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The Influence of Limiting Extended Warranty Usage Coverage on Rating and Premium Provisions

By

Fidelis T Musakwa

4 April 2014

Agenda

- Background to motor extended warranties
- Motivation
- Research problems
- Model
- Case study
- Concluding remarks

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- **Cover:** Specified vehicle parts.
- **Peril:** Mechanical breakdown.
- **Compensation:** Parts and labour cost.
- **Other Secondary Benefits:** e.g., roadside assistance, hotel accommodation and car rental.
- **Service items:** These are typically excluded from cover: e.g., oil filter, battery, brake pads and fuel filter.

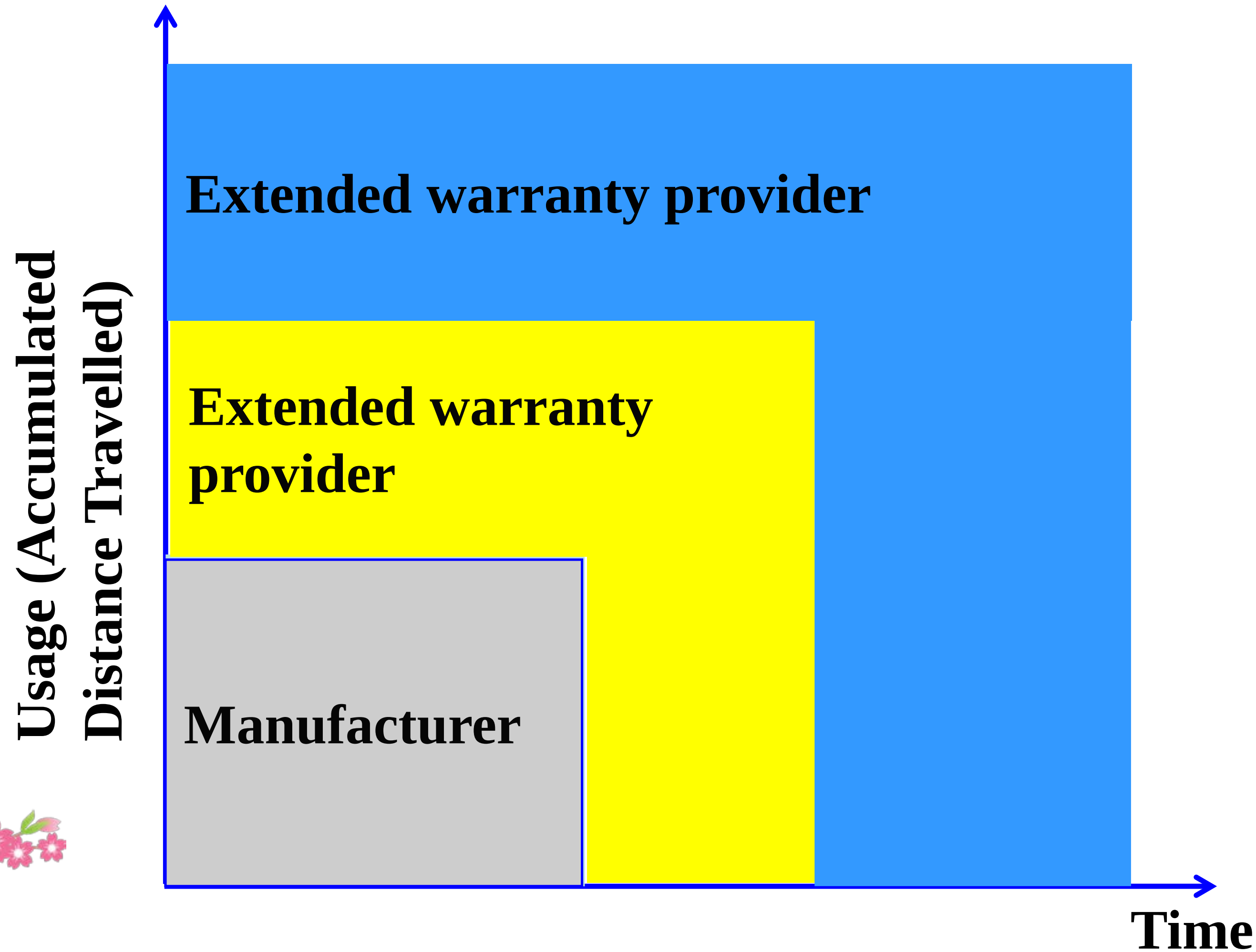
Vehicle Warranty

Base Warranty

- Issued by manufacturer
- Tied to sale of new product
- Deemed as Non-insurance in most territories

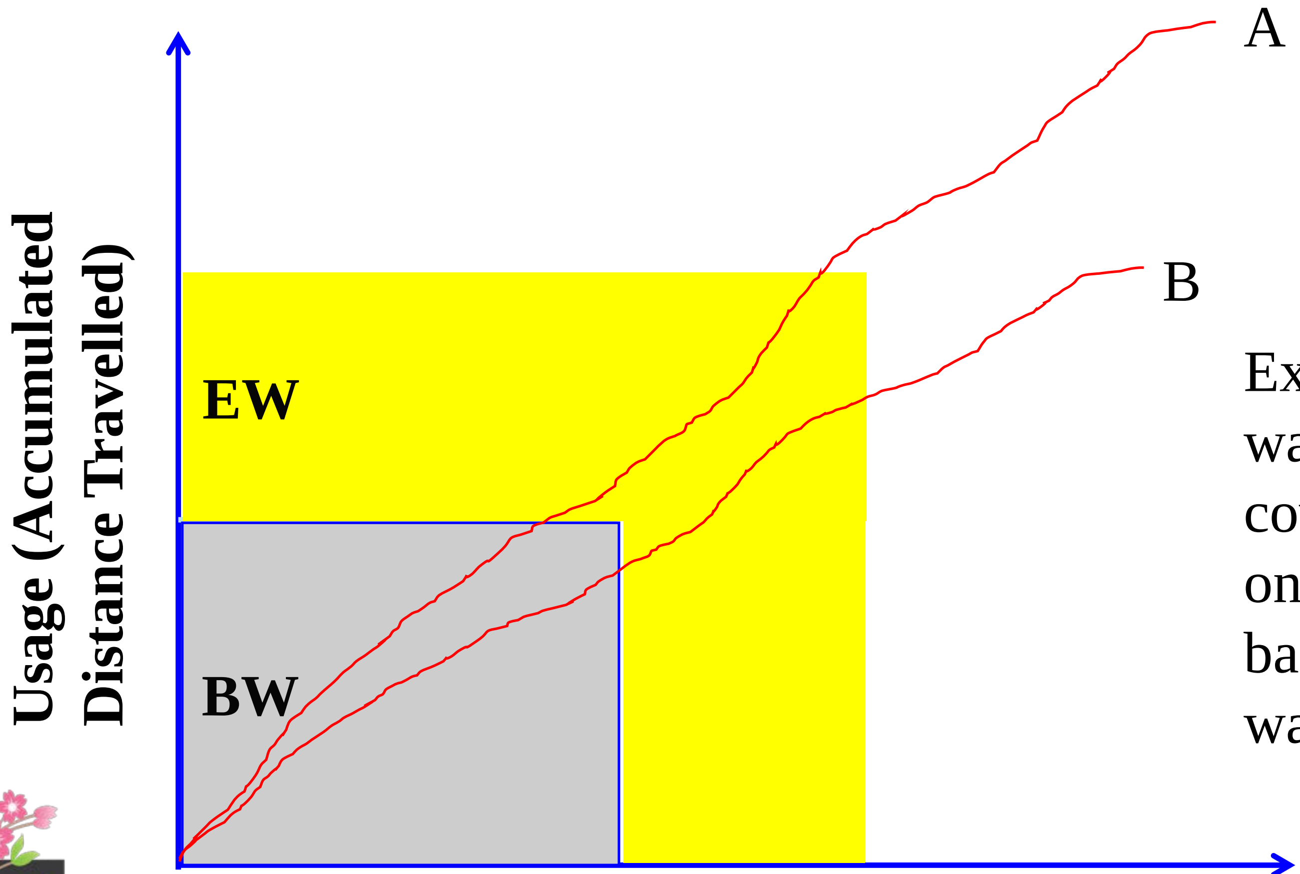
Extended Warranty

- Issued by manufacturer and other third parties
- Customer has option to buy extended warranty
- Deemed as Insurance in most territories



Extended warranty provider
Extended warranty provider
Manufacturer
Usage (Accumulated Distance Travelled)
Time

Warranty cover



Extended warranty cover starts on expiry of base warranty.

- **Rating Factor:** Warranty coverage is very significant.
- **Trend:** Warranty coverage increasing.
- **Probability of Exposure:** Knowing a provider's probability of being on risk has implications on:
  - **Pricing:** Pure risk premium.
  - **Premium provisions:** Earning patterns.

- **Status Quo on Projecting Vehicle Population at Risk:** This is done via a usage rate distribution.

Observe Usage Rates → Estimate usage rate distribution → Infer time to accumulate a specific usage

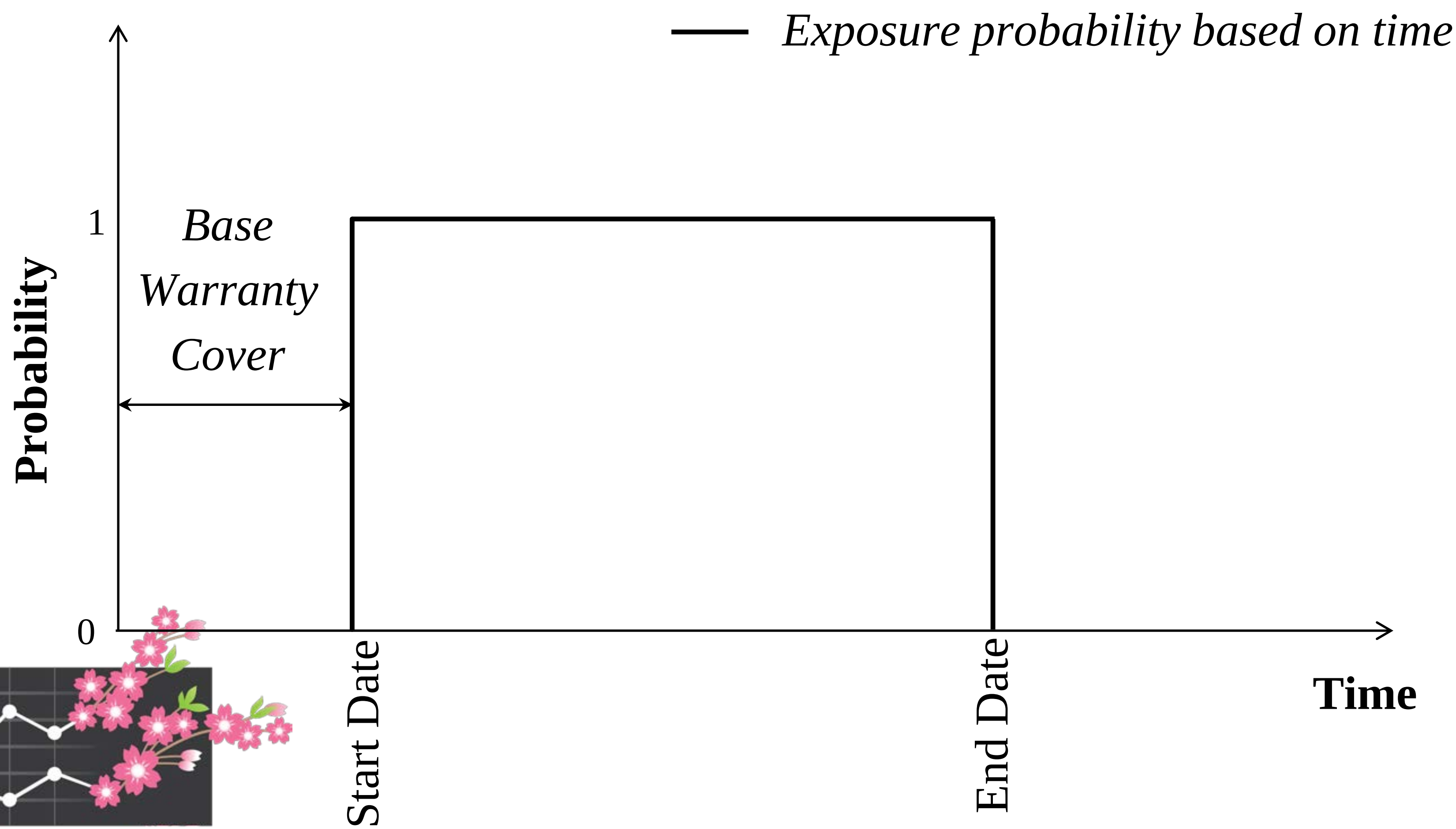
Premise:
Usage rate is **constant** on a vehicle but varies across vehicles

Cheng and Bruce (1993); Rai and Singh (2005); Majeske (2007); Alam and Suzuki (2009); Su and Shen (2012); Wu (2012); Shahanaghi et al. (2013).

- **Questions arising:**
  - Is the premise appropriate?
  - Can vehicle population at risk be estimated without such a premise?
  - How reliable is the use of a usage rate distribution in forecasting vehicle population at risk?
  - How do answers to the above influence premium provisioning and rating?

Estimator for Pr. Of Being on Risk

Interval Censored Survival Models



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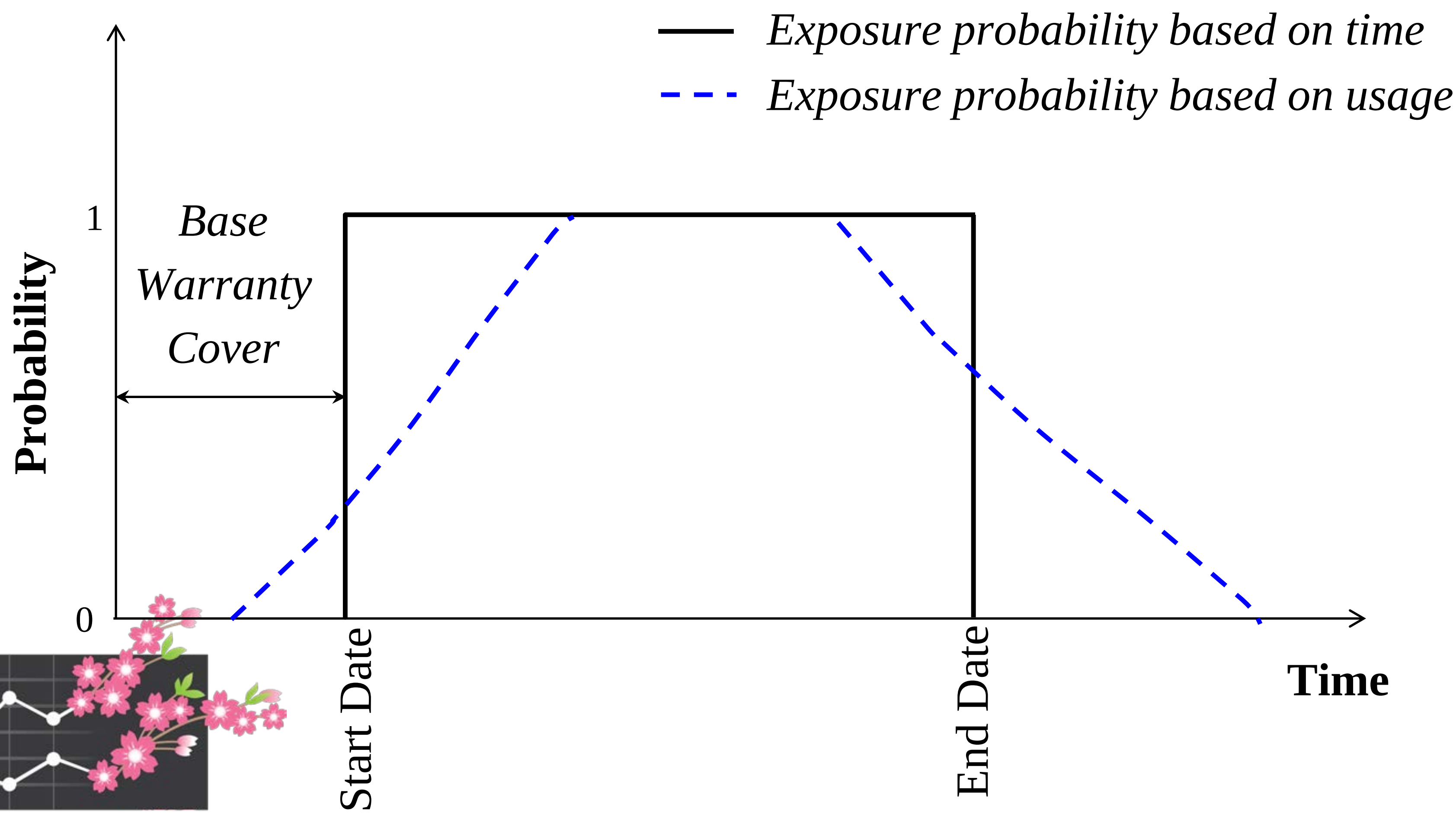
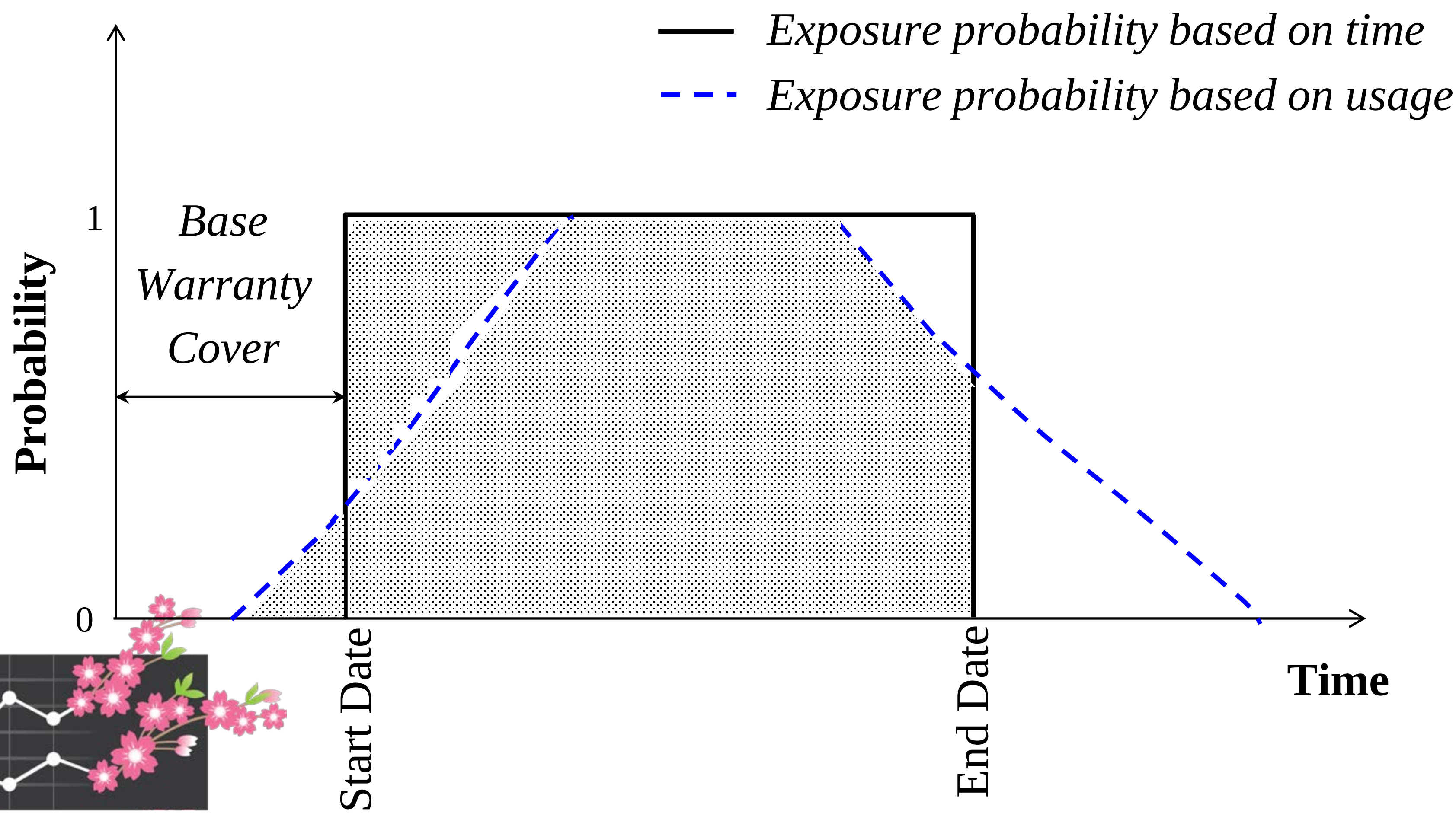
Estimator for Pr. Of Being on Risk

Interval Censored Survival Models



Estimator for Pr. Of Being on Risk

Interval Censored Survival Models



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- **Objective:** Estimating the survival function/CDF of time to accumulate a specific usage

$$S(t) = \Pr(T_U > t) = \Pr(U_t < U)$$

- **Usage Data Properties**
  - The exact time to accumulate a specific usage is not directly observable.
    - Instead, what is observed is the interval that contains the time event of interest.
    - Censored data.

- **Data observations:** $\left(L_i, R_i\right] \Longleftrightarrow \left\{T_U : L_i < T_U \leq R_i\right\}$
- **Examples of Observed Time Intervals**

32,500 kms	480,000 kms	602,001 kms	**Usage**
2 months	40 months	67 months	**Age**
Purchase Date	Date of 1st Claim	Date of 2nd Claim	**Time**

Interval for time to 400,000 kms: (L, R] = (2 months, 40 months].

Interval for time to 600,000 kms: (L, R] = (40 months, 67 months].

Interval for time to 800,000 kms: (L, R] = (67 months, ∞].

$$\text{Likelihood} = \prod_{i=1}^{n}\left[S\left(L_i\right) - S\left(R_i\right)\right]$$

- Closed form solution non-existent. So, iterative methods are used for estimation.
- For example:
  - Self consistent algorithm (Turnbull, 1976)
  - Expectation maximisation (EM) algorithm (Dempster et al., 1976)
  - Iterative convex minorant (ICM) (Groeneboom and Wellner, 1992)
  - EM-ICM algorithm (Wellner and Zhan, 1997).

How non-parametric maximum likelihood methods work

Observation	**Left**	**Right**
1	L(1)	R(1)
2	L(2)	R(2)
:	:	:
N	L(N)	R(N)

Create a set from **left** **U** **right**, excluding 0 and infinity.

Determine the **innermost** intervals

Assign **probability mass** to innermost intervals

Numerical Example

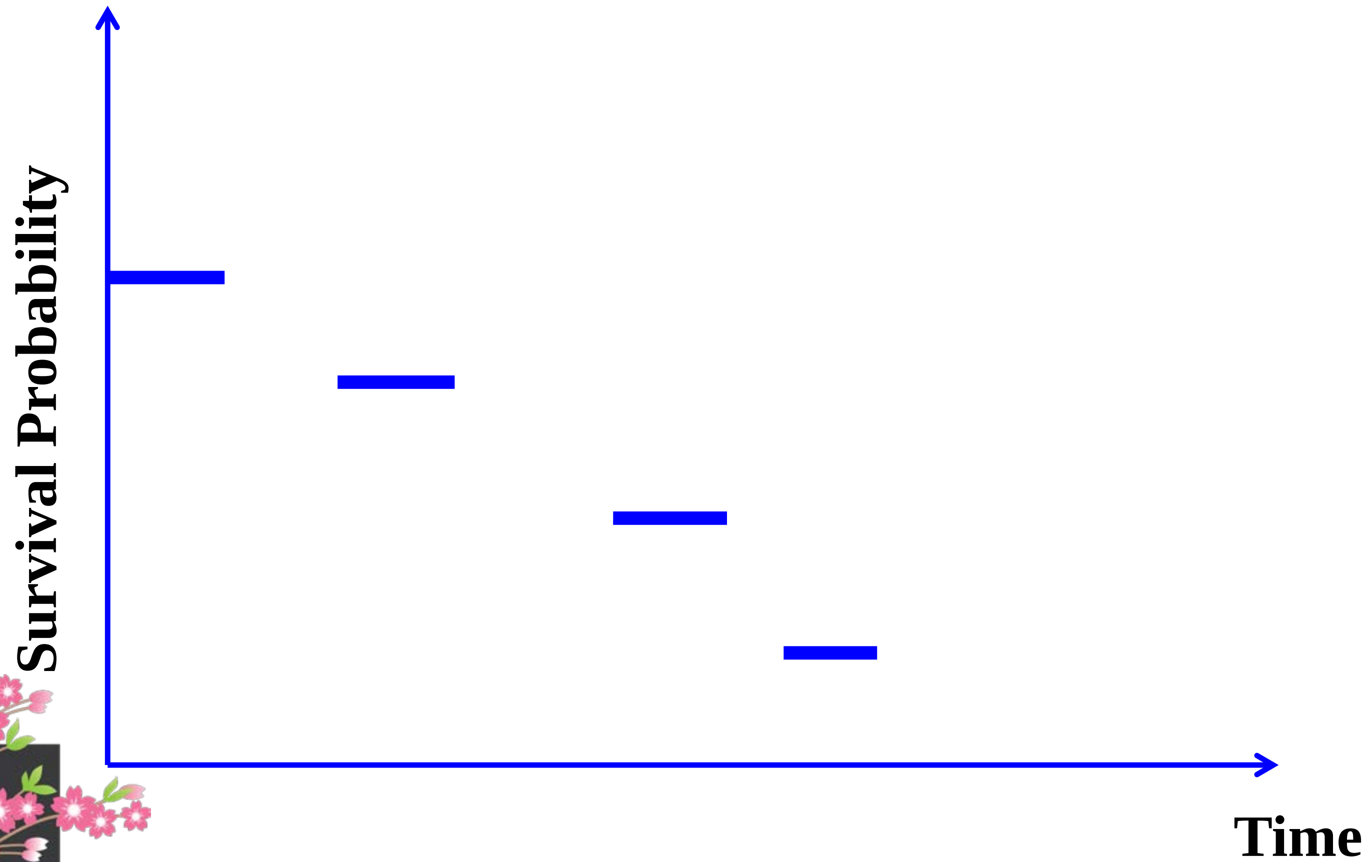
Observation	Left	Right
1	20	∞
2	0	30
3	25	40
4	35	42

20, 25, 30, 35, 40, 42

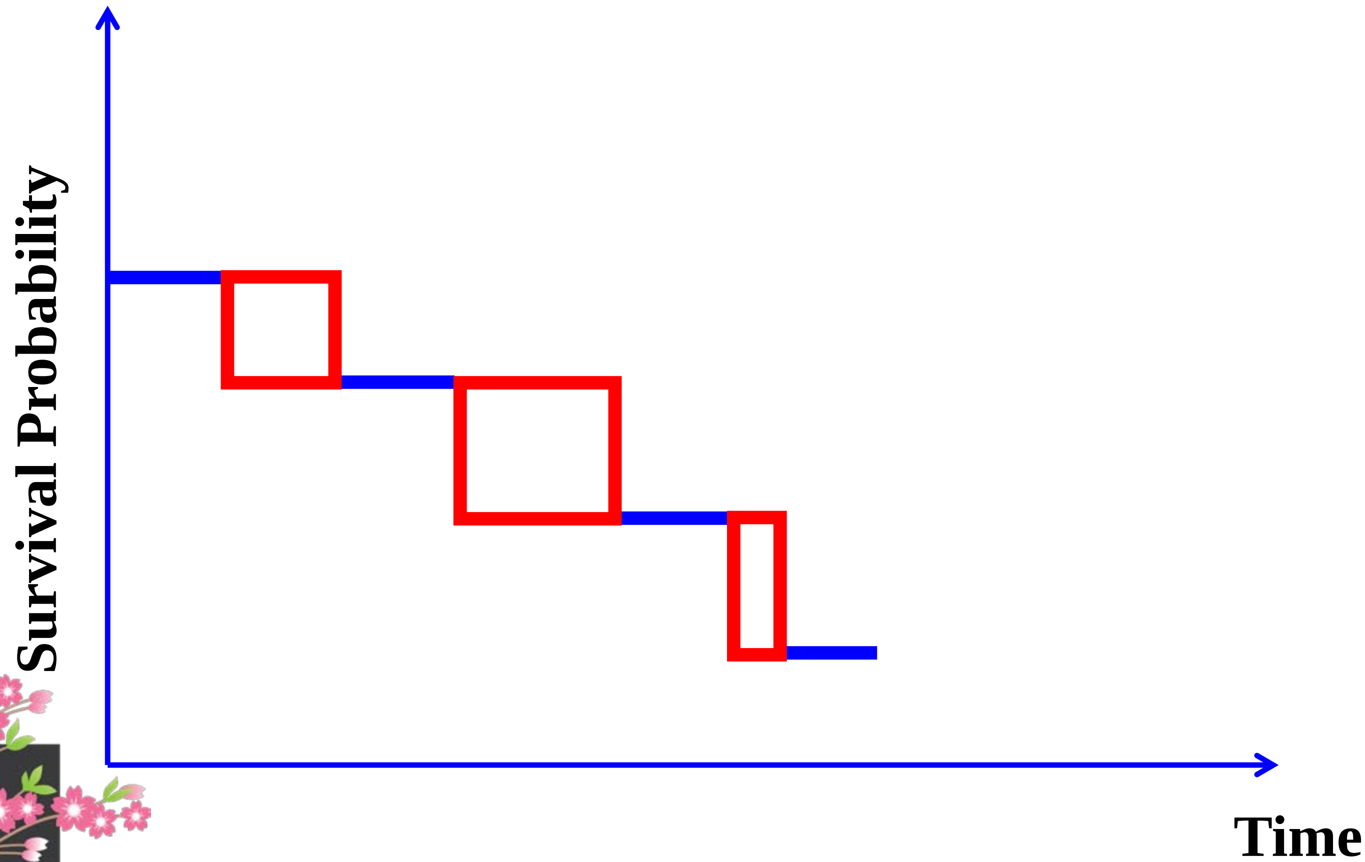
(20, 25], (30, 35], (40, 42]

Assign **probability mass** to innermost intervals

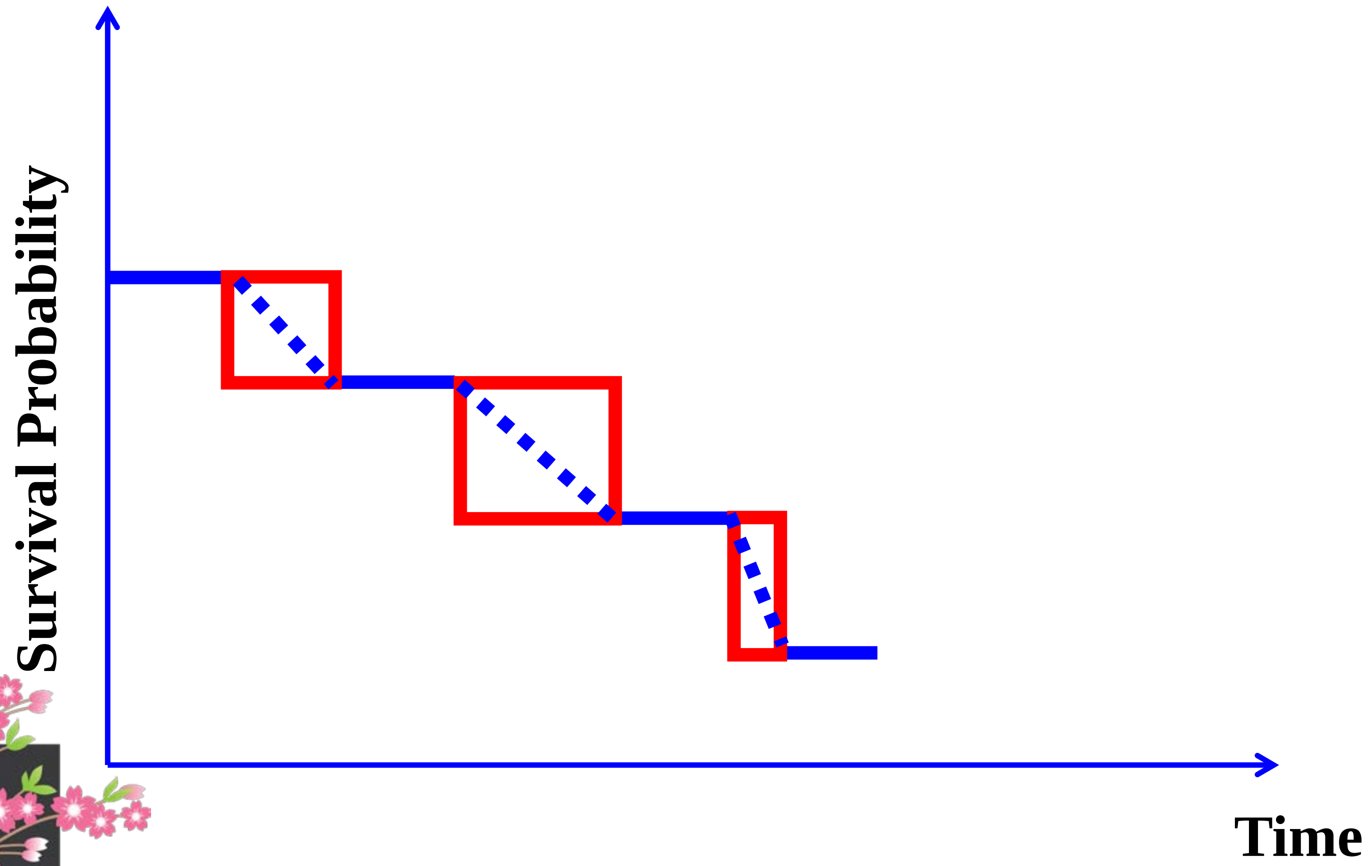
Resulting Survival Function



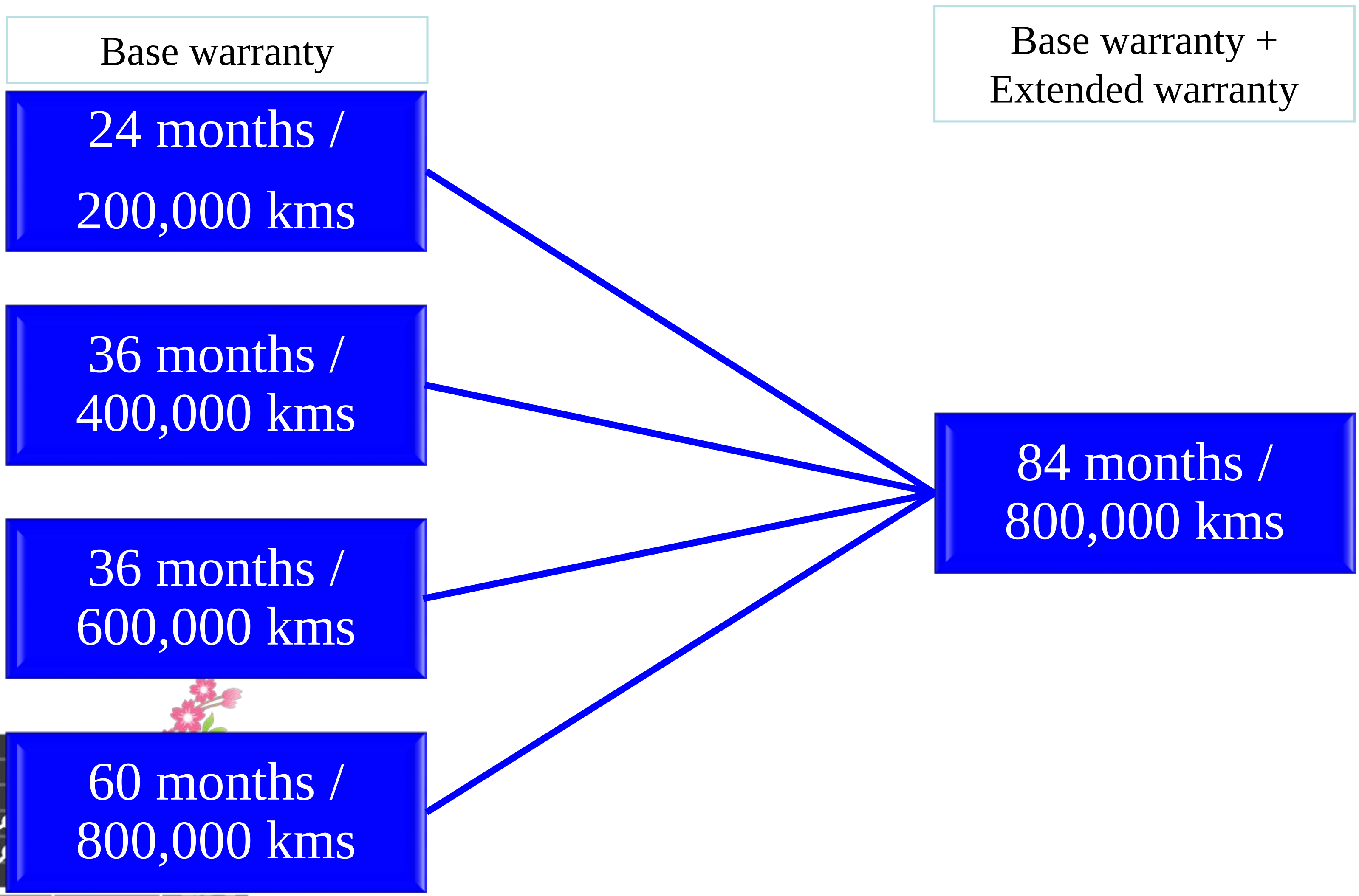
Resulting Survival Function



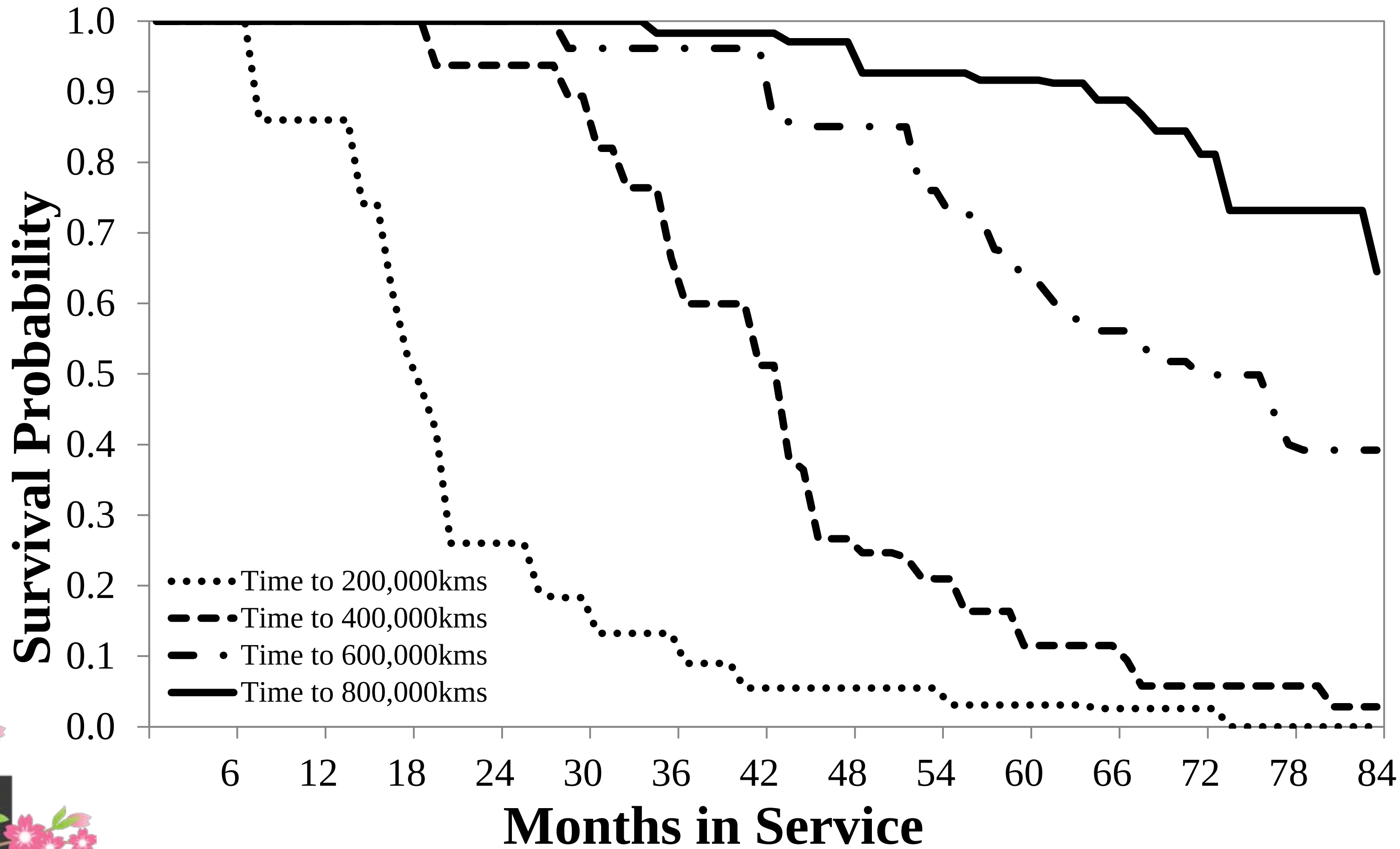
Resulting Survival Function



- Proprietary data of insurer located in South Africa
- Eligibility: heavy commercial truck involved in medium or long-haul operations.
- Usage data source: Withdrawals, claims, policy inception and maintenance records.
    - Total: 857 trucks.


Base warranty
Base warranty + Extended warranty
24 months / 200,000 kms
36 months / 400,000 kms
36 months / 600,000 kms
60 months / 800,000 kms
84 months / 800,000 kms

Time to Attain a Specific Usage



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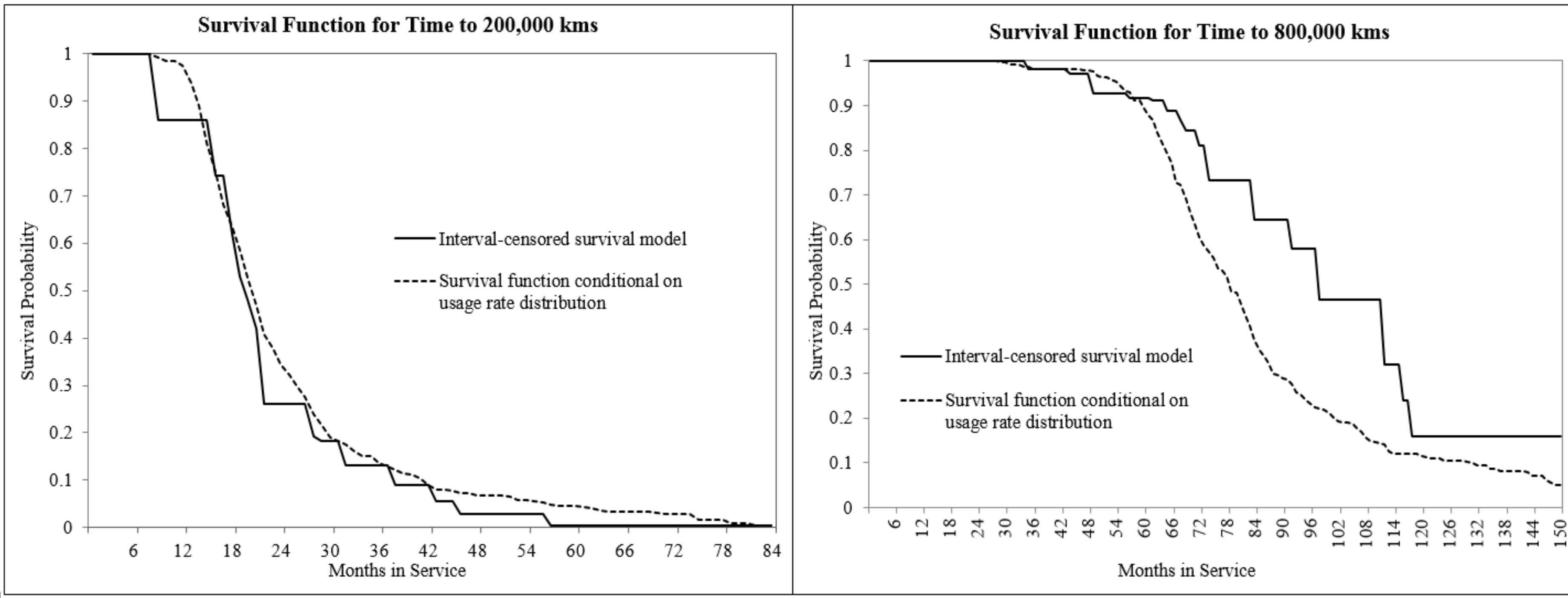
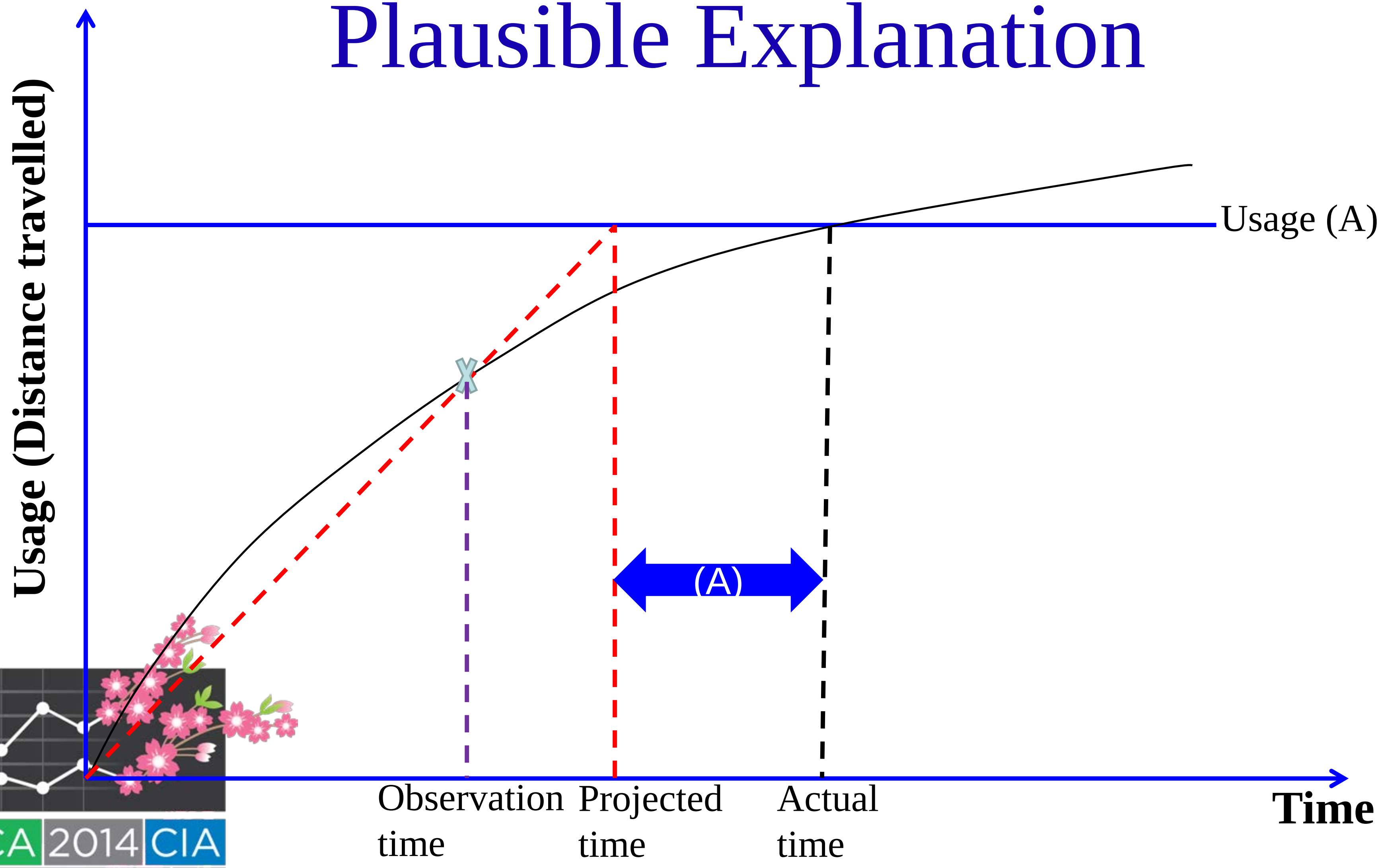
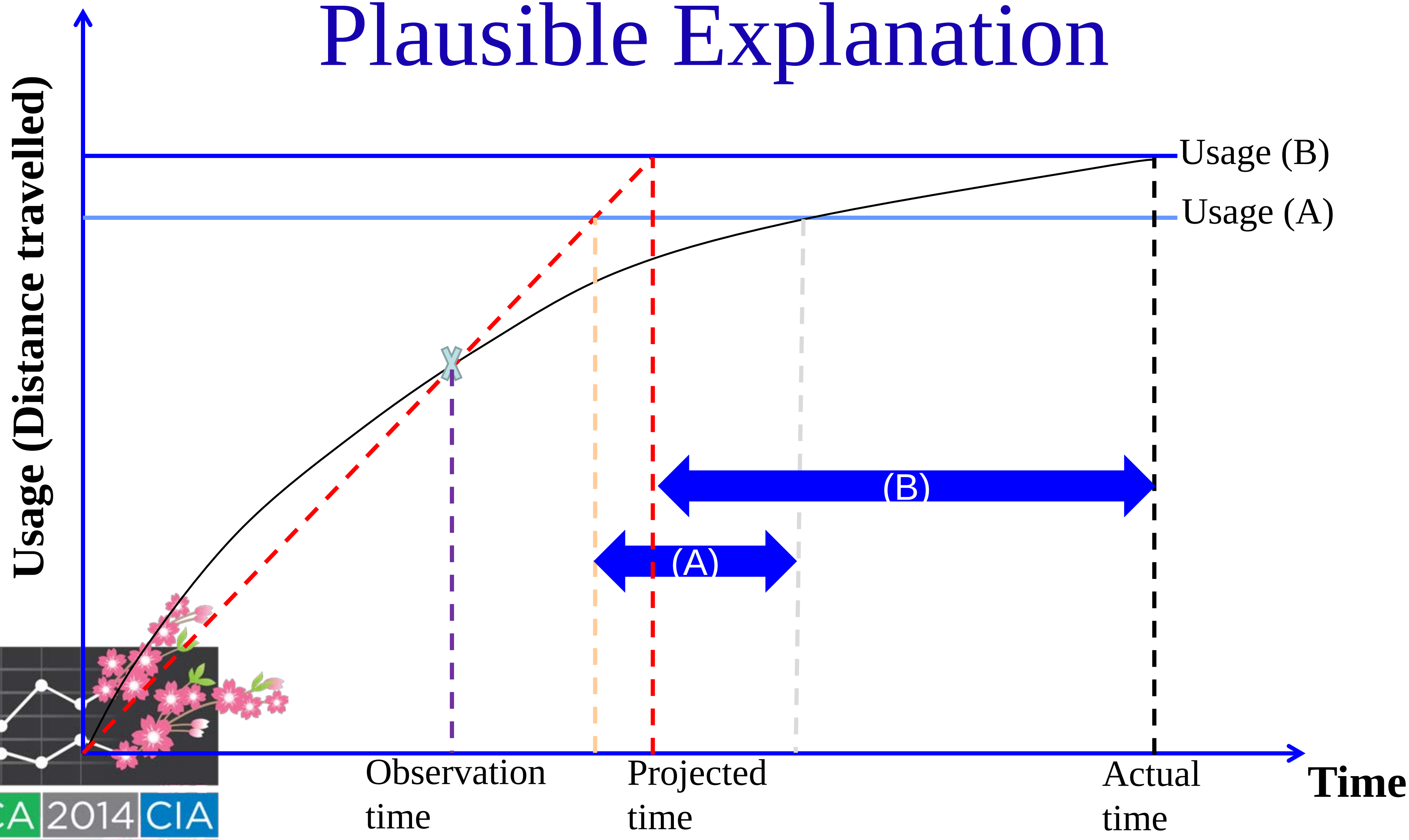
NPMLE versus Usage Rate Distribution



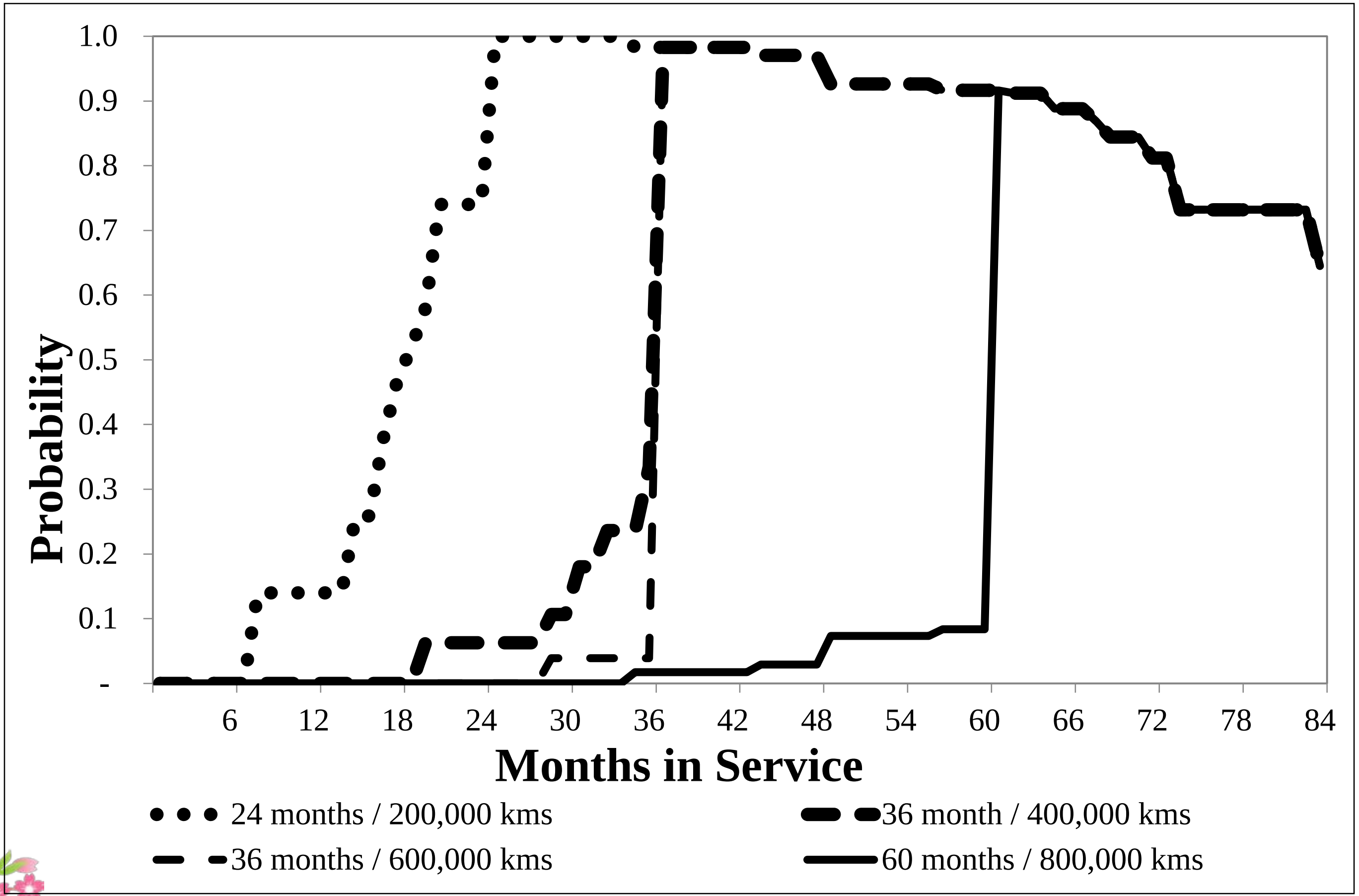
Plausible Explanation



Plausible Explanation



P [EW Provider Being on Risk]



Distribution	Parameter Estimates	Anderson-Darling Test Statistic	p-value
$Lognormal(\mu,\sigma)$	$\mu = 8.96;\ \sigma = 0.44$	0.38	0.39
$Gamma(\alpha,\beta)$	$\alpha = 8.24;\ \beta = 0.98 \times 10^{-3}$	0.27	0.66
$Weibull(\alpha,\beta)$	$\alpha = 3.22;\ \beta = 9{,}614.29$	0.25	0.73

- Results reaffirm that positively skewed statistical distributions fit well to usage rate data (Shahanaghi et al., 2013; Su and Shen, 2012; Jung and Bai, 2007; Kerper and Bowron, 2007; Majeske, 2007; Rai and Singh, 2005).

- This suggests that a fit to parametric usage rate distribution is neither a necessary nor sufficient condition for knowledge about the survival time to accumulate a specific usage.

Pure Risk Premium

Claim Frequency x Claim Severity

Claim Frequency = Count of claim incidents / Sum of exposed to risk

Claim Severity = Average Cost of Claim

Pure Risk Premium

Pr. Of Being on Risk x Claim Frequency x Claim Severity

Claim Frequency → $\frac{\text{Count of claim incidents}}{\text{Sum of exposed to risk}}$

Claim Severity → Average Cost of Claim

- Estimator of providers’ probability of being exposed to risk.
- Interval-censored survival models are best suited to estimate the value of the estimator given the incomplete nature of usage data.
- Usage rate distributions can be a potentially misleading way to estimate vehicle population at risk, particularly on the CDF of time to higher levels of accumulated usage.

- Is the distribution of time to a specific usage stable over time?
- Multiple decrements: e.g., including:
  - Withdrawal
  - Accident
  - Theft.
- Incorporating covariates, e.g. through an interval-censored proportional hazard model.

Thank You

Any questions?