

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

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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

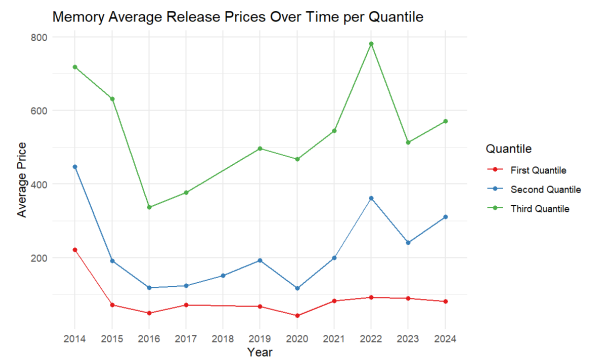
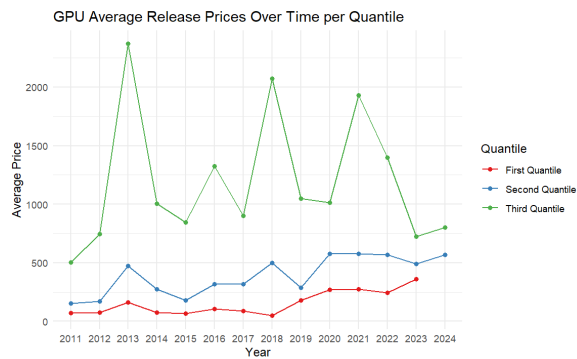
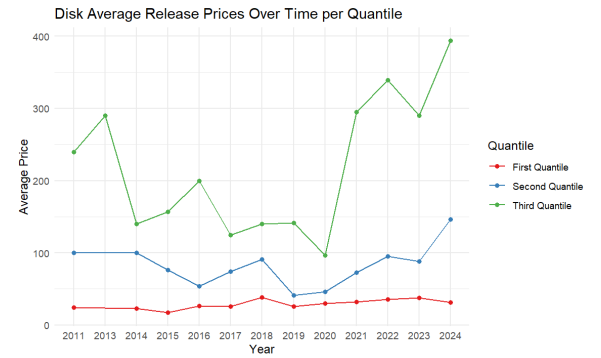
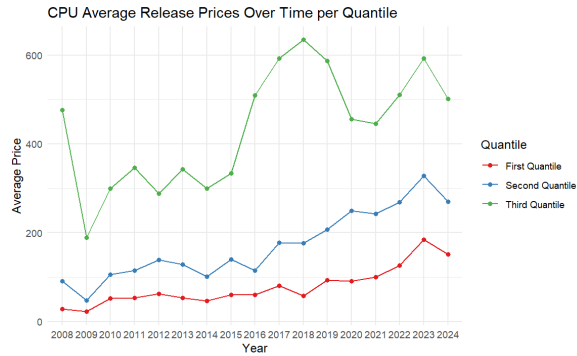


Pre-processing:
Inflation adjustment



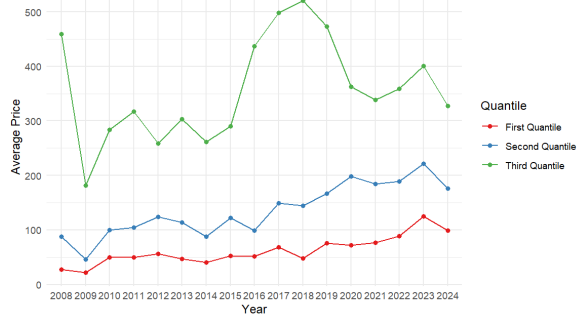
Modeling:
Development of an
optimization model

Price trends

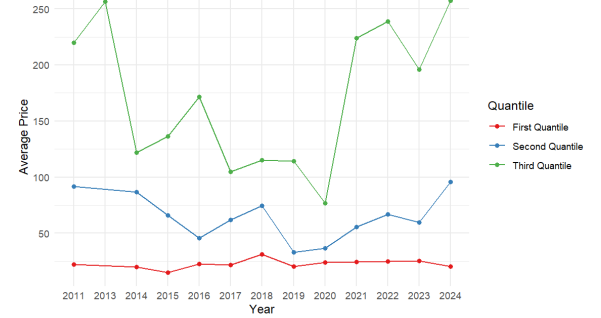


Price trends

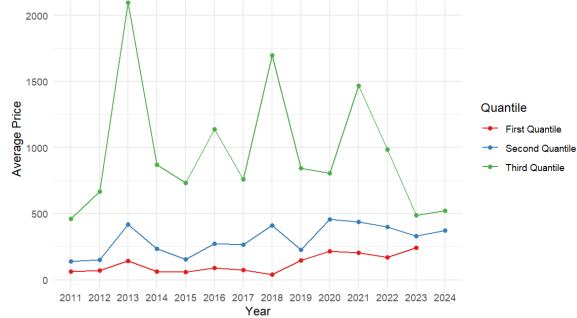
CPU Average Adjusted Release Prices Over Time per Quantile



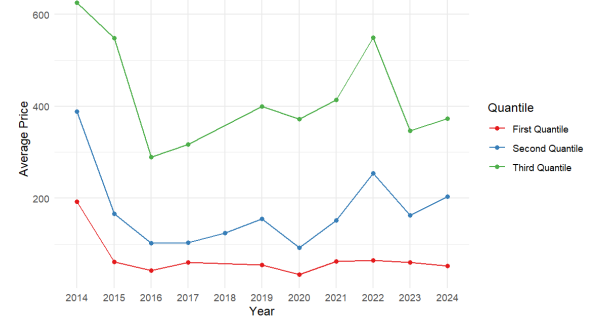
Disk Average Adjusted Release Prices Over Time per Quantile



GPU Average Adjusted Release Prices Over Time per Quantile



Memory Average Adjusted Release Prices Over Time per Quantile



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

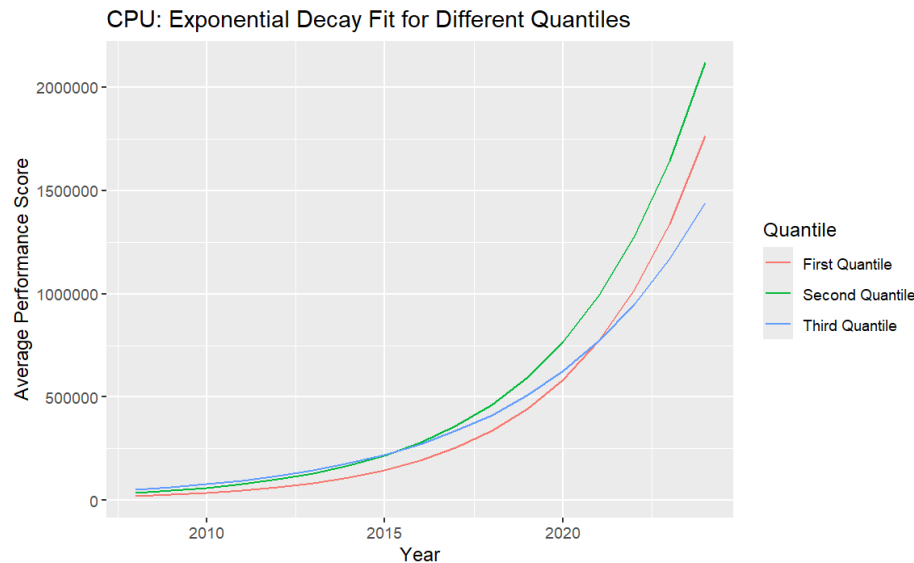
- Compare carbon emission
- Compare average yearly cost

The Erasmus logo, featuring a stylized, handwritten-style script of the word "Erasmus" in black.

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)

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

Results

- Average emission 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 |

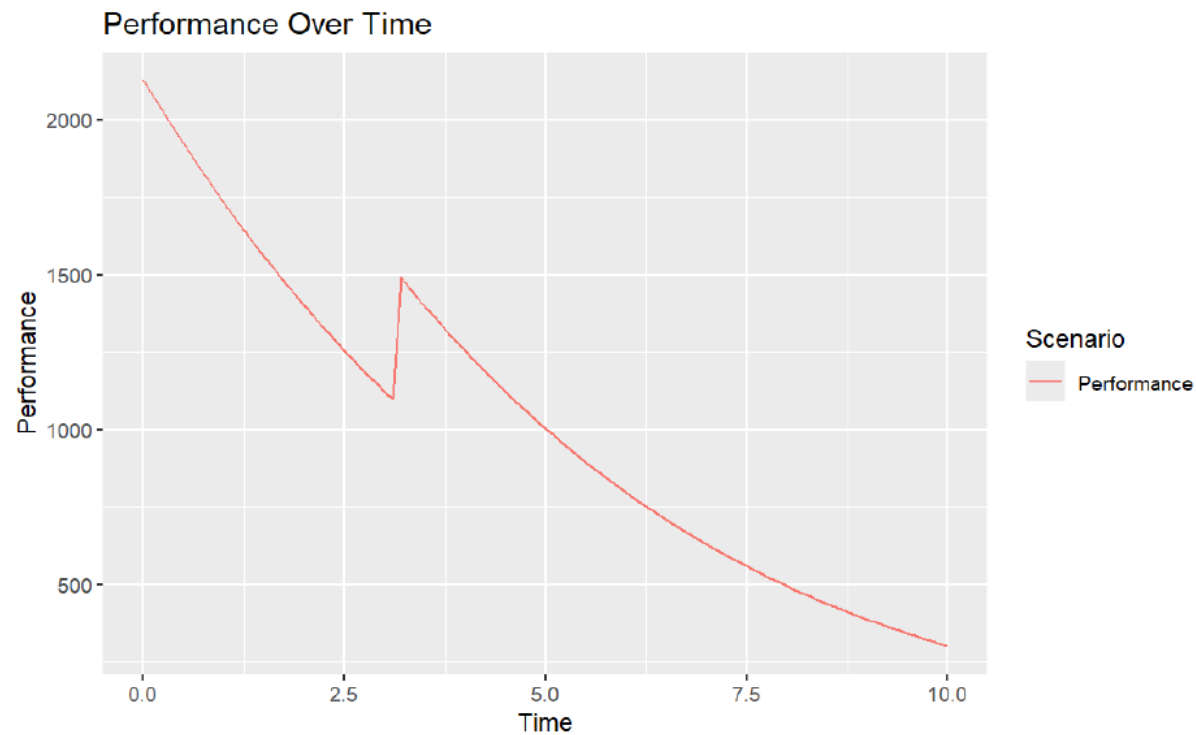


Results (2)

| 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 |

Ezra

Result (3)



Ezra

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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