ACTUARIAL SOCIETY OF SOUTH AFRICA

Valuing the Unexpired Risk Reserve of Motor Service Plans

By

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2012 CONVENTION 16 – 17 OCTOBER

Overview

1. Background of motor service plans
2. Research significance, problem and questions
3. Model of unexpired risk
4. Back-testing and numerical illustration
5. Concluding remarks and suggestions for further research

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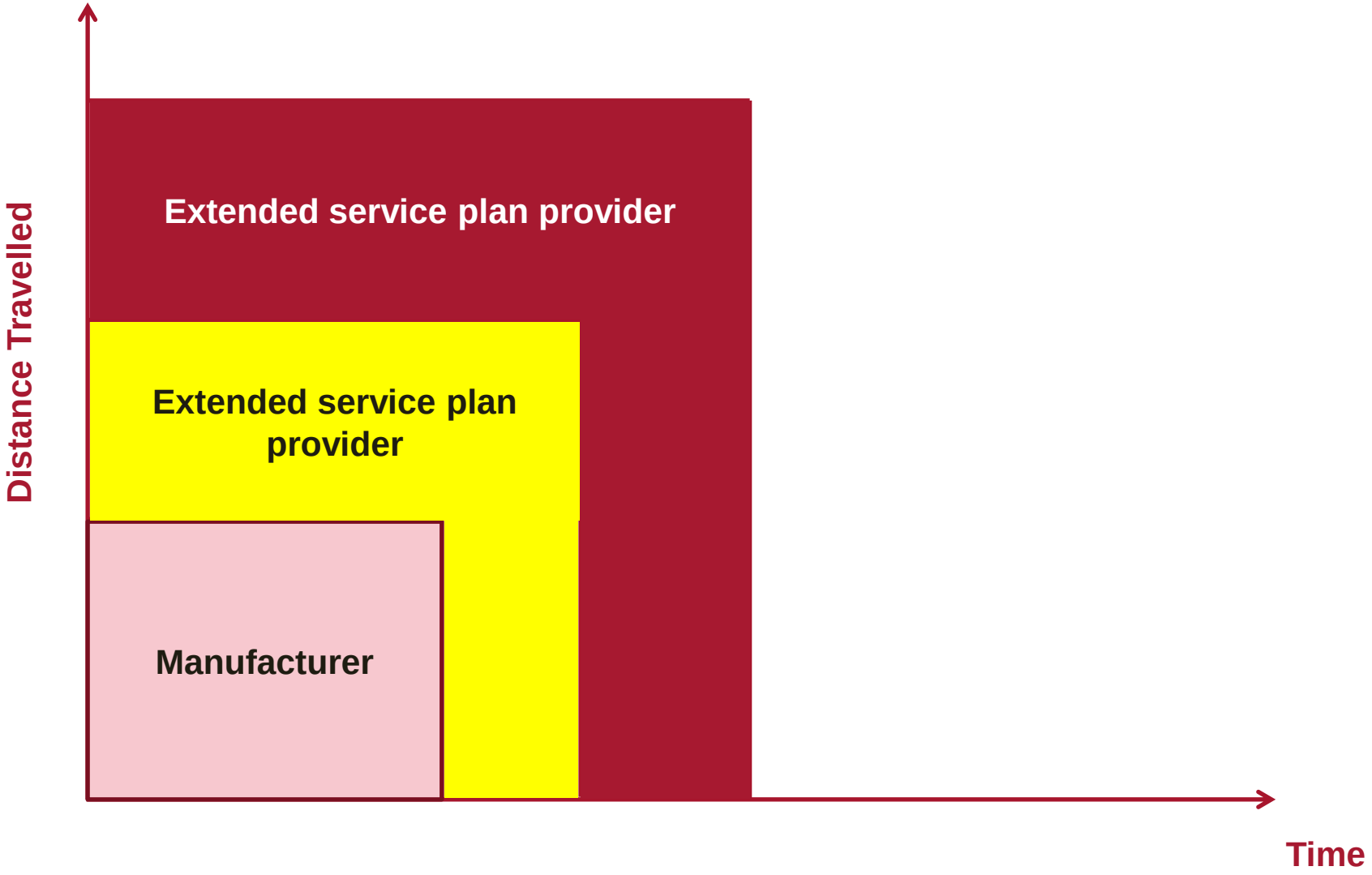
Background of Motor Service Plans

- The aim of a motor service plan is to ensure that a vehicle remains in good working condition.
- To achieve this aim, vehicle manufacturers typically recommend that scheduled services be conducted on the vehicle.
- Motor service plans are sold on new, 'near-new' and used vehicles.
- Motor service plans transfer the risk of increases in the cost of future services from the customer to the issuer.
- Service intervals specified in terms of time and usage.

Contract Expiry



Examples of Covered Parts

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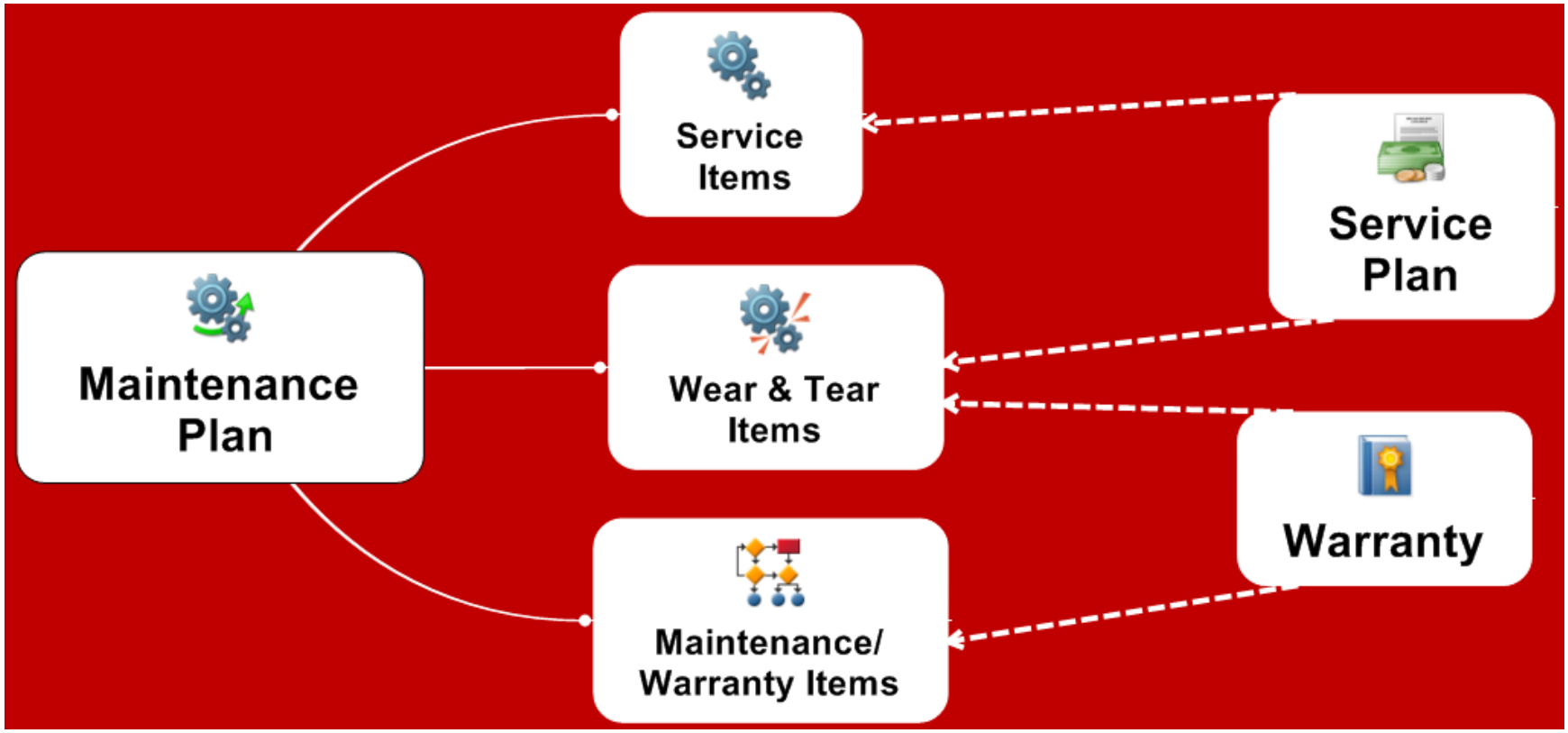
Service Items	Wear-and-tear Items	Warranty/Maintenance Items
Engine oil	Brake pads	Engine
Engine oil filter	Wiper blades	Gearbox
Sump plug seal	Engine drive belt	Differential
Air filter	Brake discs	CV joints
Pollen filter	Rear wheel cylinders	Front suspension
Fuel filter	Shock absorbers	Rear suspension
Spark plugs		Engine control unit
Brake fluid		Transfer box
Clutch fluid		Steering mechanism
Transmission fluid		Emission control unit
Differential fluid		Casings
Timing belt		Radiator
Tensioners		Alternator

Relationship Between Products



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Research Significance

- Setting provisions
- Checking the adequacy of provisions
- Determining economic capital
- Projecting profits emerging from the run-off of the portfolio

Research Problems

- The timing and count of future cash-flows is uncertain largely because of the uncertainty in usage rates, meaning distance travelled over a given time.
  - Literature mostly focused on assessing the effect of time and usage on reliability and cost. In this context, usage rates have been modelled as follows:
    - Constant usage rate (Varnosafaderani & Chikova, 2012; Murthy, 1992)
    - Parametric distributions, e.g. Gamma (Lawless & Crowder, 2010) and Weibull distribution (Kim et al., 2004)
  - *Solution*: Survival model of time to cover service distance.

Research Problems

- Literature lacks a suitable algorithm to quantify the unexpired risk of a motor service plan portfolio
- *Solution:* Stochastic discounted cash flow approach. The unique aspect of the algorithm is its focus on capturing the risk profile of motor service plans in terms of:
  - timing and count of future services
  - Estimating the probability of a service provider incurring a service cost

Research Questions

- How can the time to next service be formulated using a survival model?
- How can partial information on usage be considered when:
  - Estimating the distribution of time to next service?
  - Simulating the timing of the first future service?
- How can a provider estimate the probability of a customer claiming a scheduled service?
- What are the predictive properties of the proposed survival approach?
- How can Monte Carlo simulation be employed to determine provisions of unexpired risk at a specific ruin probability?

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Portfolio Description

- Analysis is from a motor service plan provider's point of view.
- At any point in time, the provider has multiple contracts (k = 1, 2, …, N), which may have different days to expiry.
- The contractually scheduled service time interval for vehicles in the portfolio may vary.

Modelling Time to Cover Service Distance Interval

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- Survival analysis is employed to model time to cover a specific distance.
- Kaplan-Meier product limit estimator is utilised to estimate the probability that time to cover distance, say d, is longer than a specified time, i.e. $S(t_d) = \Pr(T_d > t_d)$
- Data to estimate $S(t_d)$ is obtained from expired and active motor service plans

Example of Complete Data

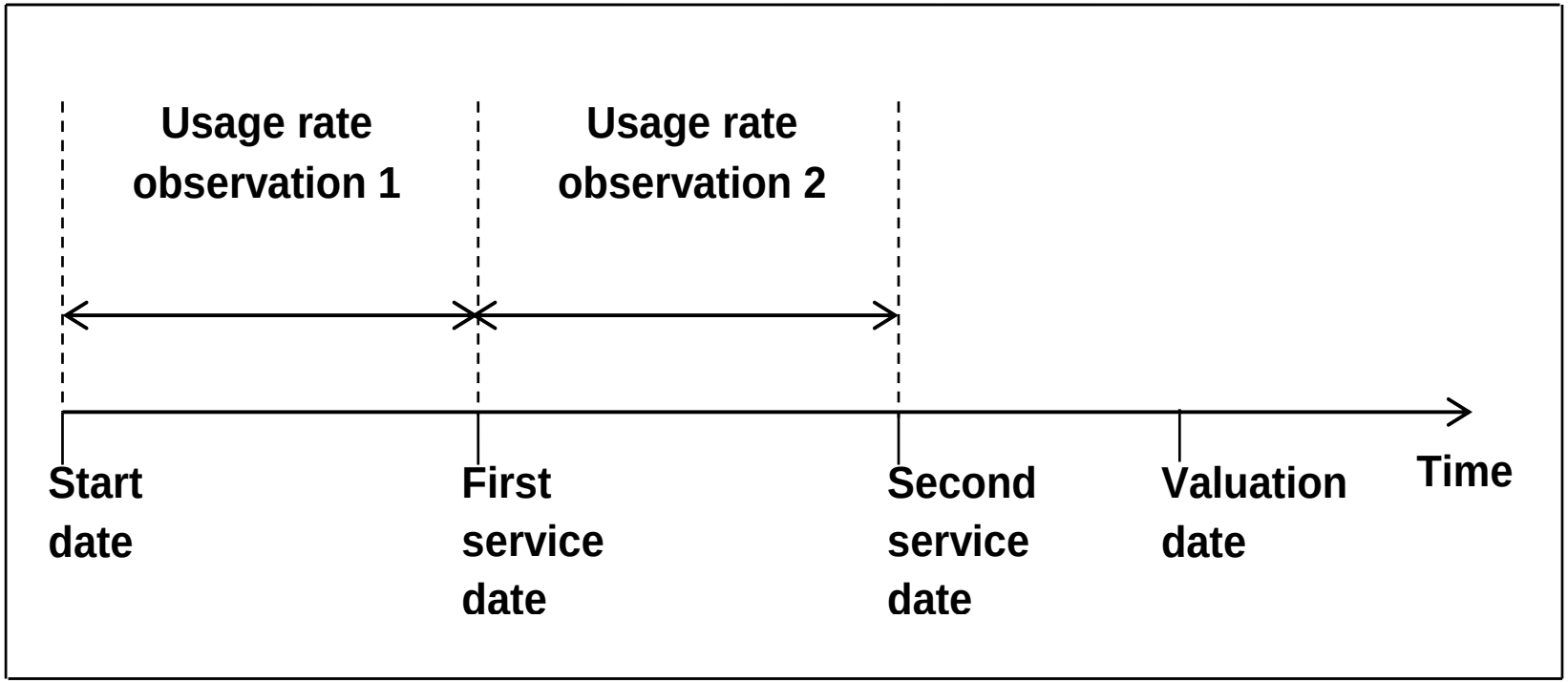
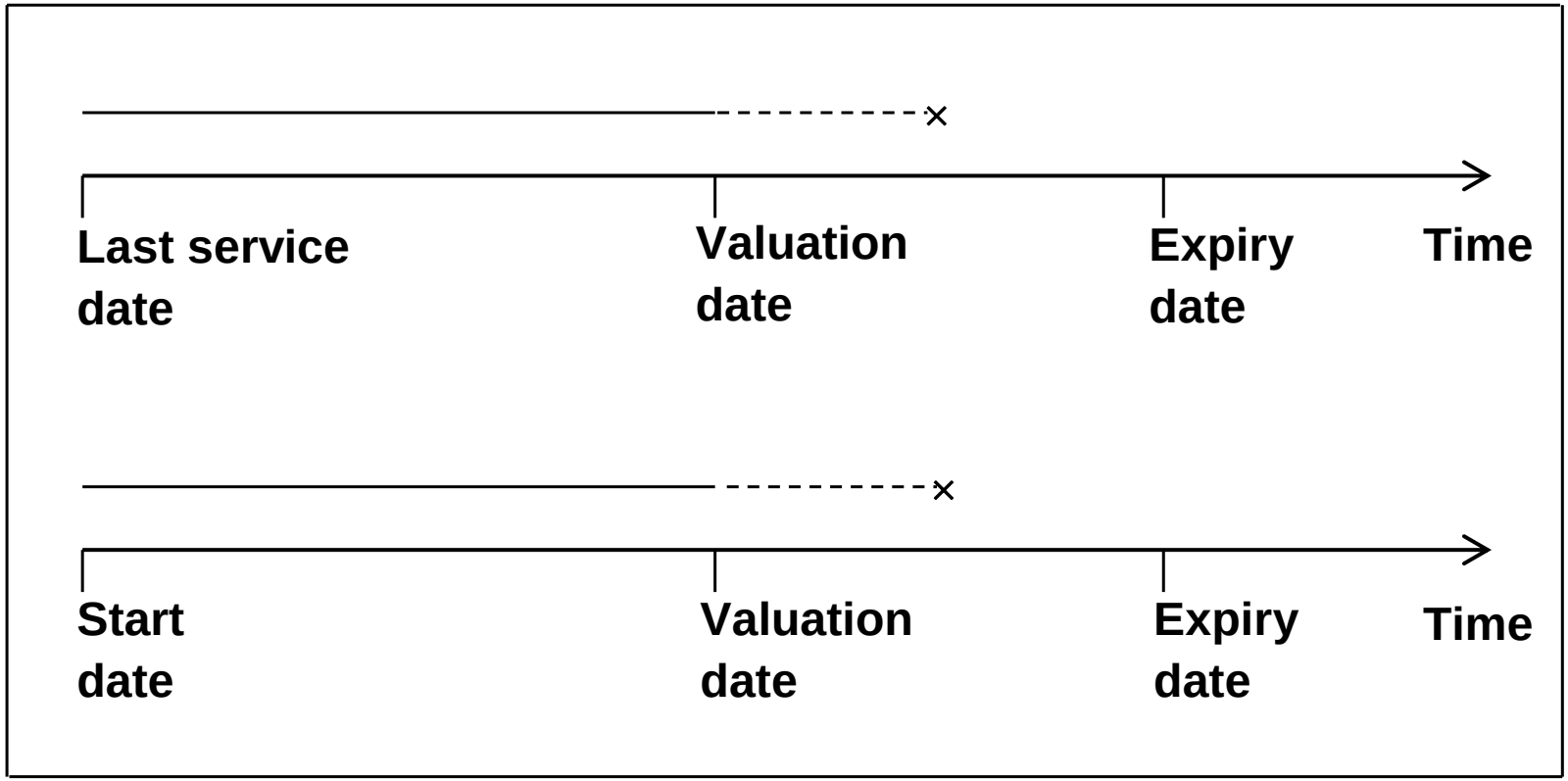


Illustration of Right-censored Data



The continuous straight line, above the time-line, represents the observed part of the time to cover service distance interval. In contrast, the dashed line represents the unobserved portion of the time to cover service distance interval. The symbol □ indicates the time that the service distance interval is reached.

Modelling Cost of Service

- Service cost comprises of the cost of labour, parts and miscellaneous items. Costing of these items can be done based on data provided by servicing dealers, vehicle manufacturers and/or other third party data vendors.
- Alternatively, inference can be made from past claims data.

Simulating the Value of Unexpired Risk

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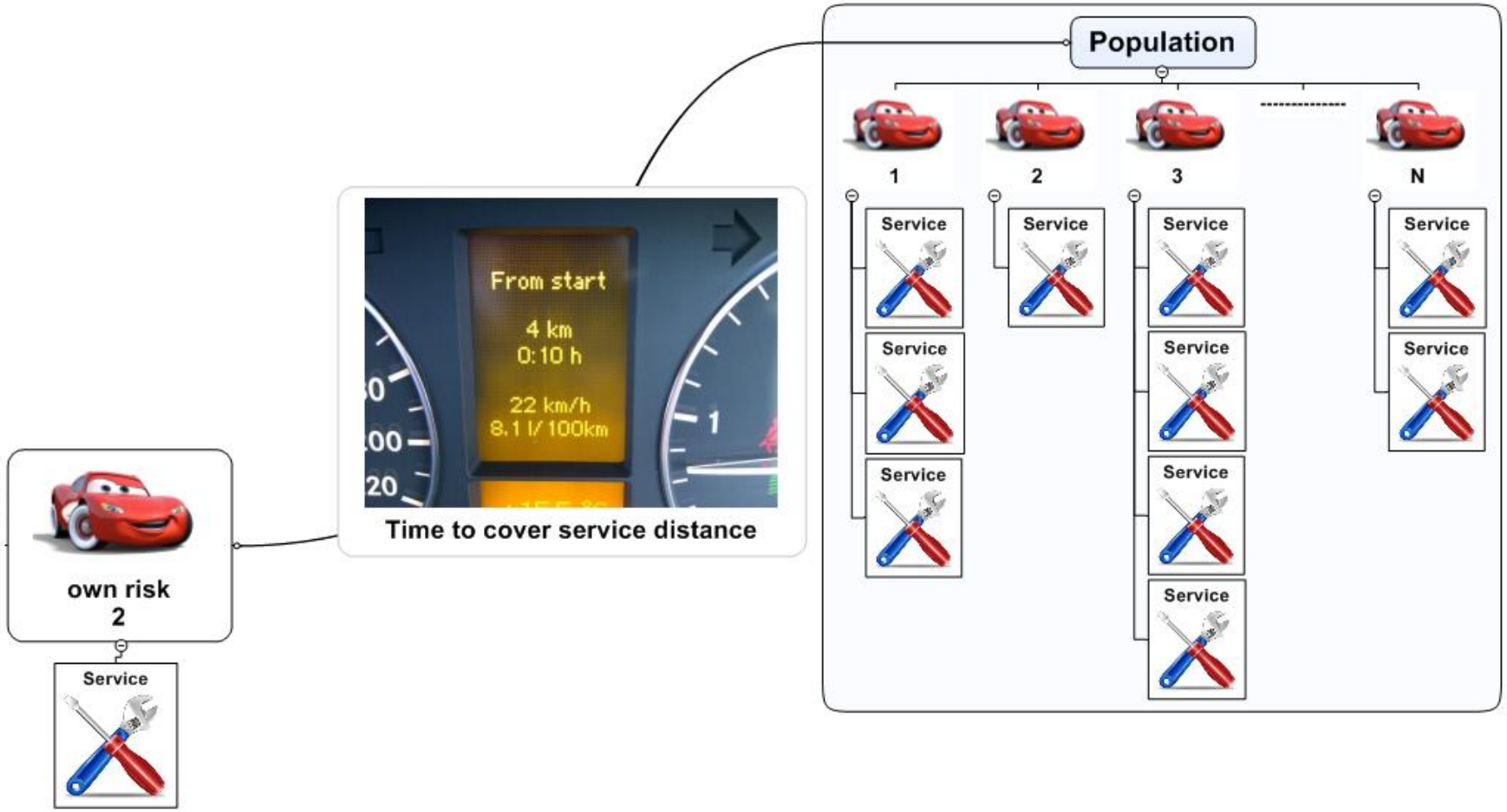
- Assume:
  - Usage rates between service plans are independent and identically distributed. This motivates the use of population usage patterns to infer future usage of an individual service plan.
  - The probability of claiming a scheduled service is independent and identically distributed.
  - Past usage patterns are a reasonable guide to future usage patterns.
  - Future inflation of service costs is constant.
  - Discount rate is constant.

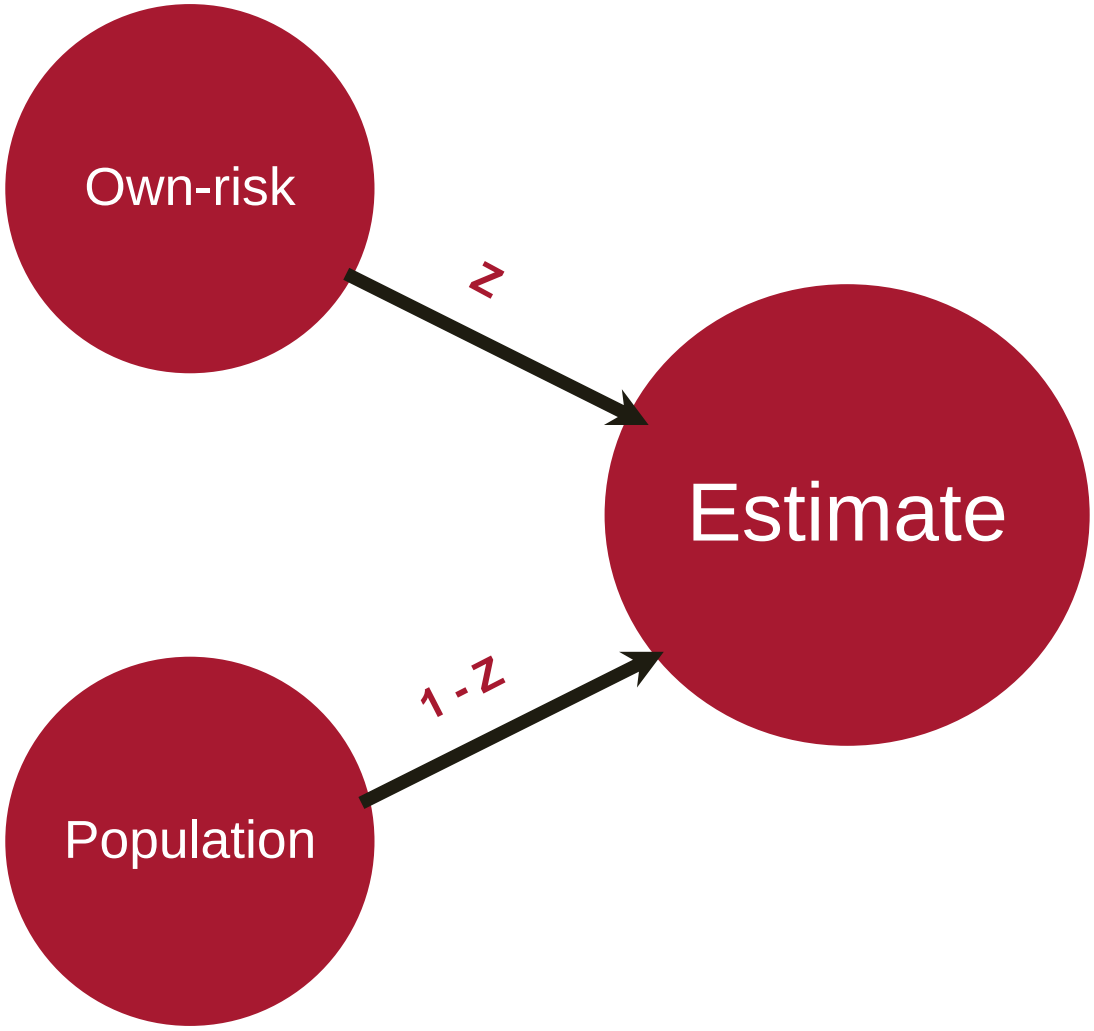
Projecting the Time to Next Service

- The time to next service is the earlier of
  1. The time to cover service distance; and
  2. The service time interval
- To estimate the time to cover service distance, experience rating is used. This employs two data sources:
  1. Own-risk data, meaning data from an individual service plan; and
  2. Population data, meaning data from a set of expired and in-force service plans

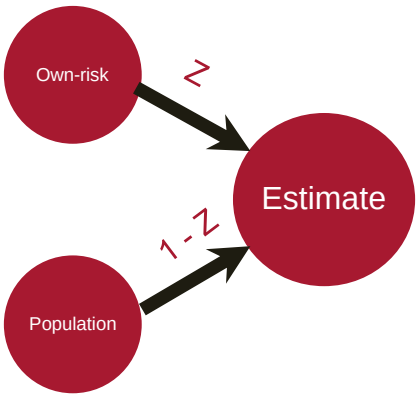
Experience Rating



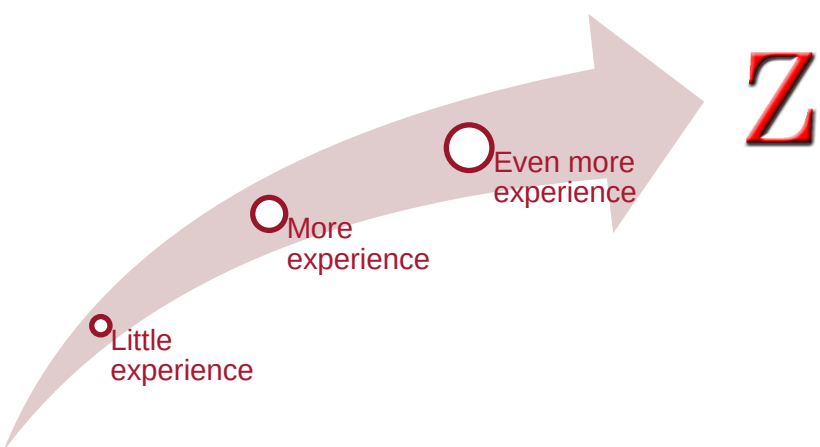
Experience Rating

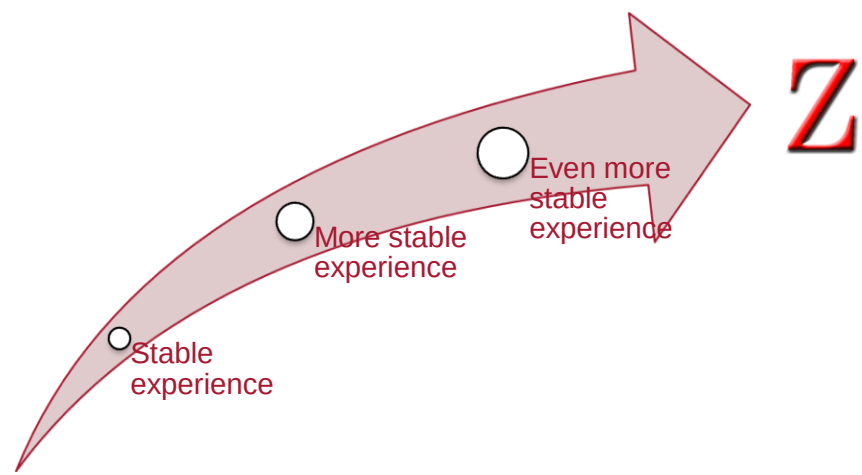


Determining the Weight of Own-Risk



$$Z = \begin{cases} \left(1 - \dfrac{1}{n_k}\right)\left(1 - \dfrac{\sigma_k}{\bar{x}_k}\right), & (n_k \geq \breve{n}) \,\&\, (\sigma_k < \bar{x}_k) \\ 0, & \textit{Otherwise} \end{cases}$$





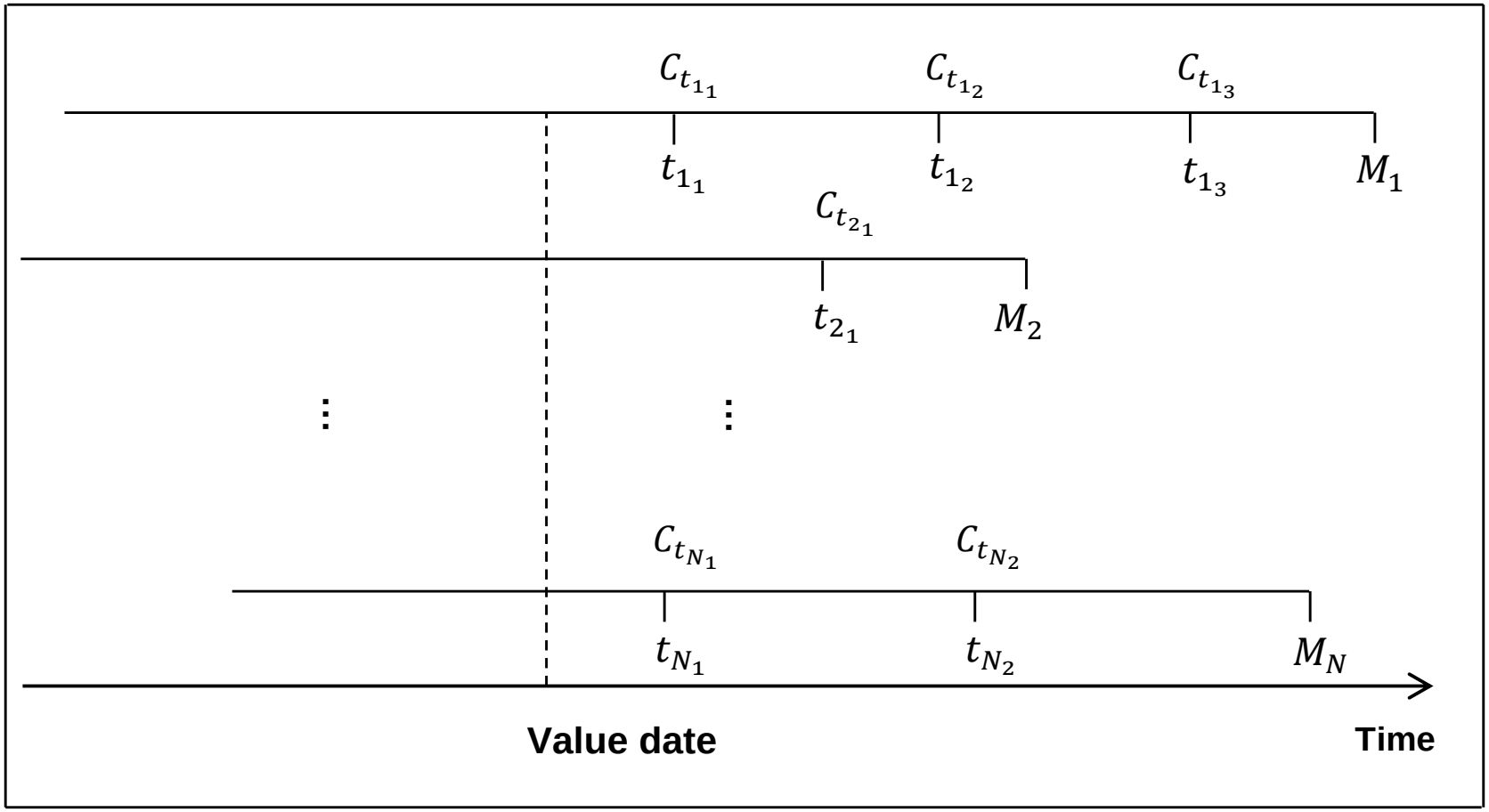
Projecting the Time to Next Service

- For each service path, we can recursively simulate the timing of future services over the period up to the service plan's expiry date
- In addition, the corresponding odometer readings are also derived.
- This enables us to project the count of future services.
- The timing of the first service should take into account the time period that has passed since the previous service.

Estimating the Probability of Claiming a Scheduled Service

- In practice, there is a possibility that a vehicle can forego a scheduled service. This can be due to, for example, the car being involved in an accident.
- To estimate, the probability of a scheduled service being claimed, the survival function is employed. That is:
  - Pr(Service being claimed) = 1 – *S*(service time interval)

Outline of a Single Simulation Run



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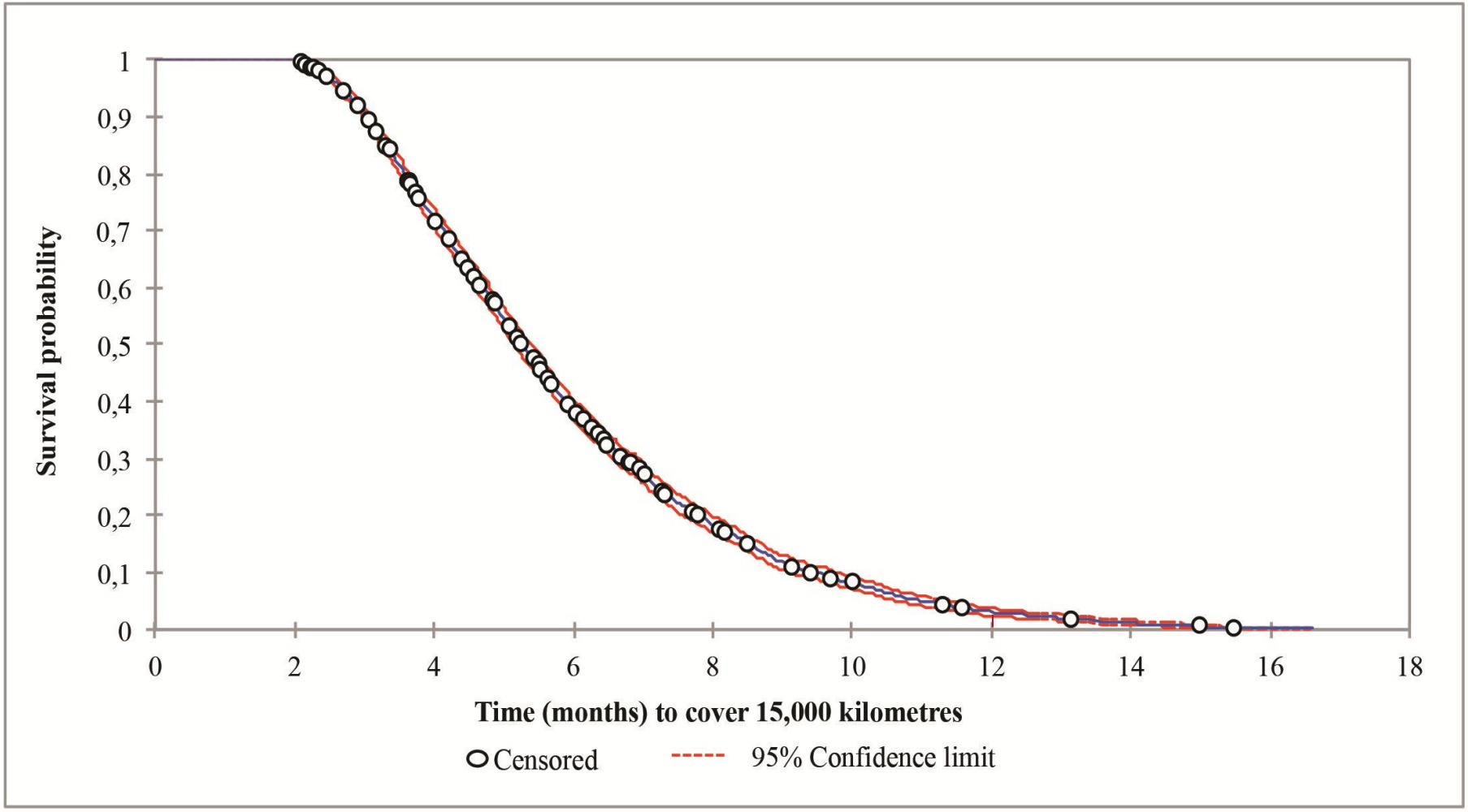
Back-testing

- For a defined period, back-testing involves comparing actual versus expected values of:
  - Count of services
  - Total claim amount of services
- Examples of such tests include:
  - Chi-square test
  - Mean absolute percentage error
- The period to back-test can be split into *fit-period* and *testing-period*.

Back-tested Time to Cover 15,000 kms Distribution



Effect of Time Horizon on Back-testing Results

	In-sample				Out-of-sample			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Actual	876	756	845	812	654	524	623	642
Expected	924	804	798	851	700	484	558	651
MAPE								
Quarterly	5.5%				6.6%			
Half-yearly	3.2%				2.5%			
Yearly	2.7%				2.0%			
Chi-squared statistic (p-value)								
Quarterly	9.90 (0.0194)				14.00 (0.0029)			
Half-yearly	5.69 (0.0171)				2.51 (0.1132)			

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Concluding Remarks

- The manner service intervals are specified can be misleading for projecting the timing of future services.
- Given data typically in possession of service plan providers, survival models are ideal to capture the uncertainty relating to the timing of future services. Moreover, survival models also provide insight on the probability of a service being claimed.
- Back-testing provides a tool to indicate when to recalibrate the model.

Suggestions for Further Research

- Does servicing type (e.g.: minor service, major service) influence the probability that a customer defaults on a service?
- What factors influence service costs?
- What is the probability of replacing individual wear-and-tear components at a scheduled service?
- Does relaxing the time homogeneity assumption of usage improve the predictive properties of the model?

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