t follows a formula similar to the previous one, but now using corrected estimates for frequency and severity:

$$E[TC_{AV,st}(t)] = \sum_{i} \sum_{rc} E[AAC_{AV,i,rc}(t)] \times E[NC_{AV,i,rc}(t)] \quad \text{for } i \in \{BI, PD, COM, COL, PI\}$$

$$AAC_{AV,i,rc}(t) = AAC_{trad,i,rc}(t) \times AAC.Multiplier_{trad,i}$$

$$\frac{NC_{AV,i,rc}(t)}{Exposure_{AV,i,rc}(t)} = \frac{NC_{trad,i,rc}(t)}{Exposure_{trad,i,rc}(t)} \times NC.Multiplier_{trad,i}(t)$$

where $Exposure_{AV,i,rc}(t)$ and $Exposure_{trad,i,rc}(t)$ are defined as the exposure for AVs and traditional vehicles, respectively. For the calculation of frequency and claim amount of AVs, multipliers are used to express the sharp frequency decrease and the increase in claim amounts, as AV's are now safer but distinctly more expensive [3]. Details on the multipliers can be found in Appendix B.

For AVs, the formula for expected total loss for new coverages at time t is given by:

$$E[TC_{AV,new}(t)] = E[TC_{AV,st}(t)] \times \sum_j c_j \quad \text{for} \quad j \in \{CR, MR, IR\}^3$$

where c_j is a multiplier based on Accenture's prediction of total market opportunity for each coverage [1]. For detailed information about the proportion of risk classes, see Appendix C.

4 Premium Analysis

4.1 Safelife Does Not Enter the AV Market: "Business as Usual"

For reasons concerning market reputation (discussed in section 3.1.2), if Safelife chooses not to develop the new policy, it is expected that market share will gradually decrease (0.5% per year) and that new revenues for AVs will be missed, making this an unfavourable scenario. The expected total loss is represented in Figure 6.

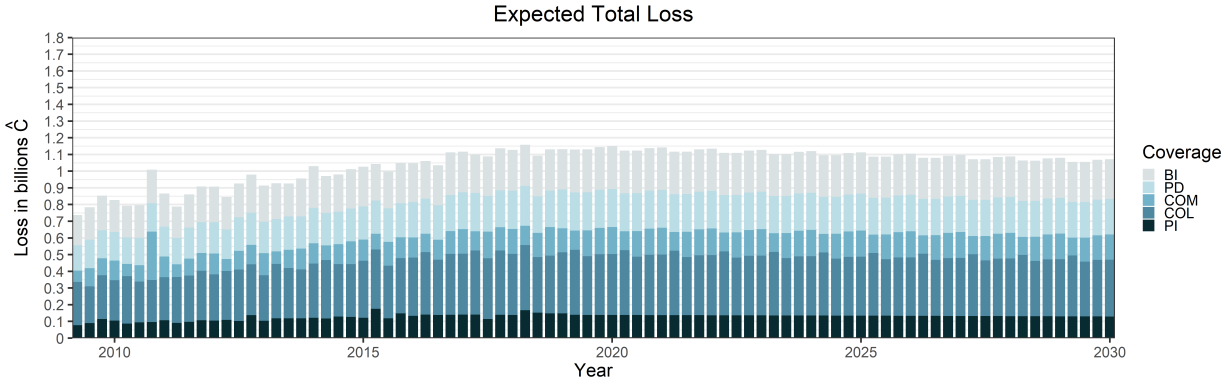

Figure 6: Expected total loss for the no entrance scenario.

[3]CR - Cyber Risk, MR - Malfunction Risk, IR - Infrastructure Risk

4.2 Entering the AV Insurance Market: Base Scenario

The pure premium estimates for the base scenario are calculated using the assumptions already discussed. There is a significant impact on total losses, now 25.3% greater in 2029 Q4 than in the "no entrance scenario", as reflected in Figure 7. However, in the long-run, pure premiums will sharply decrease as AVs become safer and the AVs share on exposure increases - from 22% in 2030 to 66% in 2040 (see Appendix D).

As AVs will constitute 22.1% of total exposure in 2029 Q4, Safelife's business goal is met. Total loss for AVs is expected to be 146,980,620 $\hat{C}$ (10.9% of total loss) at 2029 Q4. In the first 10 years after entering the market, the aggregated exposure will be 3,371,997 car-years for AVs (12.3% of total exposure).

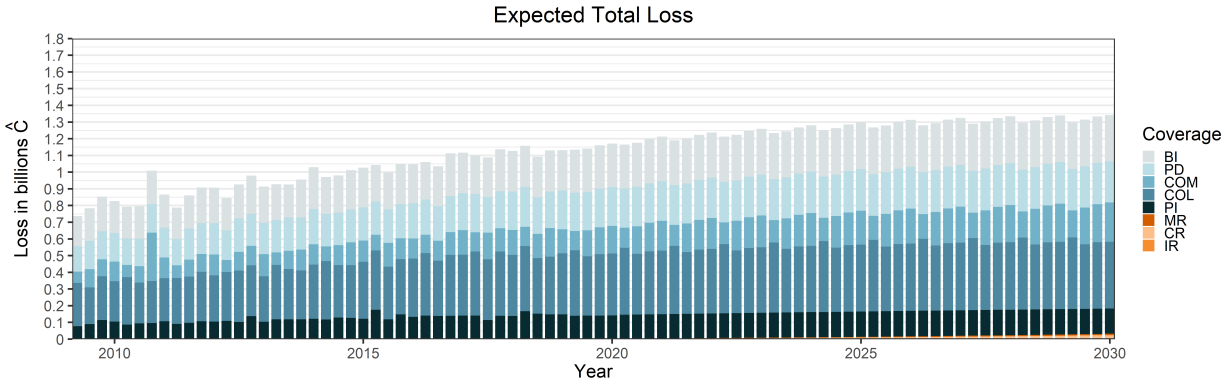

Figure 7: Expected total loss for base scenario.

Average premiums per coverage over time are represented in Figure 8. Final pricing of policies (per type and level) is presented in Appendix E.

Figure 8: Average expected loss per-policy. Note that A1 and A2 premiums are generally lower than the A0 premiums, due to the fact that the decrease in frequency outweighs the increase in claim severity. Comprehensive risk is the exception - claim frequency for this risk is independent of the autonomous level, but as the severity increases (as A1 and A2 are more expensive), comprehensive premiums for A1 and A2 also increase. Moreover, the claim frequency for A2 is lower than for A1, but the claim severity is higher, since A2 cars are safer than A1, but they cost more.

4.3 Sensitivity Analysis

4.3.1 Shocking Parameters of the Initial Assumptions

Scenario	Upward Scenario	Downward Scenario
Safelife's Market Share	A1 and A2: starts at 100% and decays after 5 years. A0: increases 1% per year.	A1 and A2: starts at 50% and decays to 35%. A0: decreases 0.5% per year.
AV Percentage	Faster implementation of AVs compared to the base scenario.	Slower implementation of AVs compared to the base scenario.
Frequency and Severity Multipliers	The shock ratios for NC and AAC (A1 and A2 vehicles) are doubled.	The shock ratios for NC and AAC (A1 and A2 vehicles) are halved.
New Coverage Premiums	Premium for new coverage is three times as high as in the base scenario.	Premium for new coverage is three times as low as in the base scenario.

Table 2: Assumptions for upward and downward scenarios. For the graphical representation of the scenarios, please refer to Appendix F.

By shocking the parameters in the initial assumptions, the impact of different scenarios on expected losses can be examined. Table 2 shows the assumptions for both the upward and downward scenarios (see Appendix F for more information).

4.3.2 Effect of Shocks on Expected Total Loss

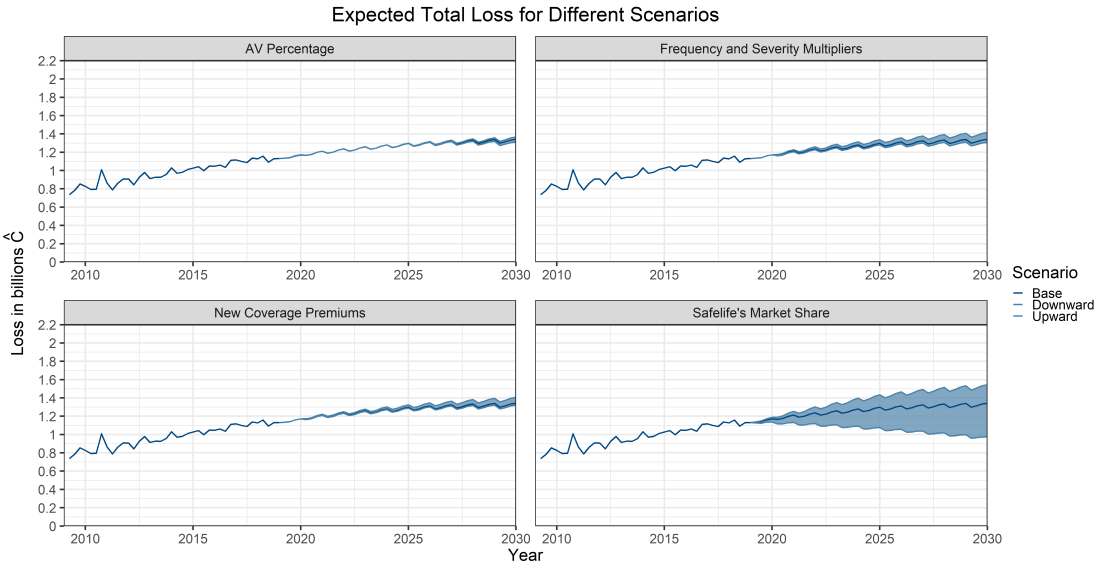

Figure 9: Scenario analysis of expected total loss. The boundaries of the blue surface are the upward and downward scenarios, while the line in the middle is the base scenario.

The results of the expected total loss scenario analysis are shown in Figure 9. The results in table 3 corroborate the robustness of the model, since all scenarios present a reasonable impact. Note that for the AV percentage, the impact on total loss is negative, whilst the impact on A1/A2 losses is positive, because the proportion of A1/A2 compared to A0 is small. For premium multipliers and new coverage premiums, only AVs are affected, which is why - although the impact is relatively big among AVs - the total impact is small.

Safelife's goal is for the new policy to account for 20 to 25 percent of its overall exposure by 2030. From Table 4 it can be concluded that the percentage of AVs influences Safelife's business the most, however the deviation is still reasonably acceptable. Note that the claim multipliers and the premiums for new coverages do not influence exposure.

Scenario	Upward Impact			Downward Impact		
	Loss A0	Loss A1/A2	Total Loss	Loss A0	Loss A1/A2	Total Loss
Safelife's Market Share	13.9%	24.6%	15.1%	-27.8%	-23.6%	-27.4%
AV Percentage	-4.8%	18.2%	-2.3%	4.1%	-16.1%	1.9%
Frequency and Severity Multipliers	0.0%	51.9%	5.7%	0.0%	-23.2%	-2.5%
New Coverage Premiums	0.0%	44.2%	4.8%	0.0%	-14.7%	-1.6%

Table 3: Impact of scenarios on pure premium in 2029 Q4, in relative terms compared to the base scenario.

Scenario	Upward Scenario	Downward Scenario
Safelife Market Share	23.7%	23.1%
AV Percentage	26.4%	18.5%
Frequency & Severity Multipliers	22.1%	22.1%
New Coverage Premiums	22.1%	22.1%

Table 4: Safelife's exposur from AVs in 2029 Q4 for different scenarios.

5 Recommendations

5.1 Safelife's Cutting-Edge Product

It is recommended for Safelife to launch the new policies in 2020 Q1, as early movers will benefit the most from this new product. It is suggested that Safelife develops a new policy that covers Cyber Risk, Malfunction Risk and Infrastructure Risk for AVs, keeping the standard coverage mandatory for both traditional vehicles and AVs. If in the future data-sharing agreements strongly reduce frauds, insurers should consider the elimination of deductibles [2].

5.1.1 A Single Insurance Policy

An important issue that could arise when liability is shared by the driver and OEM, is that a potential victim of an AV incident could be in a disadvantageous position when it comes to securing quick compensation, as both the driver's insurer and the OEM's insurer might be unwilling to take responsibility. By imposing a compulsory single insurance policy, in which both the driver and OEM are insured by the same company, this problem can be dealt with. In practice, OEMs can make arrangements with multiple insurers and the driver is obliged to buy a single insurance policy from one of these insurers [4].

5.1.2 Sharing Premiums

In the short run, with no data available, it is suggested to follow the traditional path where owners can receive an indemnity from the manufacturer when the latter is negligent. That is, the owner buys regular insurance and is also covered by the car's warranty if there is any incident caused by the technology. In the future, with more historical data available, premiums for the single insurance policy will be shared between the owner and manufacturer according to the proportion of human error vs. vehicle error. Also, once this data is available, the assignment of premiums should take into consideration risk classes, such as driver age and risk.

5.2 Keeping Up with Legislation

Future legislation will have a crucial impact on how - and how fast - the evolution of the AV market in Carbia will take place. The new policy will only work in practice if the necessary data-sharing legislation is in place. Thus, it is crucial that Safelife keeps up with industry legislation.

5.3 Increasing Profitability

Following the implementation of the new product in 2020, Safelife should take the opportunity to increase their profitability by setting a higher profit margin on their new AV policies, which is reasonable as Safelife will be the first-mover in the new market. However, in the long run, it is important to keep up with new competitors - for example by charging more attractive premiums - to achieve the goal of 20 to 25 percent of overall business by the year 2030. Even though implementation is happening now, real gains from insuring AVs are made in the long-run for those who are ready, as society transits from traditional vehicles to AVs.

6 Limitations

Limitation	Description
Aggregated historical data	The historical data does not provide information about individual claim behaviour.
AVs in historical data	Since there is no information about the presence of AV in our historical data set, it is assumed there are none.
Market share per type	It is assumed that Safelife's 34% market share applies equally to Personal and Commercial types.
Inflation	A 2.2% flat inflation is assumed to incur in all projected years (as per the average of the GLM estimates).
Risk class proportions	It is assumed that the proportion of risk classes in the portfolio will remain the same as in the last observation.
Vehicle size	The average price of the small, medium and large vehicle size is considered to price the AV. Age and risky behavior were not considered for A2 vehicles.

Table 5: Limitations

7 Appendices

A Generalized Linear Modelling

A.1 Model for Frequency and Severity of Claims

Generalized linear models are used to derive the impact of risk factors on claim behaviour. A model for frequency and a model for severity is estimated for every standard coverage, using the risk factors provided in the historical data set.

A risk class consists of four components: vehicle size, driver risk, driver age and vehicle type - where it is assumed that there exists no interaction effect between the components. Note that the standard linear model cannot be used as the data is not normally distributed. Hence, the quasi-Poisson family - which allows for different mean and variance - combined with a log-link function is used to estimate frequency. The variable exposure is treated as an offset term. Furthermore, a gamma model estimates the expected severity, with frequency as the weight. To determine which variables to include in the model, significance levels of the explanatory variables and ANOVA-tests are used. The general form of the linear predictors for expected frequency and severity models is defined in the following way:

$$\ln(E[NC_j]) = \alpha_0 + \alpha_j * Time + \beta_{j,Qtr} + \beta_{j,Size} + \beta_{j,Risk} + \beta_{j,Age} + \beta_{j,Type} + \ln(Exposure_j)$$

$$\ln(E[AC_j/NC_j]) = \alpha_0 + \alpha_j * Time + \beta_{j,Qtr} + \beta_{j,Size} + \beta_{j,Risk} + \beta_{j,Age} + \beta_{j,Type}$$

where NC is the frequency, AC is the total claim amount and j is the coverage. Note that the coefficients β depend on quarter and the risk class variables, for the purpose of displaying the model in a simpler way. Also note that the dependent variable in frequency models is defined at an individual level.

Table 6 and 7 show which variables are included in the model for frequency and severity, respectively. Note that the comprehensive and collision coverage experience seasonality. Although the model for frequency of collisions had a significant time parameter, there was no valid reason for including time in the model. From figure 10 it can be seen, from the NC_COL variable, that the expected frequency of collisions has been constant for the last 2 years. Thus, it was assumed that the expected frequency of collisions per exposure will be constant in the future. Another important note is that the increase in frequency of collisions throughout the years is due to exposure but the number of claims per exposure stays constant.

NC	Time	Qtr	Type	Vehicle Size	Driver Risk	Driver Age
BI	No	No	Yes	Yes	Yes	Yes
PD	No	No	Yes	Yes	Yes	Yes
COM	No	Yes	Yes	Yes	Yes	Yes
COL	No	Yes	Yes	Yes	Yes	Yes
PI	No	No	Yes	Yes	Yes	Yes

Table 6: Explanatory variables included in the frequency model.

AAC	Time	Qtr	Type	Vehicle Size	Driver Risk	Driver Age
BI	Yes	No	No	Yes	Yes	Yes
PD	Yes	No	No	Yes	Yes	Yes
COM	Yes	Yes	No	Yes	Yes	Yes
COL	Yes	Yes	Yes	Yes	Yes	Yes
PI	Yes	No	Yes	Yes	Yes	Yes

Table 7: Explanatory variables included in the severity model.

Figure 10 shows the expected frequency and severity for the time period 2009-2030.

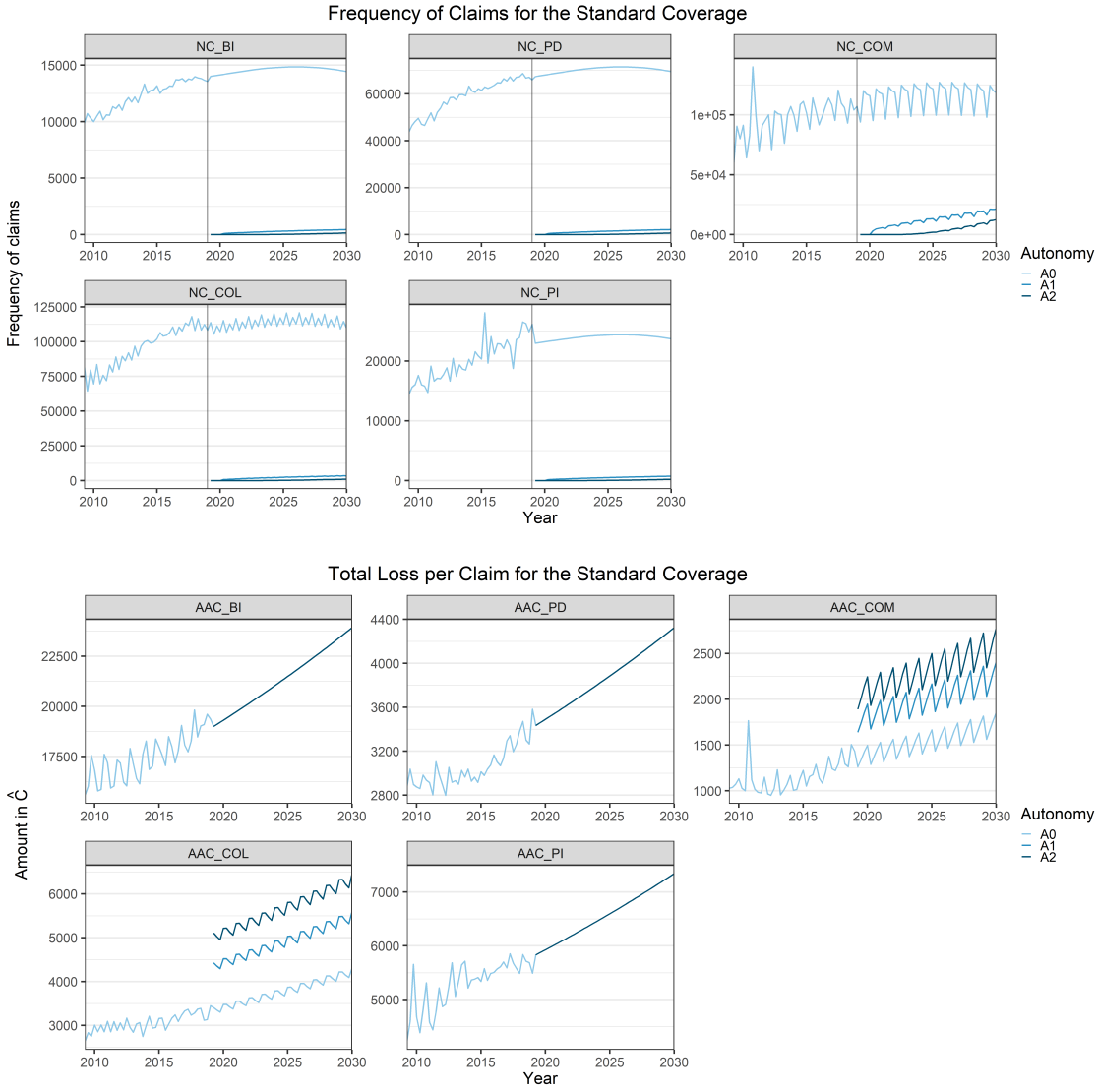

Figure 10: Expected frequency and severity for 2009-2030. The vertical line indicates when the prediction starts. Frequency increases as total exposure increases. Severity also increases because of inflation. Severity is higher for non-traditional vehicles in the comprehensive and collision coverage as it is assumed that (semi-)autonomous cars will be more expensive. The semi-autonomous graph starts when Safelife enters the market, while the full-autonomous graph starts in 2022 when A2 vehicles enter the market.

A.2 Replacing the Outlier in the Comprehensive Coverage

An outlier in the comprehensive coverage is observed in the third quarter of 2010, presumably due to a natural disaster, which is then replaced using a standard linear model. Thus, the intercept of the comprehensive models is adjusted by the ratio of severity before and after removing the outlier. The same is done for the frequency model in the comprehensive coverage. Summarizing, the model accounts for the possibility of a natural disaster happening again in the future. Figure 11 shows the effect of replacing the outlier.

Figure 11: Replacing the outlier in the comprehensive coverage. The figure compares the frequency and severity model before and after replacing the outlier.

A.3 Inflation in Vehicle Insurance

Even though the variable time is included in all severity models, it does not depend on the specific coverage. It is assumed that the variable explains the specific inflation in the vehicle insurance in Carbia. The rate of inflation used in the analysis is the average inflation over all five coverages and is found to be 2.2%. It is assumed that the inflation rate in the period 2009-2030 is flat. Furthermore, monetary values before and after 2019 were accumulated and discounted, respectively.

B Premium Multipliers for AVs

Table 8 and 9 show the frequency and severity multipliers for standard coverage. The variable $AV\%$ is defined as the share of autonomous vehicles (A1 and A2) in Carbia. Note that the frequency diminishes when $AV\%$ increases since the overall presence of autonomous cars has an impact on the number of claims. That is, the frequency of claims is directly proportional to the amount of traditional cars in the whole of Carbia, as there will be more incidents. Moreover, autonomous vehicles have a lower claim frequency for all coverages, except for the comprehensive coverage, since they are safer. However, severity increases for the comprehensive and collision coverage as autonomous vehicles are in general more expensive than traditional vehicles.

Coverage	Frequency Multiplier A1	Frequency Multiplier A2
BI	0.05 × AV% + 0.2 × (1-AV%)	0.025× AV% + 0.1 × (1-AV%)
PD	0.05 × AV% + 0.2 × (1-AV%)	0.025× AV% + 0.1 × (1-AV%)
COM	1	1
COL	0.05 × AV% + 0.2 × (1-AV%)	0.025× AV% + 0.1 × (1-AV%)
PI	0.05 × AV% + 0.2 × (1-AV%)	0.025× AV% + 0.1 × (1-AV%)

Table 8: Frequency multipliers for all standard coverages.

Coverage	Severity Multiplier A1	Severity Multiplier A2
BI	1	1
PD	1	1
COM	1.3	1.5
COL	1.3	1.5
PI	1	1

Table 9: Severity multipliers for all standard coverages.

C Risk Classes

The original risk classes still apply for semi-autonomous vehicles, since there is still a significant human input. However, for full-autonomous vehicles, risk classes consist only of the variables vehicle size and type, since it is assumed that the variables driver risk and driver age are no longer relevant for this level. To estimate frequency and severity for these new A2 risk classes the mean of the original risk classes is used. For example, for small vehicles, the mean of all risk classes beginning with S was used as an estimate for the expected frequency/severity for the new small risk class. Figure 12 shows the exposure proportion of all risk classes. It is assumed that the risk class proportions in all markets for the next 10 years will be equivalent to those in the end of 2018. This assumptions might not be realistic, as the vehicle size for autonomous vehicles might be different. Since our data is not clear about the definition of vehicle size, it cannot be incorporated in the analysis. However, the most critical variable for traditional cars is driver risk. Therefore, this assumption will not have a large effect on the expected premiums of A2 vehicles.

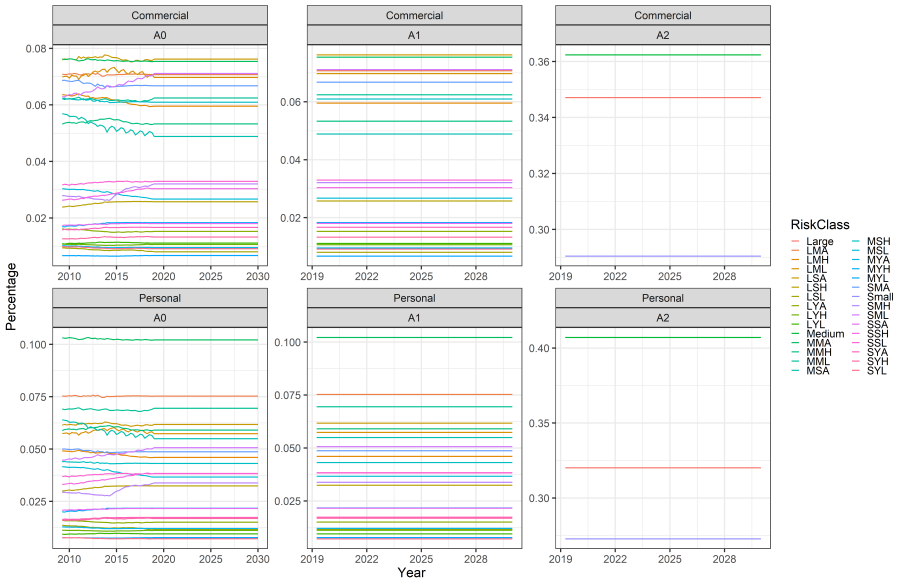

Figure 12: Risk class proportions for all markets. The figure shows how risk class proportions change over time. Note that the scales are different for different markets. In the past, proportions have been fluctuating, however, for sake of simplicity the proportions are assumed to be constant at the level of the last observed value in the upcoming period.

D Long-Term Scenario

To further observe the effects of autonomous vehicles on the expected total loss, the assumptions were extended to 2040. Figure 13 shows how total losses start decreasing after 2030, since non-autonomous vehicles are replaced by A1 and A2 vehicles. Note that all losses for standard coverages - except the comprehensive coverage - decrease, because A1 and A2 vehicles have lower frequency. The total loss for the comprehensive coverage is increasing, since frequency is constant and severity increasing for autonomous cars. Figure 14 illustrates the evolution of expected total loss for all autonomy levels.

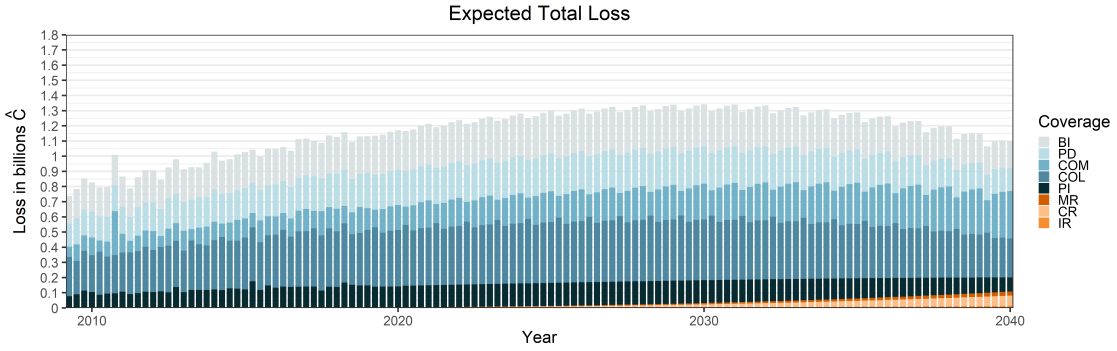

Figure 13: Long-term expected total loss.

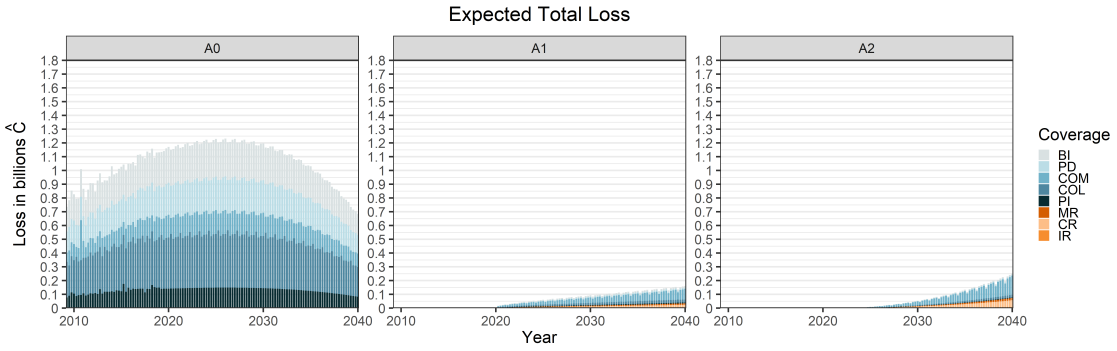

Figure 14: Long-term expected total loss for all autonomy levels.

E Per-Policy Pure Premium

Table 10 shows the per-policy pure premiums for all risk classes, averaged over the period 2020 Q1 to 2029 Q4.

Risk Class	A0		A1		A2	
	C	P	C	P	C	P
LMA	2,096	1,855	848	750		
LMH	2,632	2,342	1,127	1,004		
LML	1,464	1,303	719	637		
LSA	2,323	2,062	955	853		
LSH	2,967	2,647	1,333	1,184		
LSL	1,678	1,496	871	773		
LYA	2,341	2,080	945	848		
LYH	2,995	2,676	1,118	1,003		
LYL	1,635	1,460	796	699		
MMA	2,082	1,848	915	807		
MMH	2,708	2,414	1,118	1,003		
MML	1,523	1,357	803	714		
MSA	2,331	2,075	1,005	887		
MSH	3,070	2,743	1,274	1,134		
MSL	1,754	1,565	941	842		
MYA	2,342	2,087	893	785		
MYH	3,092	2,766	1,100	983		
MYL	1,705	1,523	831	736		
SMA	1,961	1,740	786	691		
SMH	2,566	2,286	1,080	964		
SML	1,435	1,277	669	597		
SSA	2,186	1,945	920	818		
SSH	2,891	2,580	1,245	1,105		
SSL	1,640	1,462	899	807		
SYA	2,197	1,956	886	792		
SYH	2,914	2,603	1,103	986		
SYL	1,600	1,428	737	663		
Small					861	768
Medium					922	818
Large					908	808

Table 10: Per-policy pure premium for all coverages in $\hat{C}$.

F Scenario Assumptions

This appendix discusses the assumptions made regarding the upward and downward scenarios.

- Safelife's Market Share

In the upward scenario, Safelife will dominate the A1 and A2 market in the first 5 years as no other companies enter the market. After that the market share will start to decrease to around 60% in 2030. The non-autonomous vehicle market share will increase at a rate of 1% per year.

In the downward scenario, Safelife's A1 and A2 market shares start at 50% (assuming Safelife has competitiors in the beginning of 2020) and decrease slowly to around 35% in 2030. The share in the non-autonomous vehicle market will decrease at a rate of 0.5% per year.

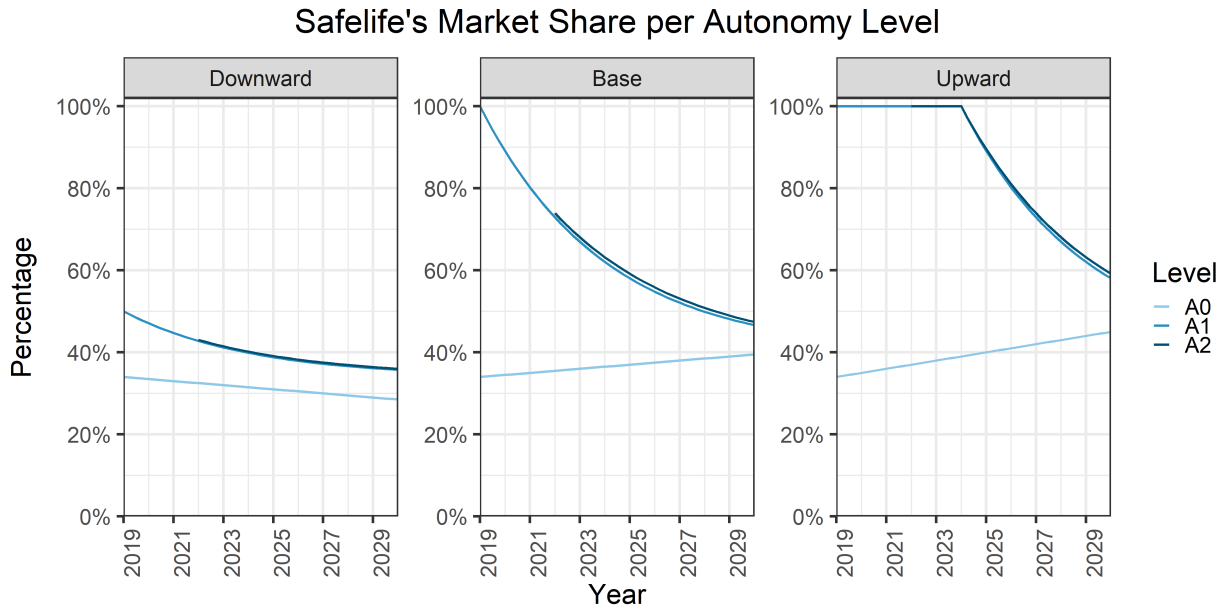

Figure 15: Scenarios Safelife's market share.

- Share of AVs in Carbia

During the first years, the A1 and A2 markets are growing faster in the upward scenario than in the downward scenario. Note that, even though A2 vehicles are only introduced in 2022, the market is growing at a higher rate than the A1 market. Figure 16 and 17 show the proportion of exposure per autonomy level for the personal and commercial market.

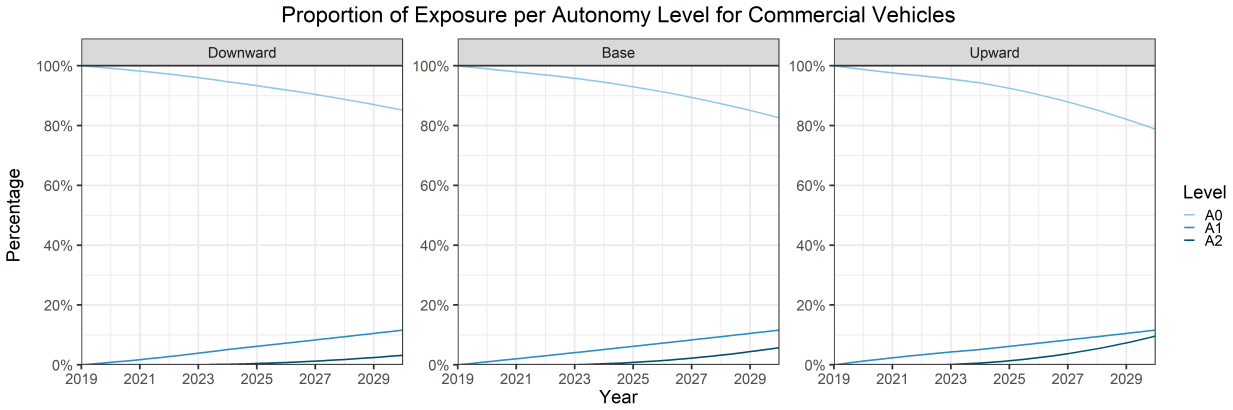

Figure 16: Scenarios for personal exposure percentage.

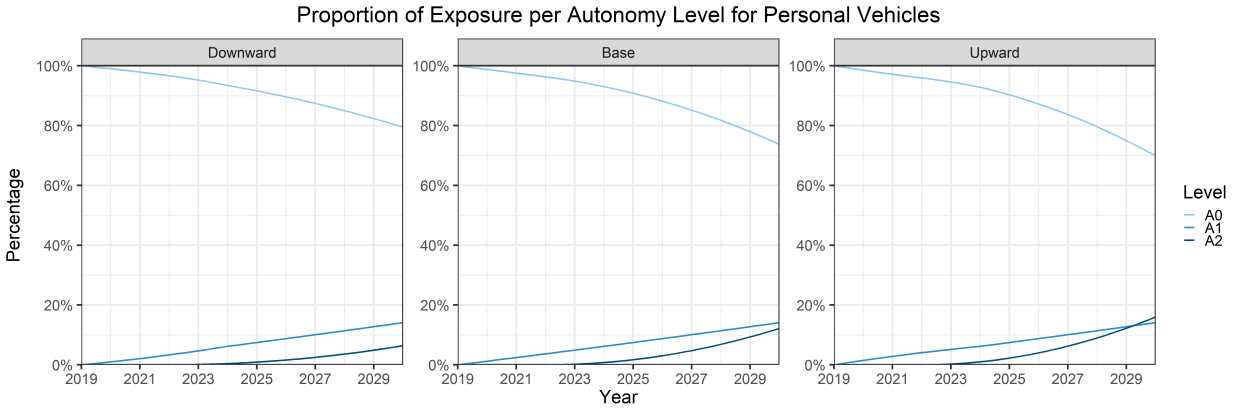

Figure 17: Scenarios for commercial exposure percentage.

- Multipliers for Frequency and Severity

To find the frequency and severity for A1 and A2 vehicles, multipliers are used that shock the frequency and severity of the A0 vehicles. In the upward scenario, the shock ratios for the multipliers double, while the shock ratios are halved for the downward scenario. For example, if the multiplier in the base scenario is 1.3 (30% shock ratio), then the multiplier for the upward scenario is 1.6 (60% shock ratio) and the multiplier for the downward scenario is 1.15 (15% shock ratio).

- New Coverage Premiums

For the upward scenario, the premium for new coverage is three times as high as in the base scenario. For the downward scenario, the premium is three times as low as in the base scenario. For example, the pure premium for Cyber Risk is 7.64% of the premium for the traditional coverage. Then, in the upward scenario the pure premium for Cyber Risk is $3 \times 7.64\%$ of the premium for the traditional coverage, and for the downward scenario it is $\frac{1}{3} \times 7.64\%$.

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