Erasmus
School of
Economics

Towards Sustainable Computing:
Effective Strategies for Product Lifetime Extension in Personal Computer

Scottie Lee (589821sl)

Supervisors: Prof.dr.ir R. Dekker and Prof. N.M. Almeida Camacho

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Erasmus University Rotterdam

Introduction

- Shift in consumer habits towards frequent PC upgrades
- Environmental impact of e-waste and rising hardware costs
- The need for sustainable practices in personal computing

Research Question

What are the most effective strategies for implementing Product Lifetime Extension in personal computers, specifically regarding the selection and timing of component upgrades, to balance technological advancement, environmental sustainability, and economic viability?

Research Methodology

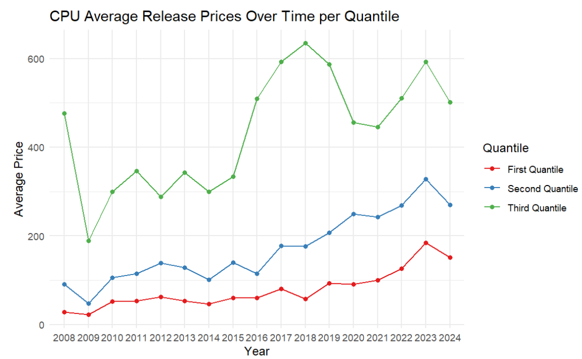
Data Collection: Web Scraping from Passmark

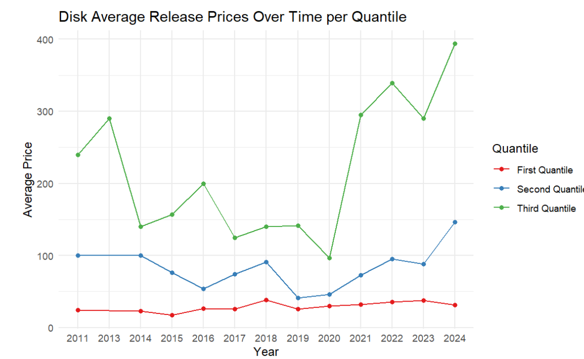
Data Cleaning: Removal of unnecessary data

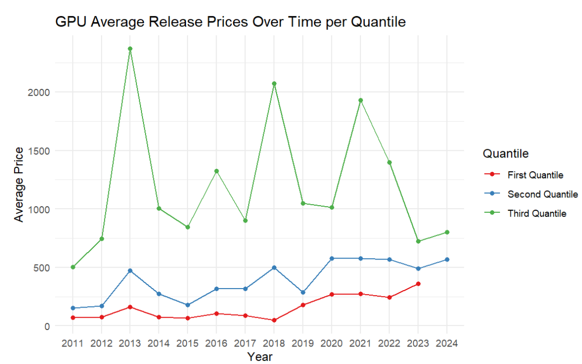
Pre-processing: Inflation adjustment

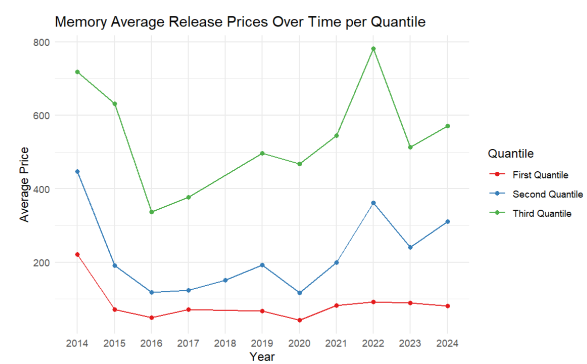
Modeling: Development of an optimization model

Price trends

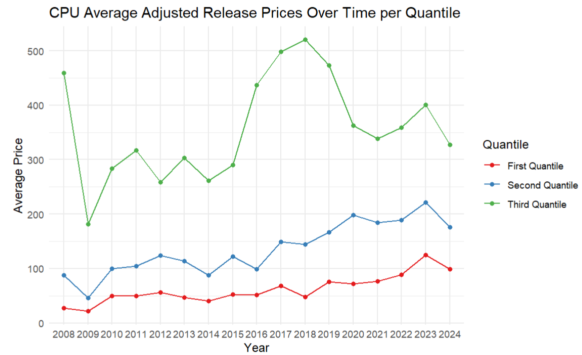


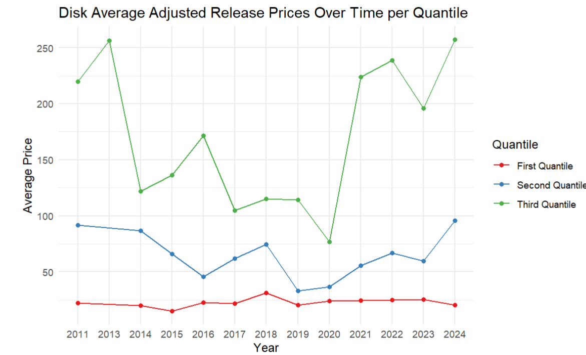


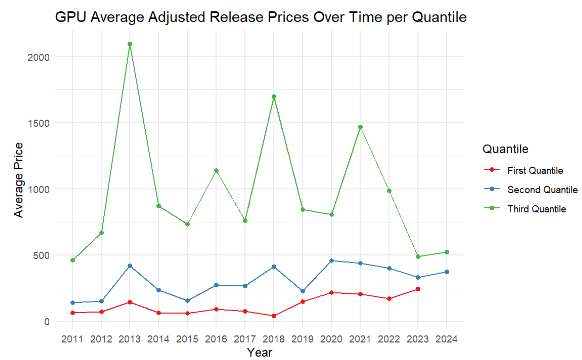


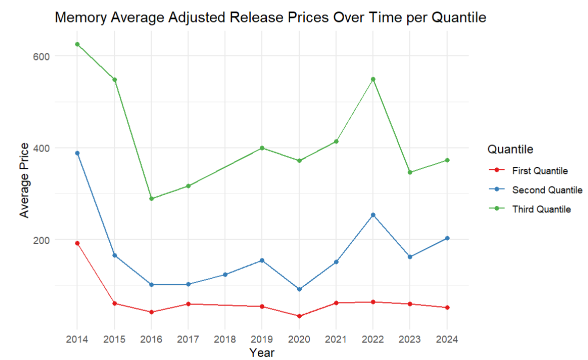


Price trends









Optimization Model

Define System Components and Tiers (Quantiles)

Component Cost and Performance

- Inflation adjustment
- PassMark Rating

Optimization Problem

- Maximize extended period while maintaining acceptable performance
- Find optimal upgrade time
- Full Replacement Policy of 5 years

Optimization Methodology

- Non-Linear Optimization: Nlopt library in R

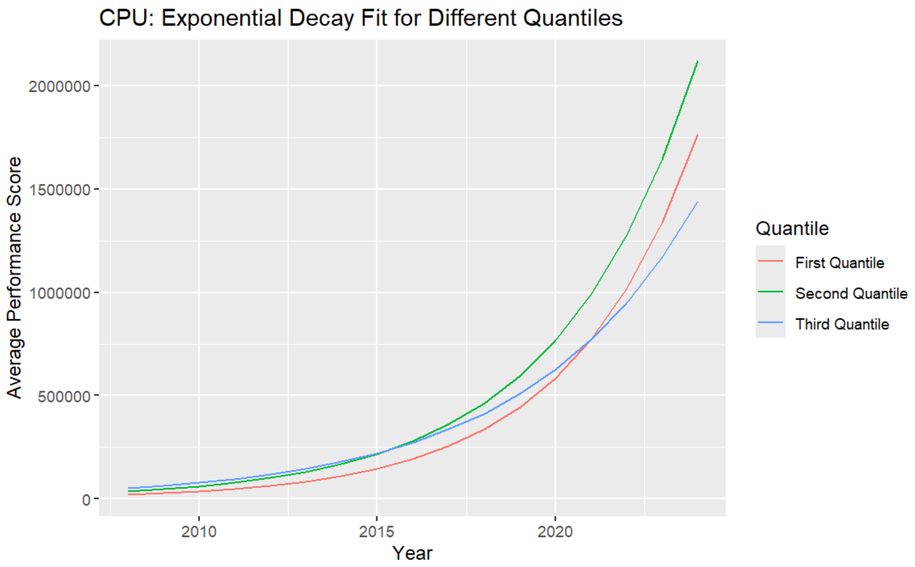
Sustainability and Cost Analysis

- Compare carbon emission
- Compare average yearly cost

Forecasting Technological Improvements (Deterioration)

- Non-linear regression
- Forecasts of technological improvements

$$\text{performance}(t) = P_0 \cdot e^{-\lambda t}$$



Optimization Model

- Full Replacement vs. Component Upgrades
  - Scenarios for one-component and two components upgrades
- System Performance (PassMark Rating)

$$\textbf{PassMark Rating} = \frac{1}{\left(\frac{1}{\mathrm{CPU}\times 0.397} + \frac{1}{\mathrm{2D}\times 3.179} + \frac{1}{\mathrm{3D}\times 2.525} + \frac{1}{\mathrm{Memory}\times 1.757} + \frac{1}{\mathrm{Disk}\times 1.668}\right)/5}$$

Results

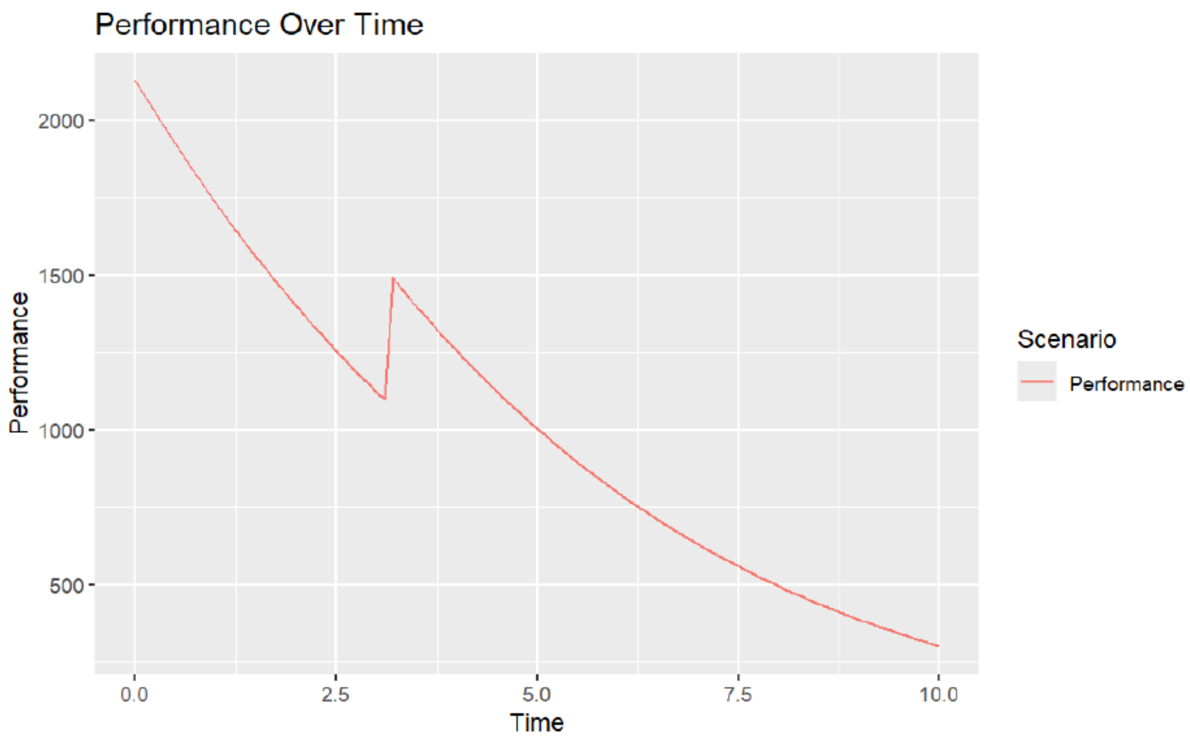
- Average sustainability is 47.8 kg/year
- Prices are in dollar
- Period is in years

Component	Quantile	Opt_Up_Time	Extended_Period	Avg_FRC	Avg_UC	Avg_Sys_Em
CPU	First	2.7098	8.225	46.82	37.83	37.78
CPU	Second	2.8274	7.65	120.37	100.25	40.61
CPU	Third	2.4122	7	365.19	334.80	44.39
Disk	First	2.1957	5.15	46.82	50.70	50.12
Disk	Second	1.8174	5.95	120.37	112.30	43.38
Disk	Third	2.0006	7.25	365.19	277.71	35.62
GPU	First	2.1213	6.925	46.82	51.73	39.67
GPU	Second	2.1673	6.3	120.37	136.42	43.61
GPU	Third	2.0697	6.175	365.19	457.51	44.43
Memory	First	2.5	5.1	48.65	57.96	49.20
Memory	Second	2.1283	5.1	120.37	141.70	49.20
Memory	Third	2.5	5.1	351.23	410.10	49.20

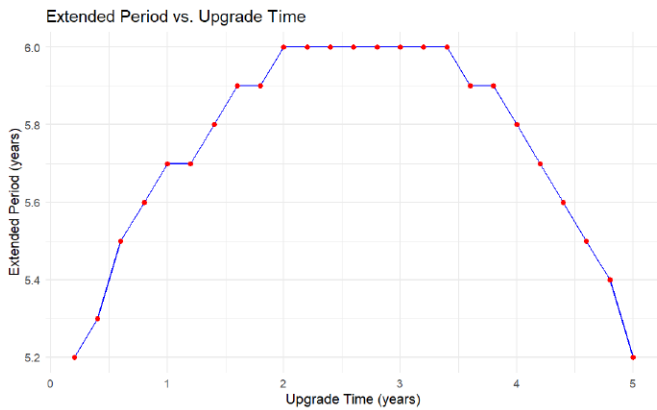
Results (2)

Component	Quantile	Opt_Up_Time	Extended_Period	Avg_FRC	Avg_UC	Avg_Sys_Em
CPU; Disk	First	2.74	11.00	46.82	22.09	29.98
CPU; Disk	Second	3.88	15.05	120.37	41.64	21.91
CPU; Disk	Third	4.19	16.75	365.19	115.64	19.69
CPU; GPU	First	4.20	19.18	46.82	12.67	18.07
CPU; GPU	Second	3.00	12.30	125.93	59.09	28.17
CPU; GPU	Third	2.91	9.47	365.19	200.25	29.03
CPU; Memory	First	2.83	10.50	46.82	23.07	30.04
CPU; Memory	Second	3.13	8.88	120.37	69.59	34.00
CPU; Memory	Third	2.46	7.75	365.19	240.16	41.54
Disk; Memory	First	2.50	5.18	46.82	45.30	48.55
Disk; Memory	Second	2.12	6.10	120.37	98.08	44.09
Disk; Memory	Third	2.00	7.95	365.19	242.09	33.64
GPU; Disk	First	2.13	6.68	46.82	35.65	42.26
GPU; Disk	Second	1.83	7.32	120.37	84.33	40.84
GPU; Disk	Third	2.68	9.15	365.19	212.96	32.75
GPU; Memory	First	2.16	6.50	46.82	36.45	41.96
GPU; Memory	Second	2.30	6.05	120.37	103.67	41.83
GPU; Memory	Third	1.96	5.90	365.19	309.15	48.16

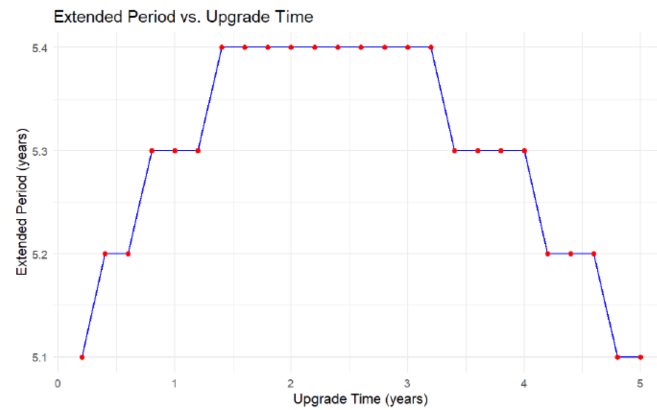
Result (3)


Performance Over Time
Performance
2000
1500
1000
500
0.0
2.5
5.0
7.5
10.0
Time
Scenario
Performance

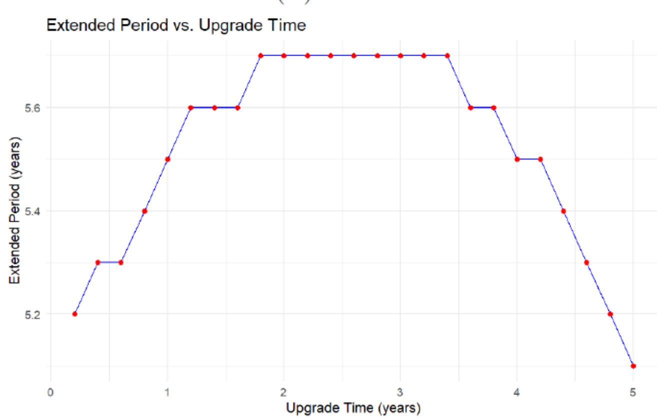
Broken Component

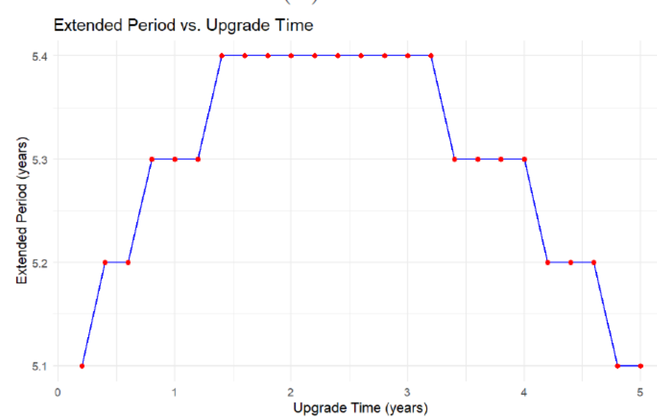


(a) CPU



(b) GPU





Key Findings

- CPU: High impact on performance, most beneficial to upgrade
- Disk: Significant benefits in higher quantiles
- GPU: High performance impact, less cost-effective due price
- Memory: Minimal effect on extending system lifespan

Marketing

- Targeted Marketing
- Sustainability Campaigns
- Product Bundling

Limitations

- Component Focus
- Price Assumptions

Conclusion

- PLE strategies extend PC lifespan, reduce costs, and lower emission
- Practical implications
- Future research

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