

An Investigation into Evaluating Laptop PCs using TBL: An Economic View

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An Investigation into Evaluating Laptop PCs using TBL:
An Economic View

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ABSTRACT

The following report is an investigation into the laptop computer usage by faculty and staff at UBC including an evaluation using the accounting concept of the triple bottom line (TBL) assessment. The TBL assessment consists of evaluations of social, environmental and economic impacts on the purchase of laptop PCs to replace the existing ones currently in use at the university. This portion of the report examines the economic view of the TBL and will be considered alongside separate reports on the social and environmental aspects. Based on data provided by the stakeholders regarding the current laptop use on campus, a sample set of laptops to be examined was researched into as part of constructing a price vs. performance ratio. The ratio would simplify the process of evaluation for the user to make more informed decisions when purchasing a laptop PC incorporated into an easy-to-understand scoring index. This index addresses the various performance and functionality components of a laptop PC that should be considered when evaluating the relevance of a laptop PC to meet the needs of a particular user. Constructing the scoring index began with research into methods previously used to evaluate laptop PCs based on performance and benchmark ratings. Next, a database of possible laptop PCs that may be adopted on campus was created with detailed technical information for each model type. Next, after further research, an equation resulting in an overall rating for a particular model was created considering the various components that affect the purchase of a laptop PC depending on the user such as benchmark rating, screen size and memory size, among others. Although the department purchases the laptops from on campus vendors, the information collected to prepare a price vs. performance ratio was collected directly from the manufacturers. The index is created with two specific users in mind: a basic user and a power user; where the power user is expected to have higher performance demands than the basic user.

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GLOSSARY

Benchmark: the act of assessing the relative performance of an object.

CPU: the hardware within a computer that carries out the instructions of a computer program by performing the basic arithmetical, logical, and input/output operations of the system.

Intel: an American semiconductor chip corporation, one of the major CPU manufacturers.

AMD: Advanced Micro Devices, Inc, an american semiconductor company, one of the major CPU manufacturers

Memory: The physical devices used to store programs and data.

Transfer rate: the rate at which digital interface of computer peripheral equipment and network devices can communicate over buses and networks.

SSD: solid state driver, a data storage device using integrated circuit assemblies as memory to store data.

HDD: hard disk drive, a data storage device using rapidly rotating disks with magnetic material to store data

Hybrid: a hybrid type of hard drive mixes SSD and HDD

CPU Speed: the frequency of the CPU processing clock

Capacity: how much disk space the computer storage can provide.

Screen resolution: the number of distinct pixels in each dimension that can be displayed.

GPU: a specialized electronic circuit designed to rapidly manipulate and alter memory to accelerate the creation of images in a frame buffer intended for output to a display.

Ultrabook: a specification and trademarked brand by Intel for a class of high-end subnotebooks which are designed to feature reduced bulk without compromising performance and battery life.

Tablet: a mobile computer with display, circuitry and battery in a single unit.

LIST OF ABBREVIATIONS

- CPU: Central Processing Unit
- GPU: Graphics Processing Unit
- HDD: Hard Disk Drive
- SSD: Solid State Drive
- TBL: Triple Bottom Line

1.0 INTRODUCTION

The UBC Information technology (IT) department is crucial for the daily operation of UBC campus as all campus electronic systems such as campus networks, student web services, security services and laptop computer services are managed and operated by the IT department. This year, the IT department is requesting an evaluation report of on-campus laptop computer usage based on the triple bottom line assessment (TBL) from the APSC 262 group. The triple bottom line assessment is made up of three general factors: “social, economic and environmental.” Technically speaking, the triple bottom line can be phrased as “people, planet, and profit” to accomplish the goal of sustainability. “People” refers to the way a corporation operates its business that it’s fair and beneficial toward the labour, the community and the region. Such operations follow a reciprocal social structure in which the well-being of corporate, labour and other stakeholder interests are interdependent. “Planet” refers to sustainable environmental practices to minimize any harmful environmental impact and to benefit the natural order as much as possible. “Profit” simply means the net economic value generated by a corporation after deducting the cost of all inputs, including the cost of the capital tied up.

This report will focus only on the economic view of the triple bottom line assessment, it will examine different laptop brands based on their price and performance to come up with an optimal performance rating dependent on the user’s specific needs. This report along with the social and environmental reports from other APSC 262 groups will act as a reference in future campus laptop updates in order to achieve maximum sustainability and profit in terms of the economy, the society and the environment.

This report begins by explaining the background details such as current problems, requests of the client and collaboration. Then, the report will proceed on introducing the research findings based on triple bottom line taking into account of benchmarking and sampling. Lastly, the report will describe the methodology used in deriving the final performance equation which contains detailed explanation of any assumptions, exclusions and factors considered along the way as well as the final results.

2.0 BACKGROUND DETAILS

Laptop computers are extensively used across the UBC campus by faculty, staff and students; each with their individual demands for their respective laptop PCs. The purchase of laptop PCs by UBC IT is done through various information technology (IT) vendors. The functionality requirements of faculty and staff vary across a wide spectrum of needs, but the majority will only require word processing, email and web browsing.

2.1 CURRENT PROBLEMS AND TBL ANALYSIS

As informed by the stakeholder, the most common brands used across campus include Dell, HP, Lenovo and Apple. A list of Dell laptops currently used at UBC was also made available through the stakeholder with a brief description of features:

Average user – 12.5” screen, 2.99lbs

E7240 – 4th gen Intel Core I3-4010U processor (1.7ghz, 3M cache)

4GB ram 1600MHz DDR3L memory, 128GB Mobility solid state drive

12.5” HD(1366x768) anti-glare WLED-backlit

Power user – 12.5” screen, 2.99 lbs

E7240 – 4th gen Intel Core I7-4600U processor (2.1ghz, 4M cache)

8GB ram 1600MHz DDR3L memory, 256GB Mobility solid state drive

12.5” HD(1366x768) anti-glare WLED-backlit

Average user – 14" screen, 3.6 lbs

E7440 – 4th gen Intel Core I3-4010U processor (1.7ghz, 3M cache)

4GB ram 1600MHz DDR3L memory, 128GB Mobility solid state drive

14" HD(1366x768) wide angle anti-glare WLED-backlit

Power user – 14" screen, 3.6 lbs

E7440 – 4th gen Intel Core I7-4600U processor (2.1ghz, 4M cache)

8GB ram 1600MHz DDR3L memory, 256GB Mobility solid state drive

14" HD(1366x768) wide angle anti-glare WLED-backlit

These samples presented an outline for the range of specifications that should be considered in the sample of laptops. The range included i3, i5, i7 intel processors and their AMD equivalents. The samples also include a wide variety in price range, style and performance to incorporate the needs of both, an average user and a power user.

2.2 CLIENT'S REQUEST

It is the request of the client to create a laptop evaluation index that takes the features of a TBL assessment into account. This report provides the economic view of the TBL and thus the index solely reflects the economics portion of the assessment focusing on the price vs. performance ratio. A complete set of data was taken into account when establishing such a ratio ensuring to take outliers into consideration to create a fair and accurate evaluation index.

Through a workshop with the stakeholder, the team gained an understanding of the project and learned that these laptops are to be used primarily for general desk functions including emails, word processing, spreadsheets, etc. The team also got a sense of the budget designated for laptops and the

amount purchased as well as the current approximate turnover rate of laptops. It was also mentioned that the index could potentially be incorporated into the student body through the bookstore or provided online to aid students in making the right choice when purchasing a laptop. All of this information helped the team build the criteria for the index and also decide what changes to recommend to keep the index relevant in future years.

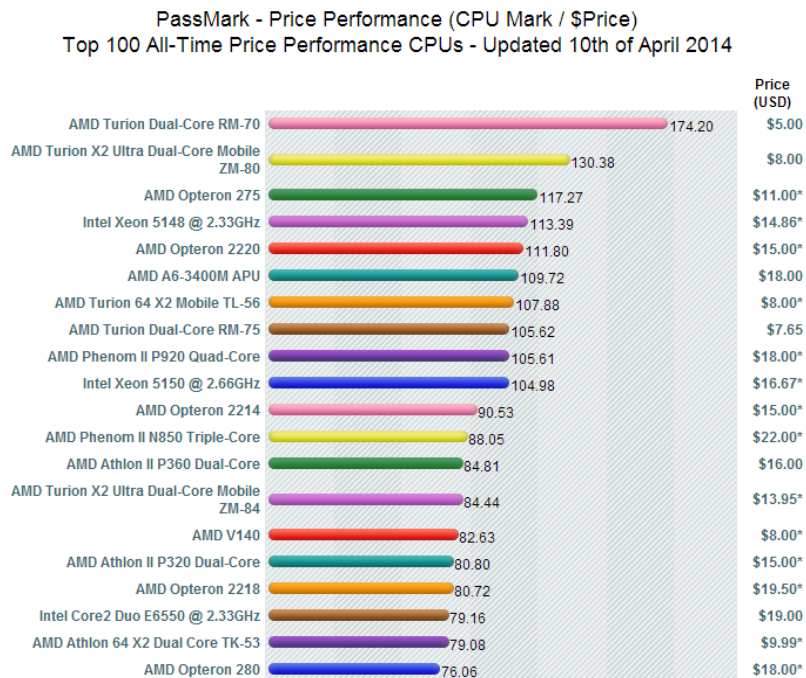
2.3 REPORT COLLABORATION

This economic portion of the report is to be taken into consideration alongside separate reports on the social and environmental aspects of the laptop TBL assessment which will be completed by other teams.

3.0 RESEARCH FINDINGS

3.1 BENCHMARKING

Benchmarking is a way of testing a computer's performance through the use of a program that is designed to test and measure its system. These can be very useful, but many exist and they are all slightly different (Jain, 1991). A CPU benchmark provides an assessment of relative performance of a specific processor in comparison to others in the market. In researching this topic two sites were found that offer free CPU benchmark results. PassMark Software has delved into the thousands of benchmark results that PerformanceTest users have posted to its web site and produced five Intel vs AMD CPU charts to help compare the relative speeds of the different processors. The other site is cpubenchmark.net which offers similar data for a more complete list of CPUs



source: http://www.cpubenchmark.net/cpu_value_alltime.html

Figure 1. PassMark - Price Performance Benchmark Screenshot

3.2 SAMPLING

According to the client's request which focuses on the Intel i3, i5, i7 and AMD equivalents for CPU components, four laptop brands were suggested by the UBC IT department and were chosen to be sampled; and ten models of each of those brands were considered as part of this project. The parameters used for sampling are decided based on prior knowledge regarding the customers' need, including CPU, memory, graphics, hard drive, GPU which are selected to evaluate the performance. Screen size and resolution, and battery duration are selected to evaluate the user experience. Thickness and weight will determine the portability. All data were retrieved from the official website of those companies. (See Appendix A)

3.3 MODELING

By the request of client, we designed two default models according to the description of each user's need: average user and power user.

The average user model optimises for daily basic use such as web browsing, document processing, and operating on software that has low to medium computing power demand. It weighs speed, portability, and cost more than computing power (CPU mark), storage capacity, and screen size. Therefore, an low end ultrabook or similar model with a cheaper price is the best choice.

For the power user model, there is a high demand on CPU performance, speed, storage capacity, and even a large screen size to increase productivity. Running large applications and programming should be smoother and less time consuming for power users. A high end laptop with a larger screen and more storage should be the best option. However, high end laptop are always much

more expensive, but the Laptop PC Index can help the user find the laptop with lowest price and a higher price to performance ratio.

4.0 METHODOLOGY

4.1 ASSUMPTIONS AND EXCLUSIONS

This project does not consider the operating system used by each computer. This variable is excluded under the assumption that Windows is the predominant operating system, especially in an office setting, and if needed an Apple machine could be set up with Boot Camp to run Windows. Also software protection is excluded under the assumption that all UBC faculty and staff will be using the Sophos Anti-Virus provided by UBC IT.

4.2 VARIABLES CONSIDERED

In this project the technical specifications of the laptop, not benchmark results, are used to measure performance. While overall benchmarking of a computer can be an effective and quick method there will always be debate over which program will result in the most complete end-user performance evaluation (Dongarra & Gentsch, 1993). Because of this and because benchmarking results are often not available to the public free of charge, this project will not use an overall benchmark. This is not a new idea, Paul Chwelos used the technical aspects of a computer to measure performance in his work on price indexes. He said that “the variables included are technical attributes and should not be subject to significant measurement error; neither do these variables require interpretation or judgement in their construction” (53). Other benefits of this approach are the availability of the information, much of the information can be obtained from the manufacturers website making this process free and easy for a wide range of users. Also by comparing the technical aspects of one laptop against the others considered this method will not become outdated as the technology improves.

The variables considered important to the user-end performance of a laptop are:

- CPU performance
- Memory size
- Hard drive capacity
- Screen size
- Weight
- Thickness
- Warranty
- Extra features of the laptop (CD drive, video output, touch screen, keyboard, Bluetooth capability, etc.)



source: http://images.macrumors.com/article/2008/02/01/062531-24-2_800.jpg

Figure 2. Components of A Laptop (Macbook Air)

4.3 EQUATION

In order to keep the equation accurate with technology that is forever changing it was decided to normalize each variable (divide each variable by the maximum present in that sample size). If a variable is directly related to performance it get added to the overall performance, variables that are

indirectly related to performance get one minus that variable added to the overall performance (Triplett, 2006). Next a series of constants were introduced to weigh the variables differently depending on how much they impacted the end-user performance. This resulted in an performance equation of:

$$\begin{aligned} \text{Performace} = & \left(\frac{\text{CPUMark}}{\text{CPU_max}} \right) * C_{\text{cpu}} + \left(\frac{\text{Memory}}{\text{Memory_max}} + \frac{\text{TransferRate}}{\text{TR_max}} \right) * C_{\text{speed}} + \left(\frac{\text{HDSpace}}{\text{HDSpace_max}} \right) * C_{\text{space}} \\ & + \left(\left(1 - \frac{\text{Weight}}{\text{Weight_max}} \right) + \left(1 - \frac{\text{Thickness}}{\text{Thick_max}} \right) + \left(1 - \frac{\text{ScreenSize}}{\text{Screen_max}} \right) \right) * C_{\text{portability}} + \left(\frac{\text{ScreenSize}}{\text{ScreenS_max}} \right) \\ & * C_{\text{screen}} + \left(\frac{\text{Warrenty}}{\text{Warr_max}} \right) * C_{\text{reliability}} + \text{EXTRAS} - \text{MissingEssentials} \end{aligned}$$

Figure 3. Equation used to measure performance of a laptop based on that laptop's technical specifications.

The CPUMark value was obtained from an open sourced site that contains benchmark ratings of the market's current cpu. This is the most effective way to measure CPU performance because benchmarks that pertain solely to the CPU are subject to less sources of variability, and the results are free to the public. Cpubenchmark.net was used in this project because it contains a wider range of CPUs. Note that the data on this site changes frequently with the introduction of new CPUs, so the data for all the laptops considered must be retrieved on the same day.

The last to elements, extras and missing essentials, are there to account for laptops that are more highly priced because of extra physical features, and laptops that are cheaper due to less physical features. The missing essentials are features of a laptop that the members of this group decided were crucial to a member of UBC faculty and staff. These features are:

- Wifi
- Keyboard
- Camera and microphone
- At least 1 USB 3.0
- Speakers
- Touchpad and or mouse button

- Some form of video output

These features could potentially change in the future years.

The extras element was introduced to deal with any features that could increase a laptop's performance. The extra features considered in this project were:

- SD card slot
- Touch screen
- Conversion to a tablet (by 360 degree hinge or by removable keyboard)
- Contains stylist
- Bluetooth capabilities
- Fingerprint reader (for security purposes)
- Optical Drive
- Extension Dock port
- Robustness (durable construction, spill proof keyboard, etc.)
- Resolution above full HD (above 1080p)

Similar to the missing essentials list the list of extras presented here is applicable to today's laptop market but is subject to change with the introduction of new technologies.

The values of the constants are as follows:

- $C_{cpu} = 6.5$
- $C_{speed} = 0.8$
- $C_{capacity} = 1.4$
- $C_{warranty} = 3.25$
- $C_{screen\ size} = 2$
- $C_{portability} = 6.3$
- EXTRAS = +1.9 ea
- Missing Essentials = -1.9 ea

This resulted in the overall graph of:

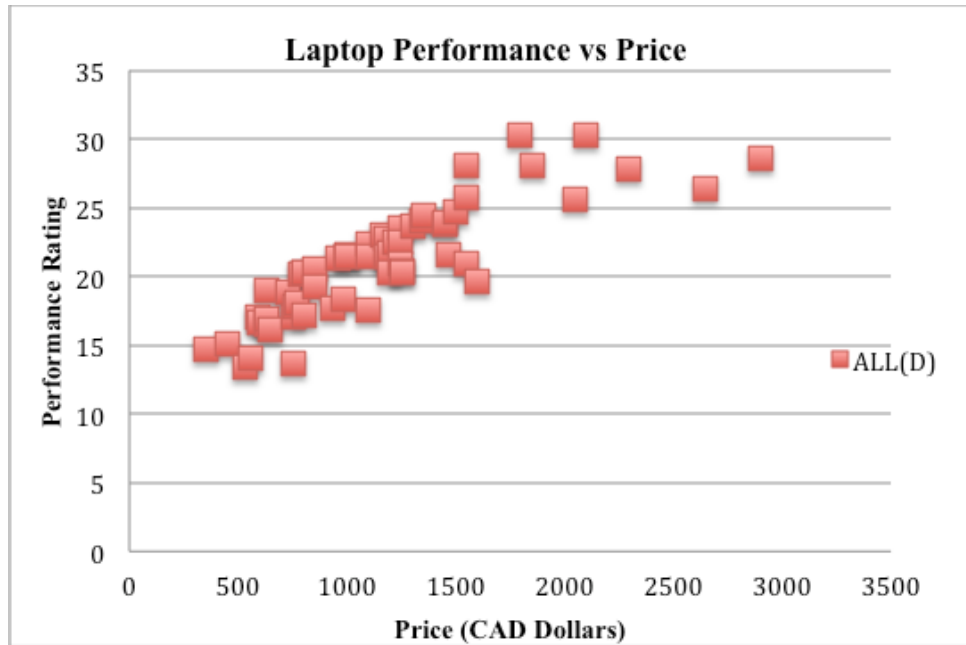


Figure 4. Performance vs. price graph of all laptops.

The constants, the weight of each variable, was set to create a graph with a linear relationship between performance and price. After much manipulation of these values the final graph has an r-squared value of 0.73, meaning it adheres closely to a direct relationship between performance and price.

4.4 INTRODUCTION OF PREFERENCE VARIABLES

In the interest of making this method applicable to a variety of users a series of preference variables were introduced into the original performance equation. These preference variables allow for different technical aspects to have different importance in respect to the overall performance. The equation with these preference variables reads:

Fit Adjusted Performance

$$\begin{aligned}
 &= \left(\frac{CPUMark}{CPU_max} \right) * C_{cpu} * D_{cpu} + \left(\frac{Memory}{Memory_max} + \frac{TransferRate}{TR_max} \right) * C_{speed} * D_{speed} + \left(\frac{HDSpace}{HDSpace_max} \right) * C_{space} \\
 &* D_{space} + \left(\left(1 - \frac{Weight}{Weight_max} \right) + \left(1 - \frac{Thickness}{Thick_max} \right) + \left(1 - \frac{ScreenSize}{Screen_max} \right) \right) * C_{portability} * D_{portability} \\
 &+ \left(\frac{ScreenSize}{ScreenS_max} \right) * C_{screen} * D_{screen} + \left(\frac{Warrenty}{Warr_max} \right) * C_{reliability} * D_{reliability} + EXTRA - MissingEsentials
 \end{aligned}$$

Figure 5. Performance equation with preference variables included.

In this report two sets of preference variables were considered, one for the average user and one for the power user. The average user UBC's faculty and staff would be using a laptop for word processing programs, emails, and presentations. For this type of user the preference variables were arranged so that the equation would favor laptops that were not overly powerful, did not have a large screen, had a long warranty, and were portable (especially important for professors). For a power user the variables were arranged so that the equation would favor powerful and fast computers, with long warranties, large screens, and that were not necessarily portable. The values set to these preference variables, out of two, were as follows:

Preference Variable (out of 2)	AVERAGE USER	POWER USER
Cpu	0.8	2.0
Speed	0.5	1.5
Capacity	1.5	0.5
Warranty	1.7	1.7
Screen Size	0.5	1.5
Portability	2.0	0.5

Figure 6. Values assigned to preference variables for the average and power users.

These variables can be changed to fit any user. When setting these variables it is important to realize that screen size and portability are indirectly related so setting both of these to the maximum value of 2 is unadvised. The findings of the social report done by another project group in the APSC 262 section T2C should also be considered when setting these variables to accurately represent UBC's faculty and staff.

With these variables the equation gives an altered graph for performance vs. price; however these graphs are not that informative as the best laptop is the one that has the highest performance with relation to price. The best way to view the results is to graph the slope of the line created when each point is joined to the origin this is a measure of how a computer's performance is rated with respect to its price.

5.0 Conclusion and Recommendations

5.1 RESULTS

This process yields the following graphs:

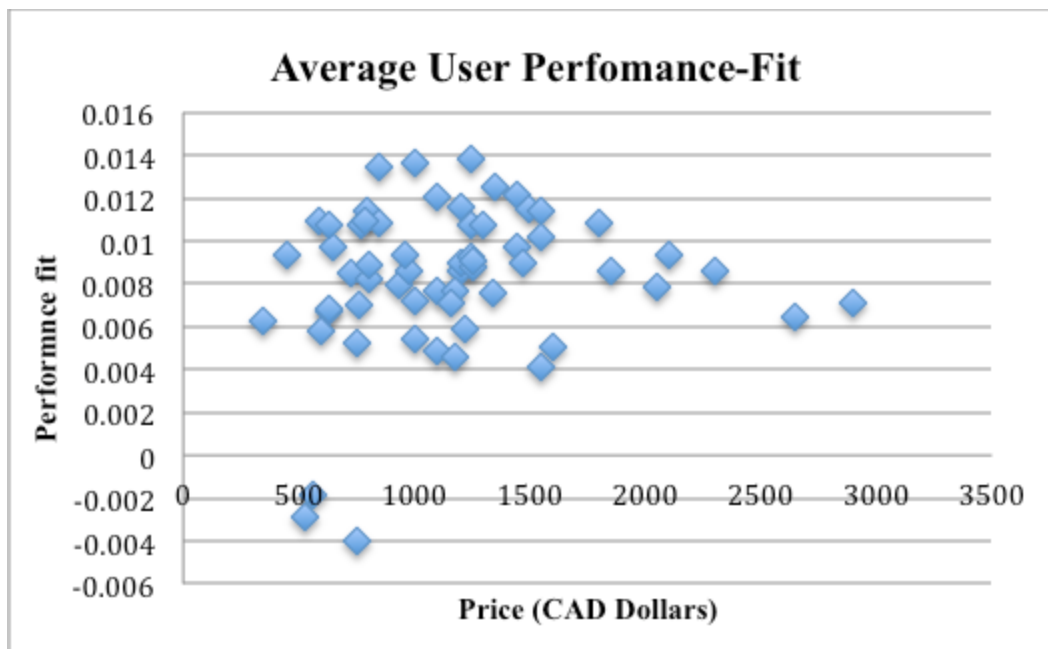


Figure 7. Graph showing the most appropriate laptops for an average user, the laptops corresponding to the highest points are shown below, in results

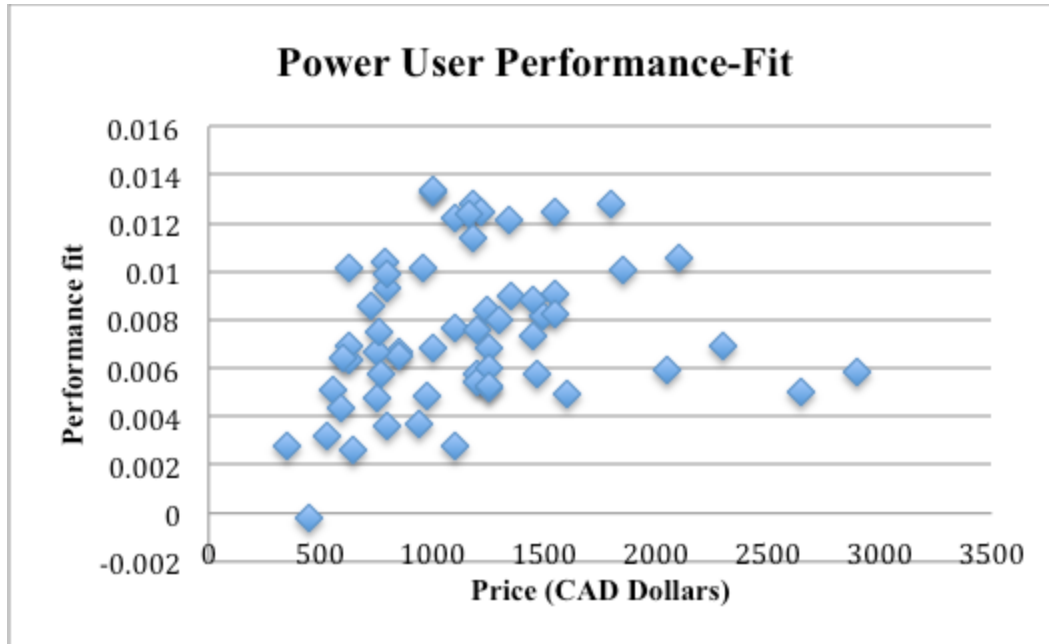


Figure 8. Graph showing the most appropriate laptops for a power user, the laptops corresponding to the highest points are shown below, in results.

The highest points on the graph related to the average user, Figure 7, are:

- MacBook Air 11" (A1465), i5, 4GB RAM, 128GB SSD (\$999 or \$1248) *
- ThinkPad Twist Ultrabook, 12.5", i3, 4GB RAM, 500GB HD (\$849)
- MacBook Air 13" (A1237), i5, 4GB RAM, 128GB SSD (\$1099 or \$1348) *

The highest points on the graph related to the power user, Figure 8, are:

- HP Envy 15-j154 ca, i7, 12GB RAM, 1TB (\$1,000 or \$1180)*
- HP Envy 17-j150 ca, i7, 8GB RAM, 1TB (\$1,000 or \$1180)*
- MacBook Pro 15" (A1398), i7, 8GB RAM, 256GB SSD (\$1549 or \$1798)*

*Higher price is with the extended warranty included (Apple = 3 years, HP = 2 years)

5.2 RECOMMENDATIONS

The Laptop PC Index is customized with users' needs and preferences in mind. Surveys conducted by the Laptop Social view team can be used to gather user preference information for better fitting recommendations. Beside the average user model and power user model, user individuals are recommended to customize Laptop PC Index to find the laptop with their personal preference instead using the default model of average and power user. It might take a longer time to gather preferences for the index to work, but it would help to get the best result and give user the best option.

When using the Laptop PC Index, conflicts occurs very often. For example, UBC Information Center staffs were interviewed for their opinions on their current working laptop and preferences. The current laptops are slow, affects staff's efficiency and mood. The staff also expressed the need for portability and larger workspace for carrying the laptop around offices and comparing documents and databases. After meeting the requirement of speed, the conflict of portability and screen size occurred since they are inverse proportional. In this case, the peripheral devices such as additional monitors, external storages, speakerphone and headset, and usb or wireless extensions such as mouse, keyboard, camera, etc. can be explored. As a result, the best solution for UBC Information Center staff is a cheaper high performance 11"-14" ultrabook that optimises speed, portability and price with the Laptop PC Index, with the addition of portable USB monitor if necessary. The USB monitor has a price range of \$100~\$300, which is not too expensive to consider. As for portability, a USB monitor such as the \$200 GeChic On-Lap 13.3in Portable Monitor can be attached and folded on the back of laptop, which does not add much to thickness and weight. The Ultrabook and USB monitor combination can be easily carried around, and resolved the conflict.



source: http://www.gechic.com/product_help_en.asp?s=3

Figure 9. GeChic On-Lap 13.3in Portable Monitor Illustrations

In the end, it is important to use the Laptop PC Index with the results of the Social and Environmental group to complete the TBL evaluation. Social and environmental concerns of a laptop should be weighted equally as economical concerns.

5.3 CONCLUSION

As the request from UBC IT department, this report evaluate on-campus laptop computer using (TBL), and will be used for future reference to improve the sustainability. As the client's request, this report focus on the economy section by compare the price and performance of recent models of Apple, HP, Lenovo and Dell. The CPU benchmarking results are chosen from PassMark Software. Several parameters were introduced to evaluate their performance, such as user experience and portability. For

the evaluation on overall performance, an equation is created. In addition, since the demand of customers varies a lot, two sets of preference variables were used in the equation for average users and power users respectively.

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