ESTIMATION OF HEDONIC PRICING MODEL FOR THE UKRAINIAN MARKET OF LAPTOPS

by

Mykola Shkolnyi

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Thesis Supervisor: Professor Maksym Obrizan

Approved by _____
Head of the KSE Defense Committee, Professor [Type surname, name]

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Date _____

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LIST OF ABBREVIATIONS

CPU Central Processing Unit

GPU Graphics Processing Unit

HDD Hard Disk Drive

IPS In Plane Switching

MPU Memory Protection Unit

OS Operating System

PC Personal Computer

RAM Random Access Memory

SSD Solid State Drive

UAH Ukrainian Hryvna

WH Watt hours

CHAPTER 1. INTRODUCTION

The market for computers has been for almost 40 years already. Without any doubt, these products reshaped the world and bring efficiency to numerous industries. The progress in computer manufacturing is overwhelming, disruptive innovation dramatically increased the speed of evolving technology and the industry is highly competitive. Nowadays there a wide variety of products derived from the computer industry: laptops, desktops, tablets, server computers, microcontrollers are the main ones. For instance, we can divide laptops into more specific product types as Chromebooks, workstations, convertible (2 in 1), ultrabooks, gaming, and many others. Though basic text editor software will run on each of those laptops, they are very different types of products design for very different purposes. Even more complicated to navigate in hardware specs as laptops are highly complicated multi-component products. In this work, I will focus only on the laptops.

The aim of this work is (i) to find the characteristics that influence the most on a laptop price, (ii) to estimate the marginal effects of those features on a laptop price, and (iii) to determine the combinations of the features that will offset the fewer CPU cores in laptops. The hypothesis of this paper is next: the brand of the laptop and processor with additional RAM going to offset fewer CPU cores

For model estimation used a data set that includes 1956 distinct laptop models. Data is web-scraped from Ukrainian e-commerce retailer "Rozetka". Web-scrapping was carried out using the programming language R. The data set contains 11 variables: laptop prices, screen refresh rate, CPU type, RAM, integrated graphics card or not, GPU size, weight, laptop brand, battery capacity, paid OS or not, storage volume.

For model estimation, I use hedonic pricing regression with log-level functional form. Haan and Diewert (2013) recommend a log-level functional form for high-tech

goods. This model shows how much the percent change in price if we change the continuous explanatory variable by one unit. If an explanatory variable is categorical then the model shows a percentage change in price when moving to another level of a categorical variable compared to the baseline.

The remainder of this paper is structured as follows. The first part of the second chapter is devoted to a laptop market overview and the second part of this chapter is a review of related studies. The third chapter is about methodology based on which I build a hedonic pricing model. Data for the model are presented in the fourth chapter. In the fifth chapter I interpret hedonic pricing models. The sixth chapter contains recommendations and conclusions.

CHAPTER 2. INDUSTRY OVERVIEW AND RELATED STUDIES

2.1 Industry Overview

While many industries all around the world suffer from the quarantine restrictions caused by pandemic COVID-19, the global PC market has the strongest growth in a decade despite the semiconductor shortage. Before the pandemic mobile phones were the focus of consumers. The necessity to work and study from the home reverses the trend and drives the demand for PC. According to the Gartner press release[1], in 2020 PC shipments reached 275 million (excluding Chromebook) units resulting in 4.8% of annual growth from 2019. The annual growth rate for some regions even more impressive, for example for the United States PC market growth rate, make up 20.6% year over year and that is the highest mark in 20 years. EMEA has shipments growth of 6.9% and Asia Pacific 8.3%. The government also contributed to the PC market growth as it has different programs for providing laptops to the pupils. For example, the British government as of 31 January delivered 927,7 thousand laptops[2].

Gartner reported[3] that in 2021 Q1 worldwide PC shipments grew by 32%. The category of Chromebooks grew by triple digits in the first quarter. At the same time, IDC reported[4], that in 2021 Q1 worldwide PC shipments grew by 55.2%. Despite the difference between the reported figures, the growth is a record for the last two decades. The category of gaming notebooks is an important driver of such growth. IDC reported[4] that the EMEA gaming PC market in 2021 Q1 grew by 50.2%, with further growth mitigation. By 2025, it

[1] Gartner – January 2021. https://www.gartner.com/en/newsroom/press-releases/2021-01-11-gartner-says-worldwide-pc-shipments-grew-10-point-7-percent-in-the-fourth-quarter-of-2020-and-4-point-8-percent-for-the-year

[2] BBC Home-school: Can you get a free laptop or cheaper broadband? – February 2021. https://www.bbc.com/news/technology-55721216

[3] Gartner – April 2021. https://www.gartner.com/en/newsroom/press-releases/2021-04-12-gartner-says-worldwide-pc-shipments-grew-32-percent-in-first-quarter-of-2021

[4] IDC - April 2021. https://www.idc.com/getdoc.jsp?containerId=prUS47601721

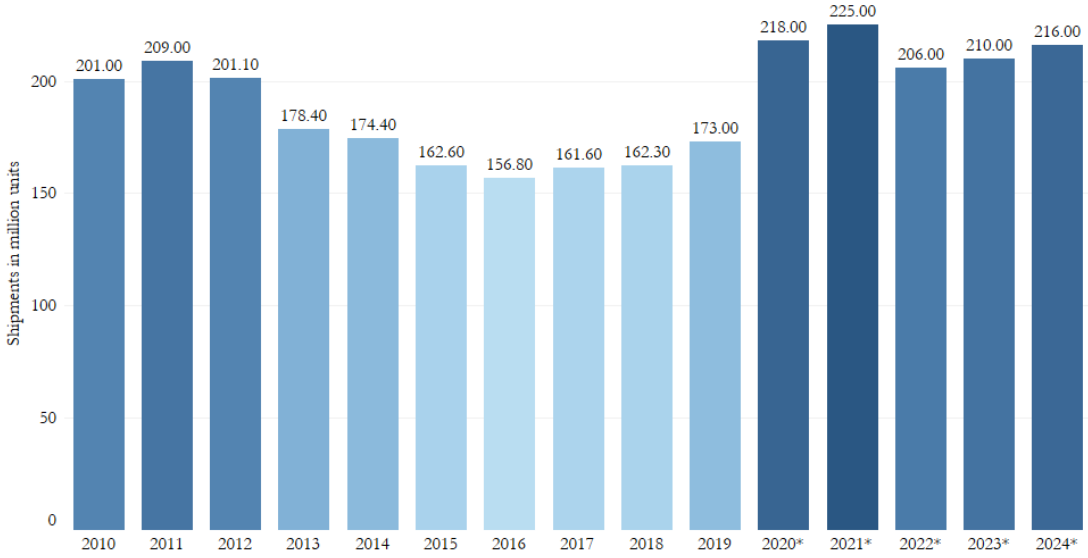
is forecasted PC gaming market to rise to 11.5 million units. Gaming notebooks are the major contributors to the positive outlook of the gaming PC category. Notebooks have 33.03% year-over-year growth, whereas desktops are 3.9% year-over-year. The main factors that lead to this market situation are pandemic restrictions (work/study from home etc.) and semiconductor shortage. Gartner says[5], global worldwide semiconductor shortage expected to persist until the 2022 Q2.

Figure 1 shows how many notebooks were shipped worldwide each year as well as forecasted shipments[6]. The maximum amount of shipments was in 2011- 209 million units. After 2011, there were five years in row decline until 2016 - 156.8 million units. From 2016 until 2019, the industry has slow continuous growth. Covid-19 pandemic has boosted the shipment from 173 million units in 2019 to 218 million units in 2020. It predicted that in 2021, the industry will reach its maximum - 225 million units and afterward there should be a decline.

[5] Gartner – May 2021. https://www.gartner.com/en/newsroom/press-releases/2021-05-12-gartner-says-global-chip-shortage-expected-to-persist-until-second-quarter-of-2022

[6] Statista: Global notebook personal computer (PC) shipments from 2010 to 2024. https://www.statista.com/statistics/269048/worldwide-portable-pc-shipment-forecast/

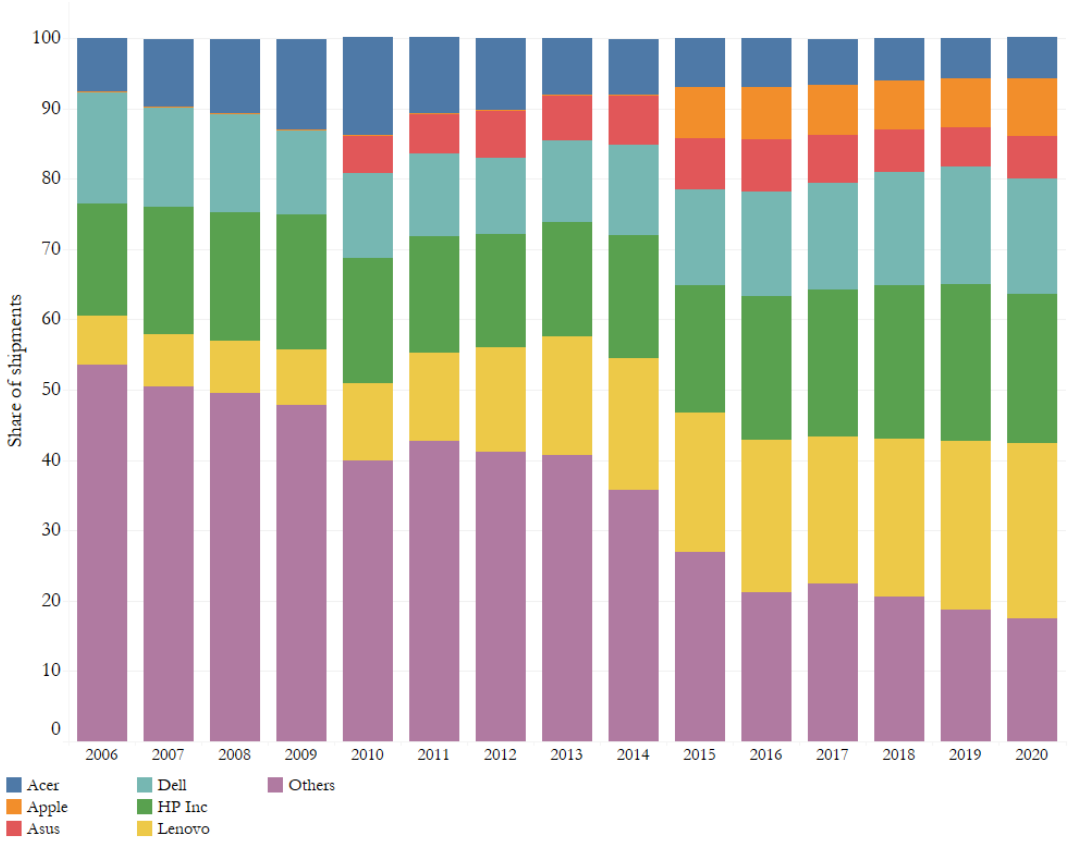
Figure 1. Global notebook shipments from 210 to 2024 (in millions units)



Source: www.statista.com

On the Figure 2, we can see the trend of last years in the personal computer vendors industry. The major market share of shipments was split by many vendors. Among them were companies such as Toshiba, NEC, Fujitsu, etc. In 2006, 53.6% of shipments were split between many vendors. Whereas HP and Dell each have got by 15.9%, Lenovo 7%, and Acer 7.6%. In further years, market share has changed. Single brand vendors gain more power. In 2020 market share of shipments for Lenovo has been 24.9%, HP 21.2%, Dell 16.4%, Apple 8.2%, Asus 6%, Acer 5.9%, other vendors brand 17.5%. Also, worth mention that two vendors Apple and Acer have become major players in the vendors' industry.

Figure 2. Market share held by the leading personal computer vendors worldwide from 2006 - 2020[7]



Source: www.statista.com

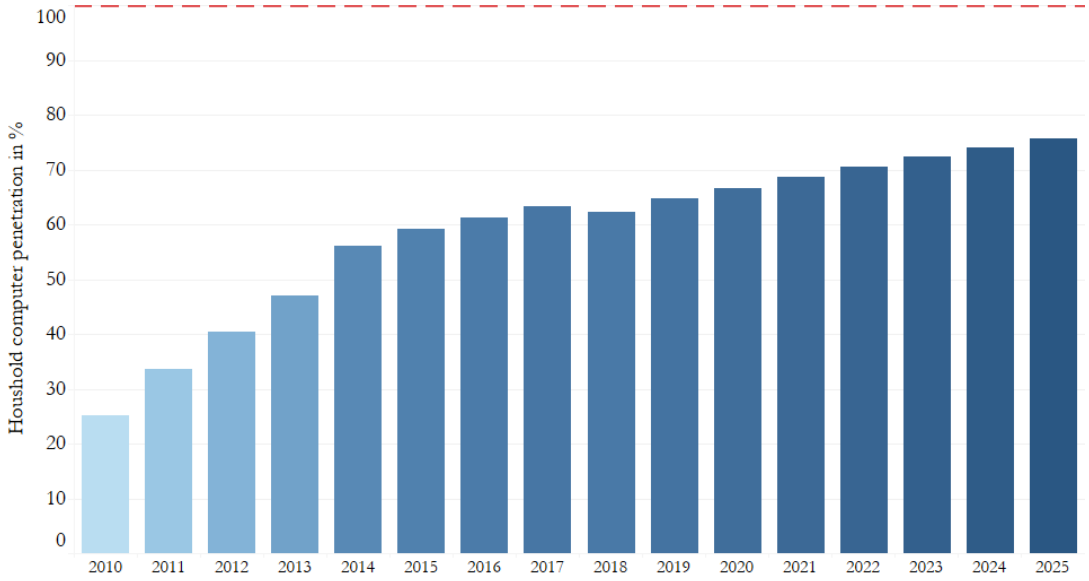
Figure 3 presented a forecast of the household computer penetration in Ukraine from 2010 to 2025. From 2010 until 2014, there was rapid growth; starting from 2015, the growth slows down. In 2018 there was an even a decline of 0.92%. In 2021, household computer penetration should compose 68.66%. In ranking of the household computer penetration in Europe by country in 2020[8], Ukraine took 38 - place among 43 countries. The first place with 100% penetration took four countries: Netherlands, Norway,

[7] Statista: Market share held by the leading personal computer vendors worldwide from 2006 to 2020. https://www.statista.com/statistics/267018/global-market-share-held-by-pc-vendors/

[8] Statista: Ranking of the household computer penetration in Europe by country 2020. https://www.statista.com/forecasts/1168953/computer-penetration-in-europe-by-country

Luxembourg, and Estonia. This parameter can point to the potential growth factor of the Ukrainian PC market and laptops in particular.

Figure 3. Forecast of the household computer penetration in Ukraine from 2010 to 2025[9]



Source: www.statista.com

Ukrainian PC market in 2020 showed an opposite trend to the global market. According to the IDC[10], (International Data Corporation) Ukrainian PC market has shrunk by 4.4% up to 973 thousand units in 2020. The shipments of the laptop make 581 thousand and desktop computers make 391 thousand. Gaming and ultra-thin laptops showed the biggest demand growth 76% and 30% in Q4. In 2021, IDC expects the Ukrainian PC market going to grow by 15.3% and there will be 1.12 million units.

Pandemic has disturbed factory operations and global shipping, these factors resulted in global supply chain glitches, U.S. - China trade tensions lead that some manufactures

[9] Statista: Forecast of the household computer penetration in Ukraine from 2010 to 2025. https://www.statista.com/forecasts/1135895/computer-penetration-forecast-in-ukraine

[10] ITC – February 2021. https://itc.ua/news/idc-ukra%d1%97nskij-rinok-pk-u-2020-roczi-skorotivsya-na-44/

started to stockpile chips and increased demand for electronic goods caused by pandemic restrictions (work/study from home) are among the main factors which created global chip shortage. This shortage has affected many industries: smartphone and laptop manufacture, automakers, home appliances manufacture and others. According to Counterpoint[11] Research, the mobile industry will grow only by 6% instead of 12%, automakers expected[12] to sell fewer cars by 4 million as a result loss of $ 110 billion in profit for other industries situation is quite similar.

Global microchip shortage has influenced the Ukrainian electronic goods market. Ukrainian retailers and large ecommerce stores admit[13] it and say that the laptop category is among the ones, which suffer the most. As consequence laptop prices are rising and the choice of laptops models and component parts are shrinking. To minimize the issues with shortage retailers are looking for offering goods alternatives and long-term supplies.

2.2 Related studies

Izquierdo and Llanos Matea (2001) conducted research for the Spanish laptop and desktop market. The data period is 1990-2000. Their models include processor speed, RAM, hard disk capacity, weight and years. The result is following annual average rate of prices decline between 1990 and 2000 is 36 % for laptops.

Chwelos (2003) estimated price indexes for laptops in the 1990s using a hedonic price model. In the study, the author trained the model on 492 observations. For

[11] The Wall Street Journal: Why the Chip Shortage Is So Hard to Overcome? https://www.wsj.com/articles/why-the-chip-shortage-is-so-hard-to-overcome-11618844905#refreshed?mod=article_inline

[12] Yahoo! Finance: 4 Critical Industries Affected by the Chip Shortage. https://finance.yahoo.com/news/4-critical-industries-affected-chip-013610213.html

[13] Retailers: How the chip shortage reflected on the Ukrainian market. What do Rozetka, Citrus and Allo think about it? https://retailers.ua/news/menedjment/12732-defitsit-gadjetov-na-ukrainskom-ryinke-chto-dumayut-ob-etom-v-rozetka-tsitrus-i-allo

continuous variables and prices were used log functional form, other was as dummy variables. The author concluded that RAM and screen size has a positive effect on the price.

Şentürk and Erdem (2010) examined which factors influence the price of laptops in Turkey. They used data obtained from e-commerce websites. Their data set includes 706 samples. Authors used the name of store, brand, processor speed, display size, graphic card capacity, RAM, SSD, Bluetooth, number of the USB port(s), availability of a web camera, and card reader. Toshiba is a base category in the brand. Their findings are next: "Asus, Dell, and MSI have lower prices, but Sony has higher prices than Toshiba". Screen size has a negative effect on the price in all models. RAM, SSD, Bluetooth have a positive effect on the price

Lee and Kim (2013) estimate willingness to pay for each laptop's feature. The authors pay attention not only to hardware characteristics but also to non-hardware. As independent variables, they use the performance of CPU and GPU, hard disk capacity, RAM, the screen size, the monitor's resolution, laptop's weight, SSD, sandy bridge CPU process, i-5 CPU, and i-7 CPU. Non-hardware independent variables are aftersales center number and a dummy variable of OS. The authors used the generalized least square method to build a model and log-log functional form. Model is trained on 320 samples. As a result, only screen size is not statistically significant. The elasticity of SSD is 0.433, for the monitor's resolution is 0.431, for Intel Core i7 is 0.325, 0.199 for Intel is Core i7. In this work, the laptop brands do not include as independent variables.

Byrne, Oliner, and Sichel (2016) studied the impact of the characteristics of PCs, laptops, and cell phones on price and the influence of actual performance measures on the price. The authors used data from January 2007 to December 2014. The data contains 55,803 models PCs, laptops, and phones. To estimate the model, they used adjacent-year regressions with log-level functional form. For PCs, the technical characteristics are the clock speed of the MPU, RAM, SSD, and thermal design power. Fixed effects are also

included the brand, its OS, GPU, etc. Results for desktop shows in the 2014 additional GB of RAM increases the price on average by 22%. If a PC is small in size, the price goes up by 13% on average.

Byrne, Dunn, and Pinto (2016) studied the price change for used computers, laptops, and tablets. Data for laptops cover the period from 2001 to 2014. As explanatory variables, they use RAM and monitor refresh rate. To explain price change over time they included age, time, and different interactions of those variables with other variables. The model shows that a doubling RAM leads to a 29.5% price increase in 2014.

Keating and Murtagh (2018) studied different quality adjustment approaches including the hedonic price model to create CPI. For this purpose, they used characteristics of laptops CPU speed, SSD, HDD, amount of embedded multimedia controller storage, RAM, GPU, stated battery life of the computer in hours, OS.

Himpens and Zafar (2019) used web scraping to build hedonic pricing model estimation for laptops. For this purpose, they collected data from 2 French online stores. Additionally, they scraped data from the websites of processor manufacturers (Intel and AMD). Data from each site were collected in two stages with a time interval of 1-2 months to also measure price changes over time. The authors' data contained 1537 observations. The authors selected 34 variables to build models. They used two methods: tree-based random forest and shrinkage method LASSO regression. According to estimations of some models, Apple-branded laptops are on average 40% more expensive than other brands. The extra GB of RAM increases the price by more than 40% on average. Keeping other variables constant, the absence of a discrete graphics card reduces the price by 10%. Processor number of cores, SSD capacity, weight, processor cache size, screen size are statistically significant. The accuracy of the models in this paper is between 78% and 87%. The random forest method is more accurate in this work.

There are also a lot of studies in other fields that use the hedonic price method. For example, Lieske et al. (2021) estimated the impact of transportation infrastructure on property prices. Wang, Sun, and Wen (2019) explored the relationship between tourism seasonality, online user ratings, and the determinants of hotel prices. Fedderke and Li (2020) analyzed South African fine art auction market in 2009–2014 using the hedonic price method.

CHAPTER 3. METHODOLOGY

3.1 Hedonic pricing model

As we know, laptops are multi-component products. They have many characteristics that customers take into account when choosing a laptop. To identify which features of laptops contribute and how they influence on price I will use the hedonic pricing method. Rosen proposed this method. According to Rosen (1974) paper, "Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them". In simple words, the total price of a product can be expressed as a sum of the price of each of its homogeneous characteristics. To estimate the influence of factors on the product's price hedonic regression is used. Thus, the price of the i-th laptop can be written as:

$$P_i = f(x_1, x_2, \dots, x_n) \quad (1)$$

where P_i is market price of a laptop; $x_1, x_2, \dots, x_n$ are of laptop characteristics.

In the data set that I use for model building there are nine variables. Not all these variables have an influence on the price. There are three main reasons to use feature selection. Firstly, it makes the model interpretable because we remove variables that are not informative. Secondly, it helps to work faster with big datasets. Thirdly, it reduces the chances of model overfitting (Fonti and Belitser 2017). So, we need to select those laptop characteristics that have an impact on the price. I will use p-value equal to 0.05.

I will estimate linear regression. According to Rosen (1974), Halvorsen and Pollakowski (1981) there is no particular functional form to be used for the hedonic regression. As suggest by Haan and Diewert (2013) "For products such as high-tech goods, the loglinear model is usually preferred, among other things because it most likely reduces

the problem of heteroskedasticity (non-constant variance of the errors) as prices tend to be log-normally distributed". In works from this field authors such as Himpens and Zafar (2019) and Byrne, Oliner, and Sichel (2016) used the log-level functional form for hedonic regression. So, I will use a log-level functional form.

$$log(P_i) = \beta_0 + \sum_j \beta_j * x_{ij} + \sum_k a_k * D_{ik} + \varepsilon_i \quad (2)$$

where P_i is market price of a laptop; β_0 is the intercept coefficient; β_j is the regression coefficient of laptop for some quantitative characteristics j; a_k is the regression coefficient of laptop for some qualitative characteristics k; ε is error term.

The hedonic pricing model potentially can have two problems. The first problem is heteroscedasticity. It means that the variance of residual is not the same for any value of explanatory variables. The reason is due to the low, middle and high price of laptops segments. It leads to regression coefficients shows incorrect estimations. To prevent this, I check heteroscedasticity using the Breusch-Pagan test and use robust standard errors.

The second problem is multicollinearity. It means there are high correlations between two or more independent variables. In this case, weight correlates with screen size, screen refresh rate, and the number of cores. This problem can cause inaccurate coefficients in the model.

I explore the relationship between laptop characteristics and prices in 4 segments. The first one is all laptops regardless of whether it is Ultrabook or gaming laptop. The second segment is Ultrabook. Ultrabook include all laptops weighing less than or equal to 1400 grams. The third segment is office laptops. Office laptops are weighing more than 1400 grams and have built-in graphics cards. The fourth segment is gaming laptops. Gaming Laptops are weighing more than 1500 grams and do not have built-in graphics cards.

Possible predictors, their descriptions and expected sign in the model are presented in Table 1.

Table 1. Possible predictors and anticipated signs with respect to laptops prices

Variable name	Description	Expected sign
Screen size	Continuous variable measures in inches	?
Screen refresh rate	Dummies for Screen refresh rate in Hz: 60, 120, 144, 300	+
Storage type	Dummies for 9 storage types	?
CPU type	Dummies for 12 CPU types	?
RAM	Dummies for RAM in GB: 4, 8, 12, 16, 32, 64, 128	+
GPU	Dummies for GPU in GB: 2, 4, 6, 8, 16	+
Integrated graphics card (Yes, No)	Dummies for graphic type: integrated (Yes), not integrated (No)	not integrated (No) +

Weight	Continuous variable measures in kg	-
Laptop's brand	Dummies for 10 popular brands from "Rozetka"	?

3.2 Validation set approach

In this work, I use a validation set approach to estimate the hedonic pricing model. The validation set approach is randomly dividing the data set into two parts: training set and validation set. The training set contains 80% of all observations and validation set contains 20%. Kuhn and Johnson (2013) write: "Ideally, the model should be evaluated on samples that were not used to build or fine-tune the model so that they provide an unbiased sense of model effectiveness". I build a model using a train set and evaluate the model on validation data set. Validation set approach I use for each of laptop market segment.

The validation set approach potentially has two problems. The first problem is test error rate and R^2 are highly variable depending on observation that include in train and validations sets. James et al. (2013) formulate the second problem "the validation set error rate may tend to overestimate the test error rate for the model fit on the entire data set."

Model evaluation helps to understand model performance. For this purpose, I use R^2 and RMSE. R^2 measures how much variability in dependent variable can be explained by the model.

$$R^2 = 1 - \frac{SS_{RES}}{SS_{TOT}} = 1 - \frac{\sum_i (y_i - \hat{y_i})^2}{\sum_i (y_i - \bar{y})^2} \quad (3)$$

where SS_{RES} is the residual sum of squared errors of regression model and SS_{TOT} is total sum of squared errors; $\widehat{y_i}$ is predicted value of y_i; $\bar{y}$ is mean value if y.

RMSE is the standard deviation of the residuals.

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(\widehat{y_i} - y_i)^2}{n}} \tag{4}$$

where $\widehat{y_i}$ is predicted value; y_i is observed value; n is the number of observations

CHAPTER 4. DATA

The data includes information about the prices of laptops and their characteristics. The data was obtained using web scraping of the largest online store in Ukraine "Rozetka". There are two types of sellers on the website: "Rozetka" and other sellers. The site contains more than 6 thousand records about laptops. The buyer can purchase a new laptop or a used one. For the purposes of this work, I use the information only about new laptops.

Web scraping was carried out using program language R. I used rvest, purr and dplyr libraries to collect information from "Rozetka". On the first step, I scraped all laptop's URLs, prices, and names. On the second step, I added to URL "characteristics/" to obtain a full list of laptops parameters.

Initially, 3989 observations were collected. 78 scraped records contained information about products from other categories and were removed. Also, I have deleted records containing missing values and outliers. I use Interquartile Range (IQR) method for outliers' detection and removing. The interquartile range is the area between the 75th and the 25th percentile of a log-price distribution. I delete all observation that lies above 75th percentile or below the 25th percentile by a factor of 1.5 times the IQR:

$$Lower\ log-price\ outlier = Q1 - 1.5 * IQR \tag{5}$$

$$Upper\ log-price\ outlier = Q3 + 1.5 * IQR \tag{6}$$

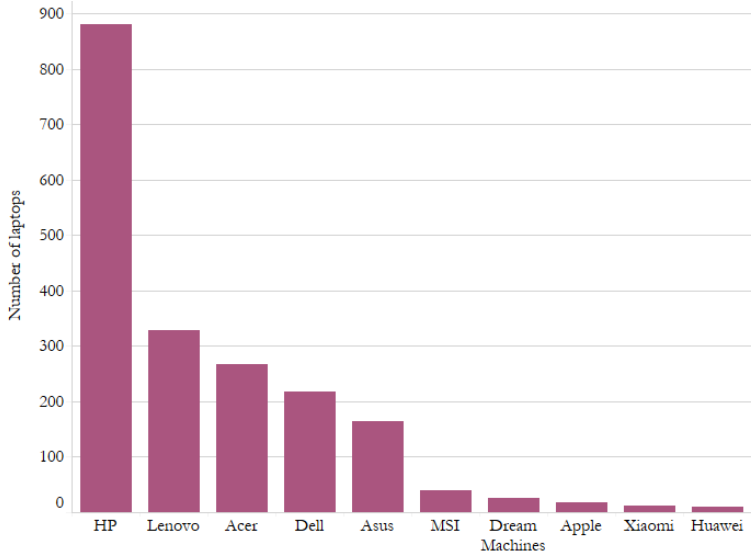
where $Q1$ is 25th percentile of a log-price distribution; $Q3$ is 75th percentile of a log-price distribution; IQR is Interquartile Range.

After that, there are left 1963 records. Data preparation was performed with RStudio specifically using packages dplyr and stringr. I removed all units of measure such as UAH from price, inches from screen size, kg from weight etc. My data set includes 11 variables:

- price (UAH)
- screen refresh rate (Hz)
- CPU types
- RAM (GB)
- integrated graphics card (Yes, No)
- GPU (GB)
- weight (kg)
- laptop brand
- battery capacity (WH)
- paid OS (Yes, No)
- storage volume

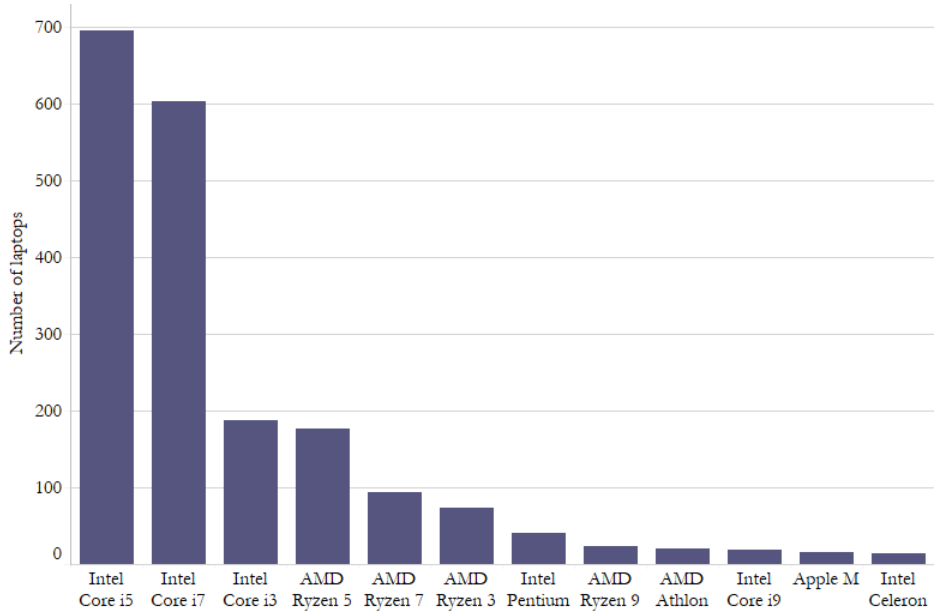
In Figure 4 we can see the distribution of laptops by brands. HP-branded laptops (880) are the most common in this dataset. On the second place is Lenovo (329), on the third place is Acer (268). MSI, Dream Machines, Apple, Xiaomi, Huawei are presented in smaller quantities. These brands represent 5% of the number of laptops in the dataset.

Figure 4. Laptop brand distribution



The most laptops have Intel branded CPU. 1578 laptops have Intel CPU, 401 laptops have AMD CPU and 15 laptops are with Apple CPU. In Figure 5 we can see laptops CPU types. The most common CPU is Intel Core i5 (695), on the second place is Core i7 (604). 187 laptops have CPU Intel Core i3 and 177 laptops have CPU AMD Ryzen 5. Laptops with powerful processors like AMD Ryzen 9 and Intel Core i9 are presented in small numbers 23 and 18 pieces respectively that could be a clear indication of the lack of notebooks with powerful processors. The dataset contains 4% of laptops with outdated processors (Intel Pentium, Intel Celeron, AMD Athlon). Since these laptops are still on sale, I included them in the hedonic pricing model training dataset.

Figure 5. CPU types

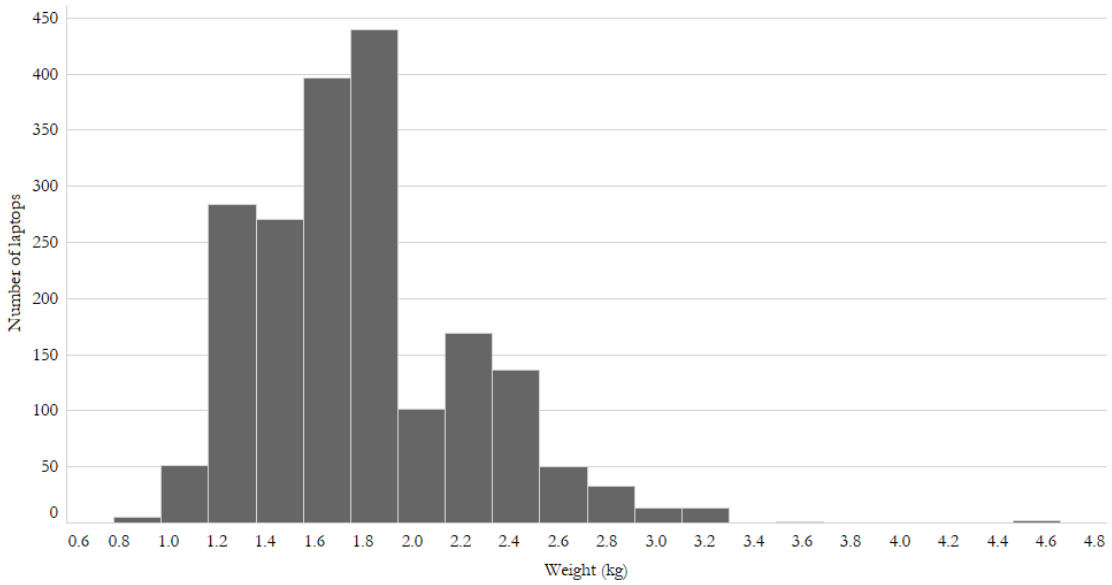


87% of all laptops (1729) have 60 Hz screen refresh rate. 150 laptops are with 144 Hz screen refresh rate. The laptops that have a screen refresh rate higher than 60 Hz usually are powerful gaming laptops. Range of battery capacity is from 30 to 100 WH. The median value of this characteristic is 50 WH. Laptops with battery capacity from 40 to 45 are the most represented (666 laptops or 34%) in the data set. There are different types of storage

such as SSD, HDD and combined. 46% of all laptops (901) have 512 GB SSD, 27% laptops have 256 GB SSD. In third place in popularity are laptops with 1 Tb SSD (16% or 319). So almost 90% of all laptops have storage from 256 GB to 1 TB SSD.

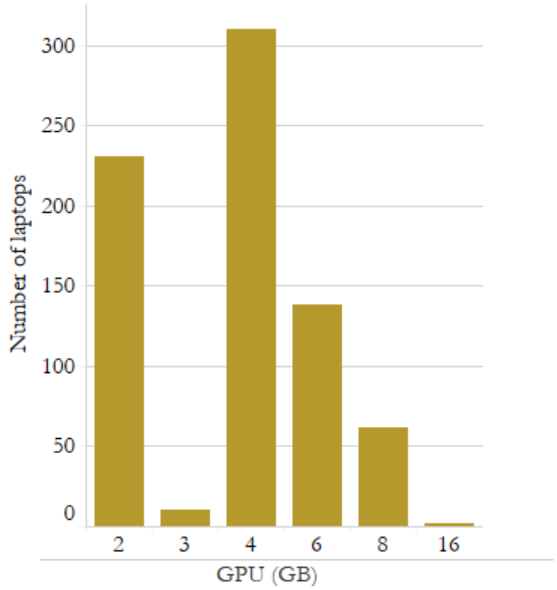
The weights of laptops distributed from 880 g to 4.5 kg (Figure 6). Median weight is 1.74kg. Between the 25th percentile and 75th percentile of laptops' weight lie laptops with weights from 1.450 kg to 1.990 kg.

Figure 6. Weight distribution for laptops



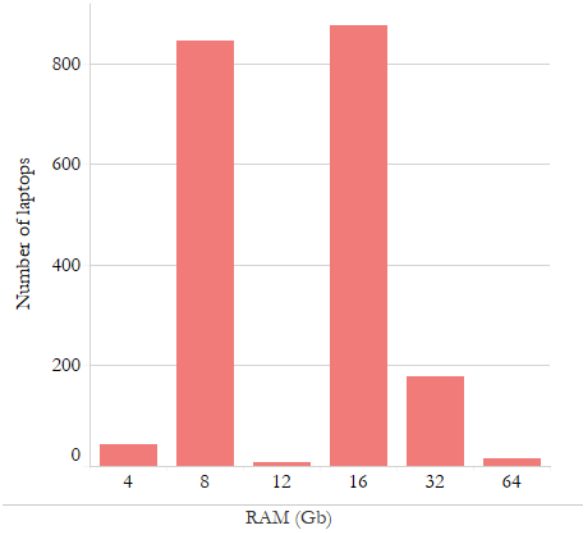
768 laptops have integrated GPU and 1189 laptops have discrete graphics. Among those laptops that have discrete graphics 4 and 2 GB GPU are most popular (Figure 7). Laptops with 6 GB and 8 GB GPU account for 18% (or 138 laptops) and 8% (62 laptops) of all laptops with GPU (753). Laptops with 16 GB GPU are rare (only 2 model).

Figure 7. GPU in laptops



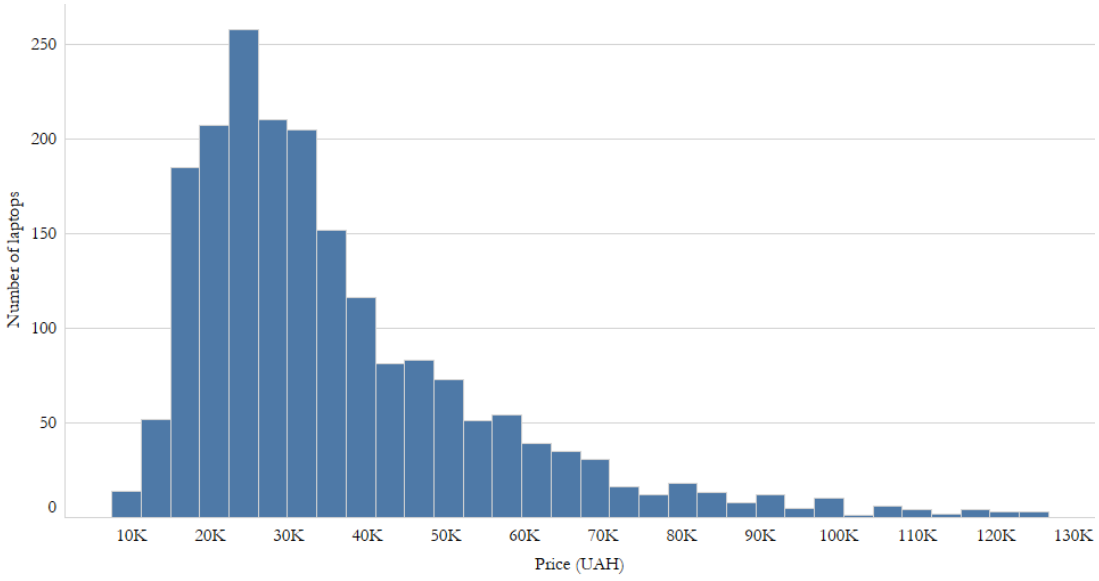
On the Figure 8 we can see the most common RAM value is 16 GB (875), on the second place is 8 GB (844). 178 laptops have 32 GB RAM. The laptops with 4, 12, 64 GB RAM are presented in smaller quantities in the data set.

Figure 8. RAM in laptops



In Figure 9 we can see price distribution for laptops. Price distribution right skewed. The biggest number of laptops in the low and middle-price segment. The median price is 30 499 UAH. Half of all laptops are in the range from 22 999 UAH to 44 378 UAH

Figure 9. Price distribution for laptops



CHAPTER 5. RESULTS

5.1. Description of categories

I built 8 models overall and decide to show 4 best models. The first model is trained on data which include all laptops. I build this model in order to see general trends in laptops regardless the category to which they belong. Results of this model gave me an understanding that I need to split my dataset into the categories to be more specific in estimation of influence of laptop parameters on price in each laptop group. Therefore, I split all laptops into three most common categories: 'Ultrabook', 'multimedia' and 'gaming'. My second model is the hedonic pricing model for 'Ultrabook'. 'Ultrabook' – is a lightweight laptop with weight up to 1.5 kg, according to the marketplaces. In the dataset, there are 438 laptops weighing less than 1500 g. The third model is used to explain how characteristics influence the prices of 'multimedia' laptops. 'Multimedia' type of laptops – is a general laptop which do not have a discrete graphics card and weigh more than 1500 g. There are 545 'multimedia' laptops. The last model describes 'gaming' laptops (there is a discrete graphics card, and the weight is more than 1500 g). Dataset contains 603 'gaming' laptops.

5.2 All laptop categories

Appendix A shows estimation results for the hedonic price model for all laptops. The first column contains information about variables influencing log-price. In the second column is estimated coefficients of variables. Also, there are standard error and p-value. Standard error is robust because of heteroscedasticity problem that was checked with Breusch–Pagan test.

The brand baseline is Acer. On average Apple branded laptops are 45.7% more expansive than Acer. Dell, HP is more expensive than Acer by 7.4% and 9.3%. Lenovo

laptops have on average the same prices as Acer. Asus, Huawei, MSI and Xiaomi are cheaper than Acer by 10.1%, 27.4%, 7.3% and 38.9% respectively.

The presence of a discrete graphics card in a laptop has a positive effect on the price. Therefore, price for laptops with discrete GPU higher by 4.8% than price of laptops with integrated GPU. The base category in CPU type is Intel Core i3. Laptops with Intel Core i3 costs by 19.5% higher than laptops with Intel Core i5, with Intel Core i7 by 33.6% and with Intel Core i9 by 49.5%. In general, all Intel Core CPU costs more than AMD CPU except of Intel Core i9 compared to AMD Ryzen 9. Base category for RAM is 8 GB. Laptops with 4 GB of RAM are cheaper by 15.3% than laptops with 8 GB of RAM. Laptops with 16 GB cost by 22% more than laptops with 8 GB RAM. Base category for storage is 512 GB SSD. Laptops with 256 GB SSD are not statistically significant different from 512 GB SSD. Laptops with 128 GB SSD have 16.1% lower prices than laptops with 512 GB SSD. Laptops with 1 TB SSD are by 8% expensive than laptops with 512 GB SSD and with 2 TB SSD costs more by 19.3% than 512 GB SSD. Base category for screen refresh is 60 Hz. Laptops with 120 Hz screen refresh rate are by 8.4% more expensive than laptops with 60 Hz and laptops with 144 Hz screen refresh rate have 11.3% higher prices. than 60 Hz. Weight negatively affects the price, that is if we increase weight by 1 kg, we expect the price to decrease on average by 6.8% keeping other variables constant. Increase in battery capacity by 10 WH leads to an increase in the price of a laptop by 10%.

5.3 'Ultrabook' category

Appendix B shows estimation results for the hedonic price model for 'Ultrabook' category (columns 2,3). In 'Ultrabook' laptops category with 8 GB RAM are not statistically significant different in price from laptops with 4 GB RAM. 'Ultrabook' with 16 GB RAM are by 25.9% more expensive than 'Ultrabook' with 8 GB RAM and 'Ultrabook' with 32 GB RAM are by 54.1% more expensive than 'Ultrabook' with 8 GB RAM. Base category for storage type is 512 GB SSD. Only 'Ultrabook' with 2 TB SSD have higher prices than 'Ultrabook' with 512 GB SSD. Laptops with discrete GPU in this category are by 5.2%

more expensive than 'Ultrabook' with integrated GPU. 'Ultrabook' with paid OS have 25.6% higher prices than 'Ultrabook' with free OS.

Apple-branded laptops are not included in 'Ultrabook' category because of perfect collinearity problem: all Apple 'Ultrabook' have CPU Apple M. Acer is a base category for brand. Dell, HP, Lenovo are more expensive than Acer by 32.1%, 20.8%, 10.4% respectively. Asus, Huawei and Xiaomi are cheaper than Acer by 10.6%, 15.9% and 27.5% respectively. Weight have statistically significant influence on price in the 'Ultrabook' category. Keeping other variables constant if we increase weight by 500g we expect a decrease in price by 32%.

CPU Intel Core i3 is a base category for CPU type. 'Ultrabook' with Intel Core i5 and Core i7 are more expensive than 'Ultrabook' with Intel Core i3 by 17.3% and 30.8%. Ultrabook with Intel Celeron are cheaper than 'Ultrabook' with Intel Core i3 by 29.4%. 'Ultrabook' with AMD CPU Ryzen 5, Ryzen 7, Ryzen 9 are more expensive by 11.7%, 18.6% and 92.4% more expensive than 'Ultrabook' with Intel Core i3. Keeping other variables constant if we increase battery capacity by 10 WH we expect an increase in price by 7%.

5.4 'Multimedia' category

Appendix B shows estimation results for the hedonic price model for 'multimedia' category (columns 4,5). In 'multimedia' category laptops with 8 GB RAM by 12.9% more expensive than laptops with 4 GB RAM. 'Multimedia' laptops with 16 GB RAM are by 18.9% more expensive than 'multimedia' laptops with 8 GB RAM and 'multimedia' laptops with 32 GB RAM are by 29.3% more expensive than 'multimedia' laptops with 8 GB RAM. Base category for storage type is 512 GB SSD. 'Multimedia' laptops with 1 TB, 2 TB SSD have higher prices than 'multimedia' laptops with 512 GB SSD by 12% and 36%. 'Multimedia' laptops with 128 and 256 are cheaper by 21.9% and 2.9%. 'Multimedia' laptops with 1 TB HDD+128 GB SSD are cheaper than laptops with 512 GB SSD by 12.4%. Laptops with

1 TB HDD+512 GB SSD have 12.9% higher prices than laptops with 512 GB SSD. 'Multimedia' laptops with paid OS have 21.1% higher prices than 'multimedia' laptops with free OS.

Apple branded laptops have 60.2% higher prices than Acer-branded laptops. Dell, HP, Lenovo are more expensive than Acer laptops by 6.6%, 11.7% and 9.4%. Asus, Huawei, Xiaomi are cheaper than Acer by 6.6%, 14.6% and 30.5%.

'Multimedia' laptops Intel Core i5 and Core i7 are more expensive than 'multimedia' with Intel Core i3 by 17.3% and 32.2%. 'Multimedia' laptops with Intel Celeron are cheaper than 'multimedia' with Intel Core i3 by 30.1%. 'Multimedia' laptops with AMD CPU Ryzen 3 are cheaper than Intel Core i3 by 11.9%. 'Multimedia' laptops with AMD CPU Ryzen 7 are more expensive by 5.5% more expensive than 'multimedia' laptops with Intel Core i3. Keeping other variables constant if we increase battery capacity by 10 WH we expect an increase in price by 11%.

5.5 'Gaming' category

Appendix B shows estimation results for the hedonic price model for 'gaming' category (columns 6,7). In 'gaming' laptops category with 16 GB RAM are more expensive than laptops with 8 GB RAM by 15.6%. 'Gaming' laptops with 32 GB and 64 GB RAM are by 39.5% and 51.6% more expensive than 'gaming' laptops with 8 GB. 'Gaming' laptops with 1 TB SSD have higher prices than 'gaming' laptops with 512 GB SSD by 7.3%. 'Gaming' laptops with 1 TB HDD+128 GB SSD are cheaper than laptops with 512 GB SSD by 11.1%. 'Gaming' laptops with paid OS have 20.6% higher prices than 'multimedia' laptops with free OS.

Apple and HP branded laptops have 31.8% and 4.6% higher prices than Acer-branded laptops. Asus, Dell, Lenovo, MSI, Xiaomi are less expensive than Acer laptops by 9.4%, 7.3%, 6.9%, 9.6% and 27.8%.

'Gaming' laptops with Intel Core i5, Core i7, Core i9 are more expensive than 'gaming' laptops with Intel Core i3 by 23.2%, 38.5%, 49.8%. 'Gaming' laptops with AMD CPU Ryzen 5, Ryzen 7 Ryzen 9 are more expensive by 12.7%, 26.6% and 50.9% more expensive than 'gaming' laptops with Intel Core i3. Keeping other variables constant if we increase battery capacity by 10 WH we expect an increase in price by 9%.

5.6 Models' evaluation

Models' evaluation is shown in the Table 2. These results I obtained on validation data sets. In Appendix C there are residual distribution for each model.

Table 2. Models' evaluation

Metric	Model all laptops	Model Ultrabook laptops	Model multimedia laptops	Model gaming laptops
R^2	0.861	0.803	0.871	0.851
RMSE	0.169	0.189	0.141	0.171

Appendix D shows scatterplots with actual and predicted log-prices for each of 4 model.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

In this work, I build four models for different laptop categories to explain which characteristics influence the price of laptop and estimate the marginal effects of those features on a laptop price. With the hedonic pricing model, I discovered the main characteristics, which influence laptop prices in 'Ultrabook', 'Multimedia', 'Gaming' categories. Such features as laptop brand, CPU, battery capacity, storage type, paid OS or not are among the main ones for all categories. Increase in RAM size leads to increase in price in all laptops categories. Apple laptops were excluded from the 'Ultrabook' category due to the perfect collinearity problem. Therefore, the most expensive brand in the 'Ultrabook' category is Dell, which are by 11.3% and by 21.6% more expensive than HP and Lenovo. The cheapest brand is Xiaomi, it has by 48.2% lower prices than HP. 'Ultrabook' with Intel Core i5 are in the same price category as 'Ultrabook' with AMD Ryzen 7. The lighter the 'Ultrabook', the higher the prices: reducing the weight by 100 grams leads to a 6.4% increase in price. Increase in the battery capacity by 10 W*h leads to a 10% increase in price of 'Ultrabook'.

All laptop in 'Multimedia' category with Intel CPU have higher prices than laptops with AMD CPU except for outdated models with Intel Pentium and Celeron. Among 'Multimedia' laptops Apple are the most expensive. They have 53.6% and 50.6% higher prices than Dell and Lenovo. 'Multimedia' laptops with one TB SSD are by 12% more expensive than the same laptops with 512 GB SSD.

In 'Gaming' category laptops with AMD Ryzen 9 and Intel Core i9 are the most expensive. They have 24.3% and 22.3% higher prices than laptops with AMD Ryzen 7. Laptops with Intel Core i5 and i7 have higher prices than AMD Ryzen 3, 5 and 7. Apple and HP do not have statistically significant difference in price. Xiaomi is the cheapest brand in 'Gaming' category. 'Gaming' laptops with 16 GB GPU have by 30.2% higher prices than laptops with 2 GB GPU. 'Gaming' laptops with 1 TB SSD are 7.3% more expensive than laptops with 512 GB SSD.

As mentioned above the situation on a market is unique, shortage from the vendor's side, high demand from consumers and AMD CPU outperformance of Intel CPU. I suggest considering two situations based on real market products from the seller point of view.

As real market products, I will use the next laptop models: Dell Latitude 7300 and Asus Vivobook Pro, both laptops are in the same market segment but with significant price differences (Appendix E Figure 6).

The main difference in hardware characteristics is CPU - different brand, class, number of cores and performance. Based on PassMark software we got the next results (Appendix E Figure 7).

Scenario 1 - shortage of powerful CPU in laptops: From the hedonic pricing model for 'Ultrabook', we know that consumers value Intel Core i5 CPU in the same way as AMD Ryzen 7, even though Core i5 has less power and Dell is a more preferable brand than Asus. On 'Rozetka' website, there are only 9 laptop models with Ryzen 7. Therefore, if the seller doesn't have laptops with Ryzen 7 in stock he still can satisfy the demand from consumers by offering laptops with Core i5, on 'Rozetka' website there are more than 150 laptop models with Core i5. Even though almost by all hardware specs, Dell is underperformed or has the same except for a weight 1.25 kg compared to Asus 1.4 kg and it cost more 43 299 UAH than Asus – 33 999 UAH, Dell stay preferable for many consumers. In such way on real example, we can see that laptop and CPU brand offset fewer CPU cores in laptops.

Scenario 2 - undervalued hardware: Asus superior to Dell in next specs: CPU performance and the number of cores (21633 PassMark and 8 cores compared to Dell 6403 PassMark and 4 cores), screen (14" (2880x1800), 90 HZ refresh rate and OLED matrix compare to Dell 13,3" (1920x1080), 60 HZ and IPS matrix), sound system and

battery capacity 63 WH compared to Dell 60 WH, it has the same volume of RAM and SSD storage, it loose only in weight though the difference is minor. With objectively superior hardware in laptops, the seller has an opportunity to increase margin from selling such laptops.

Therefore, the real market data is perfectly affirm findings from our hedonic pricing model. Mentioned scenarios helps sellers be flexible and stay profitable, as in any case consumer should be satisfied. In case of shortage of powerful laptops in "Ultrabook" categories offering the correct brand of laptop and CPU should offset it. Due to the complexity of laptop's component parts consumers are slow in switching from one CPU architecture (Intel) to another (AMD) therefore current AMD CPU and GPU generation are undervalued, this creates opportunity for both consumers and sellers.

The laptops from 'Gaming' category suffer the most from the shortage. For example, there is no single newly released laptop from Dell Gaming - series, HP - Omen, Lenovo - Legion and many other brands with gaming models. Most gaming laptops on the market were produced a few years ago or used hardware from previous years production.

Main characteristics, which influence laptop prices in the 'Gaming' category: volume of GPU, Laptop brand, CPU, RAM, battery capacity, SSD volume.

Even though, in "Gaming" category present some newly released laptops from Asus and Acer but the absence laptops from major players in this segment leaves consumers without choice. Alternatives could be the laptops from 'Multimedia' and 'Ultrabook' categories, which has approximate hardware specs. Sellers may offer laptops from "multimedia" category similar to those mentioned in Appendix F and widen the choice of consumers in "Gaming" laptop category. Such an alternative is not without a trade-off, because even though laptops from those categories often have approximate or similar characteristics they built for different purposes.

The main characteristics in the 'Multimedia' category that influence laptop prices are RAM size, weight, battery capacity, brand, storage type, CPU type and OS.

The "Multimedia" category is least affected by CPU shortage and it has the widest range of laptops. Due to the ordinary and moderate components, performance (CPU, RAM, battery capacity) laptops from all brands are presented. Represented models mostly compose out of newly produced components. Due to the vast choice of laptops in this category as well as performance characteristics and price it even may substitute laptops from other categories as it often has very similar characteristics.

In this work, I obtained the following results:

- I revealed marginal effects and the characteristics that influence the most price of a laptop in four main categories: 'Ultrabook', 'Multimedia' and 'Gaming'. These characteristics are the most significant for all categories - laptop brand, CPU, battery capacity, storage type, paid OS, or not. Additional important feature for 'Ultrabook' category is presence of discrete GPU. In the 'Gaming' category volume of GPU affects the price;

- the analysis confirmed the hypothesis that the brand of the laptop and processor with additional RAM going to offset fewer CPU cores;

- in the 'Ultrabook' category expensive laptop brand and CPU brand can offset fewer CPU cores. Market data example from 'Rozetka' shows that fewer Intel CPU cores with more expensive laptop brand offset bigger number of AMD CPU cores;

- 'Multimedia' laptops suffer the least from the shortage, as they do not need high-performance components. This market segment is the largest;

- the ‘Gaming’ segment is harmed the most because this category needs powerful CPU and GPU. Due to the shortage, we do not see major players in this category on the ‘Rozetka’ website and elsewhere. Those laptops that are present often were released in the previous years. Therefore, I suggested alternatives from others laptop categories.

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APPENDIX A

Table 3. Hedonic pricing model for all laptops

	Coefficient	Std. Error	p-value
Intercept	9.532	0.047	0.000
Refresh rate 120	0.084	0.028	0.011
Refresh rate 144	0.113	0.021	0.000
Refresh rate 240	0.153	0.065	0.095
Refresh rate 300	0	0.063	0.993
RAM size 4	-0.153	0.038	0.001
RAM size 16	0.22	0.013	0.000
RAM size 32	0.463	0.023	0.000
RAM size 64	0.535	0.048	0.000
Weight	-0.068	0.017	0.000
Battery capacity	0.01	0.001	0.000
Brand Apple	0.457	0.119	0.001
Brand Asus	-0.101	0.018	0.000
Brand Dell	0.074	0.02	0.000
Brand Dream Machines	0.014	0.033	0.743
Brand HP	0.093	0.014	0.000
Brand Huawei	-0.274	0.032	0.000
Brand Lenovo	0.027	0.02	0.136
Brand MSI	-0.073	0.032	0.072
Brand Xiaomi	-0.389	0.045	0.000
GPU integrated Yes	-0.048	0.014	0.000
Storage type 1 TB HDD	-0.086	0.033	0.053
Storage type 1 TB HDD 128 GB SSD	-0.124	0.037	0.010
Storage type 1 TB HDD 256 GB SSD	0.033	0.025	0.235
Storage type 1 TB HDD 512 GB SSD	-0.007	0.032	0.865
Storage type 1 TB SSD	0.08	0.017	0.000

Table 3 (continued)

Storage type 128 GB SSD	-0.161	0.046	0.003
Storage type 2 TB SSD	0.193	0.048	0.000
Storage type 256 GB SSD	-0.008	0.012	0.519
CPU type AMD Athlon	-0.224	0.04	0.000
CPU type AMD Ryzen 3	-0.085	0.021	0.002
CPU type AMD Ryzen 5	0.027	0.018	0.242
CPU type AMD Ryzen 7	0.156	0.025	0.000
CPU type AMD Ryzen 9	0.571	0.067	0.000
CPU type Apple M	0.276	0.127	0.056
CPU type Intel Celeron	-0.253	0.042	0.000
CPU type Intel Core i5	0.195	0.015	0.000
CPU type Intel Core i7	0.336	0.019	0.000
CPU type Intel Core i9	0.495	0.05	0.000
CPU type Intel Pentium	-0.122	0.031	0.003
OS paid yes	0.247	0.012	0.000
Observations	1525		
R^2	0.868		
Adjusted R^2	0.864		

APPENDIX B

Table 4. Hedonic pricing model for (1) 'Ultrabook', (2) 'Multimedia', (3) 'Gaming'

Variable	Coefficient (Ultrabook)	Std. Error (U)	Coefficient (Multimedia)	Std. Error (O)	Coefficient (Gaming)	Std. Error (G)
Intercept	10.311***	0.164	9.193***	0.086	9.592***	0.061
RAM size 4 GB	-0.023	0.042	-0.129**	0.033	-0.188	0.043
RAM size 12 GB	-	-	-	-	-0.12	0.049
RAM size 16 GB	0.259***	0.025	0.189***	0.018	0.156***	0.018
RAM size 32 GB	0.541***	0.039	0.293***	0.05	0.395***	0.033
RAM size 64 GB	0.616***	0.079	0.347***	0.099	0.516***	0.065
Weight	-0.64***	0.094	0.07*	0.032	-0.061***	0.022
Battery capacity	0.007***	0.001	0.011***	0.001	0.009***	0.001
Brand Apple	-	-	0.602***	0.064	0.318.	0.057
Brand Asus	-0.106*	0.047	-0.066*	0.023	-0.094**	0.023
Brand Dell	0.321***	0.046	0.066*	0.022	-0.073*	0.034
Brand Dream Machines	-	-	-	-	-0.034	0.04
Brand HP	0.208***	0.032	0.117***	0.018	0.046*	0.022
Brand Huawei	-0.159	0.046	-0.146*	0.043	-	-
Brand Lenovo	0.104**	0.046	0.094***	0.024	-0.069**	0.029
Brand MSI	0.049	0.049	-0.044	0.024	-0.096**	0.038
Brand Xiaomi	-0.275**	0.068	-0.305**	0.184	-0.278***	0.049
GPU integrated Yes	-0.052.	0.037	-	-	-	-
Storage type 1 TB SSD	0.027	0.031	0.12***	0.033	0.073***	0.02
Storage type 128 GB SSD	-0.121	0.039	-0.219***	0.057	-	-
Storage type 2 TB SSD	0.142*	0.07	0.36***	0.104	0.014	0.057
Storage type 256 GB SSD	0.024	0.026	-0.029.	0.014	-0.035	0.023
Storage type 1 TB HDD	-	-	-0.113**	0.026	-0.134	0.085

Table 4 (continued)

Storage type 1 TB HDD 128 GB SSD	-	-	-0.124*	0.06	-0.111*	0.048
Storage type 1 TB HDD 256 GB SSD	-	-	-0.024	0.057	0.006	0.02
Storage type 1 TB HDD 512 GB SSD	-	-	0.129**	0.027	-0.007	0.031
CPU type AMD Ryzen 3	-0.051	0.038	-0.119***	0.026	-0.065	0.034
CPU type AMD Ryzen 5	0.066	0.043	-0.031	0.021	0.127*	0.042
CPU type AMD Ryzen 7	0.135*	0.06	0.055.	0.029	0.266***	0.041
CPU type AMD Ryzen 9	0.873***	0.085	-	-	0.509***	0.067
CPU type Intel Celeron	-0.294.	0.089	-0.301***	0.038	-	-
CPU type Intel Core i5	0.173***	0.031	0.173***	0.017	0.232***	0.037
CPU type Intel Core i7	0.308***	0.039	0.322***	0.024	0.385***	0.04
CPU type Intel Core i9	-	-	-	-	0.498***	0.06
CPU type Intel Pentium	-0.2*	0.04	-0.115**	0.022	-0.055	0.04
CPU type AMD Athlon	-	-	-0.256***	0.032	-0.178	0.084
OS paid yes	0.256***	0.021	0.211***	0.015	0.206***	0.021
GPU size 3 GB	-	-	-	-	-0.047	0.079
GPU size4 GB	-	-	-	-	0.097***	0.023
GPU size6 GB	-	-	-	-	0.163***	0.029
GPU size8 GB	-	-	-	-	0.302***	0.046
GPU size16 GB	-	-	-	-	0.385***	0.078
Observations	439		545		603	
R^2	0.831		0.895		0.883	
Adjusted R^2	0.820		0.889		0.875	

Note: .p<0.1; *p<0.05; **p<0.01; ***p<0.000

APPENDIX C

Figure 10. Residuals' visualization: model for all laptops

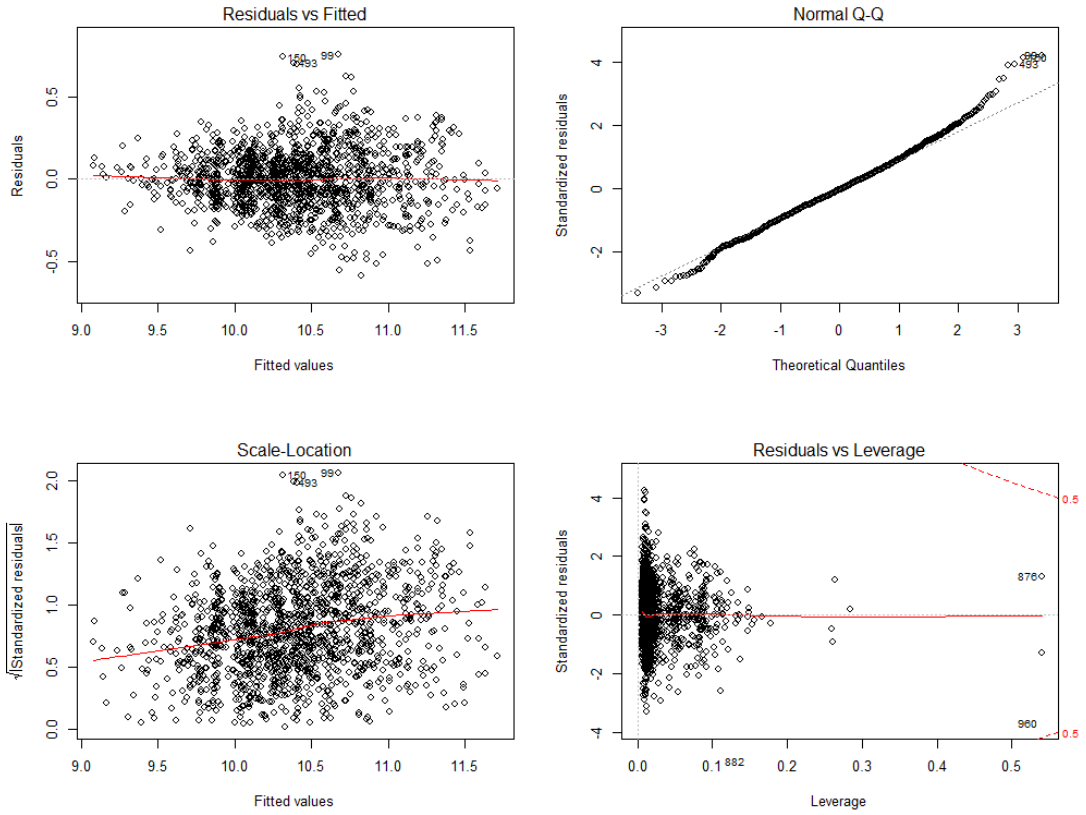


Figure 11. Residuals' visualization: model for 'Ultrabook' category

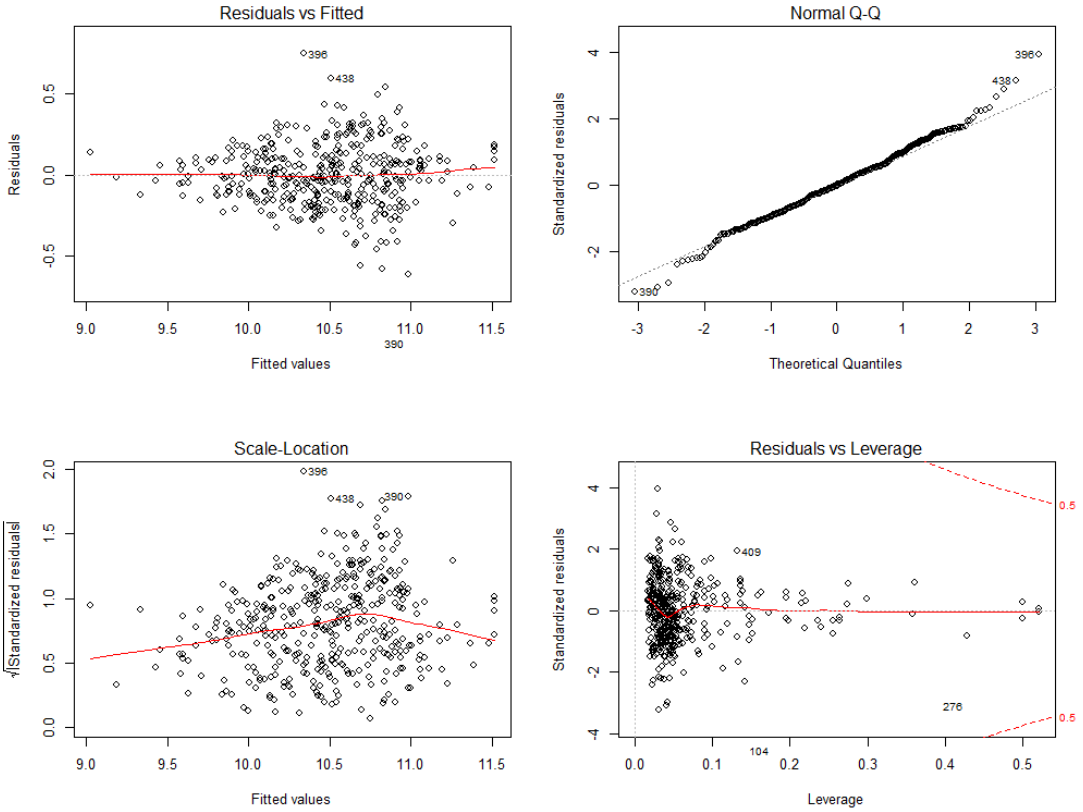


Figure 12. Residuals' visualization: model for 'multimedia' category

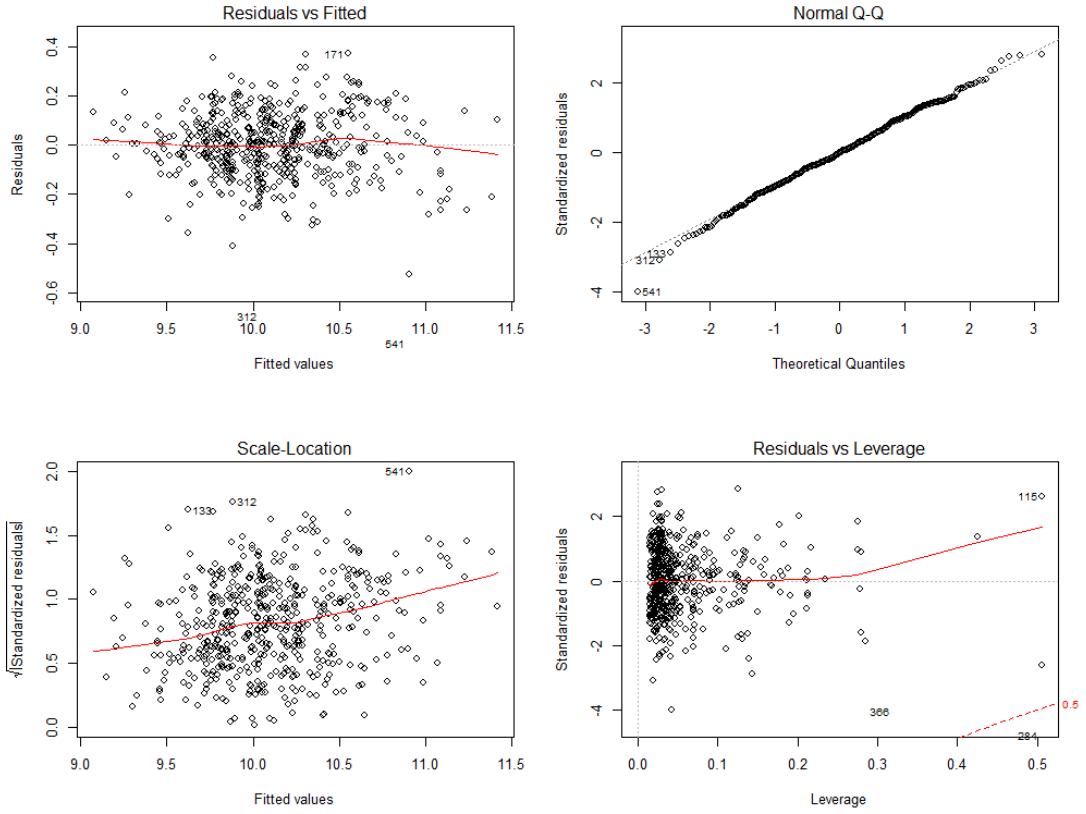
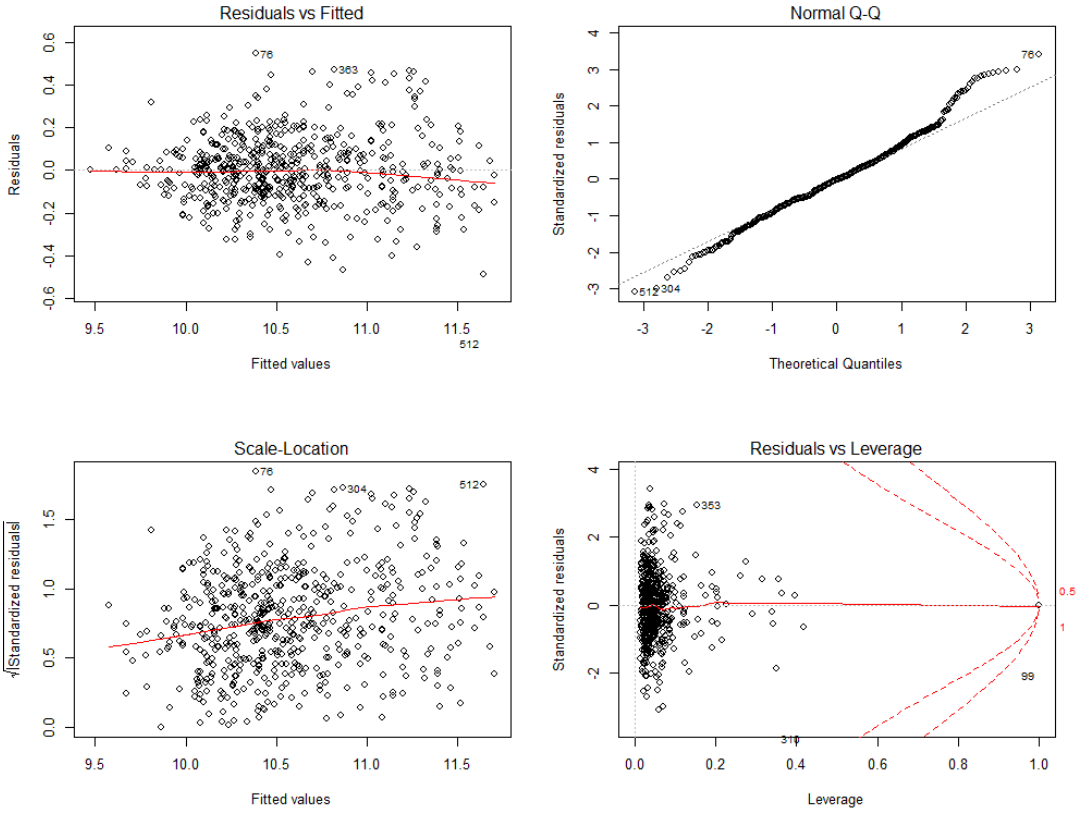
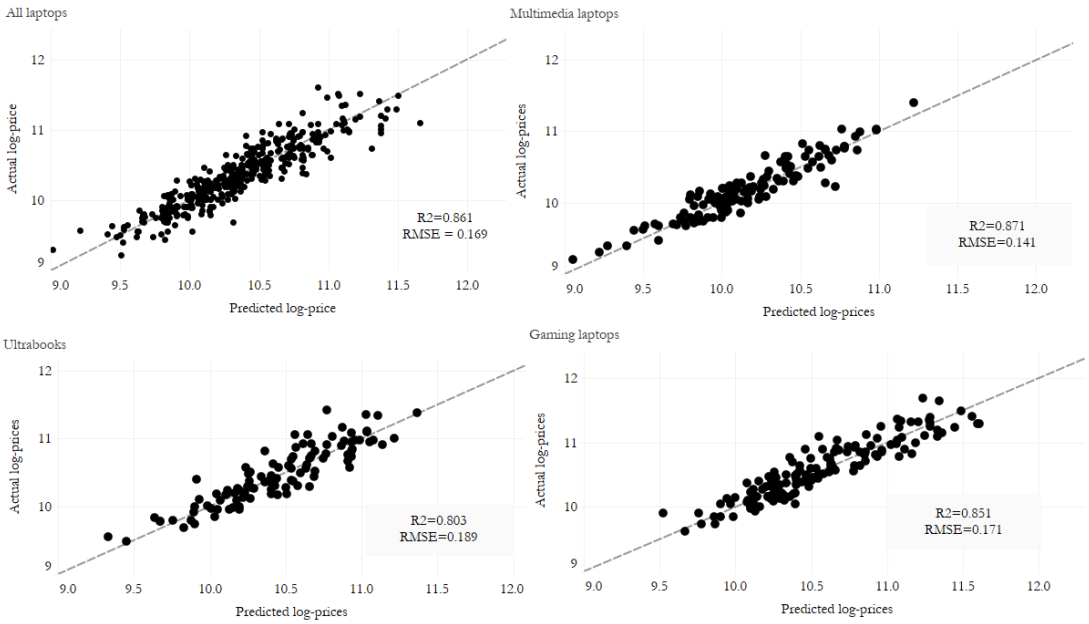


Figure 13. Residuals' visualization: model for 'gaming' category



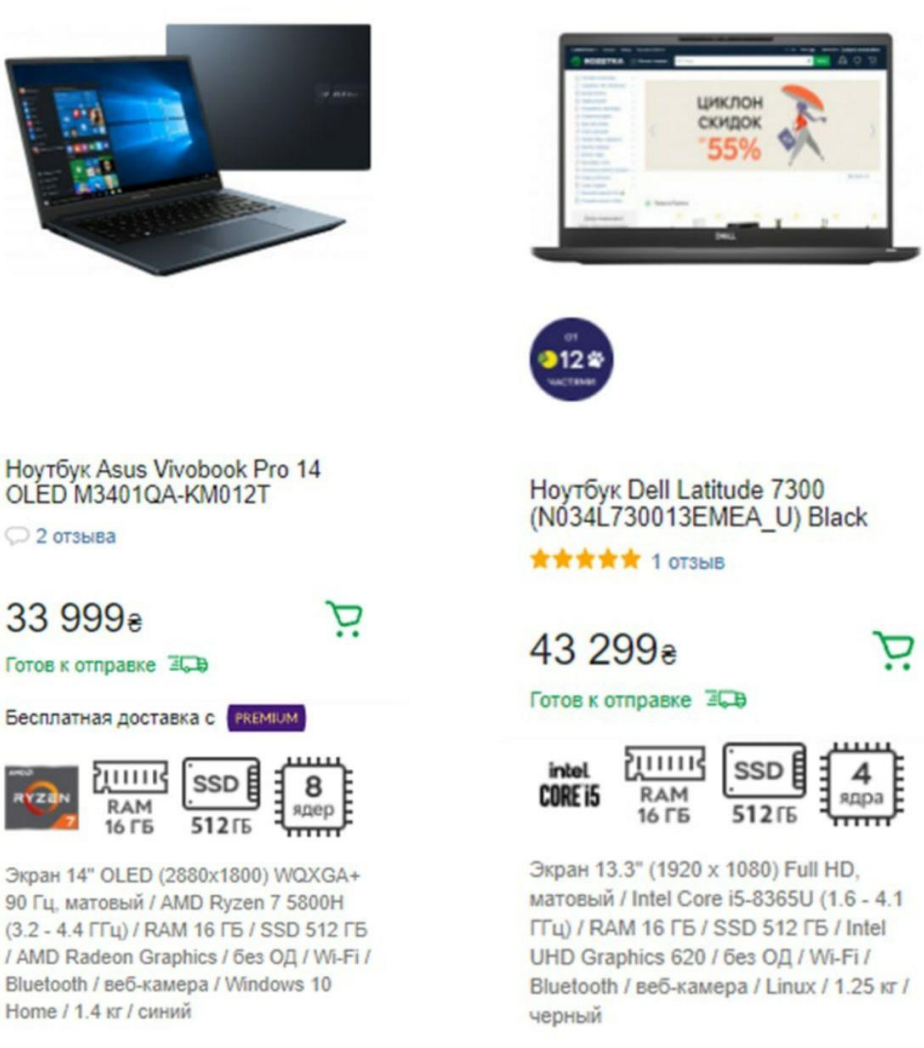
APPENDIX D

Figure 14. Actual and predicted prices for (1) all laptops, (2) 'Ultrabook' category, (3) 'multimedia' category, (4) 'gaming' category



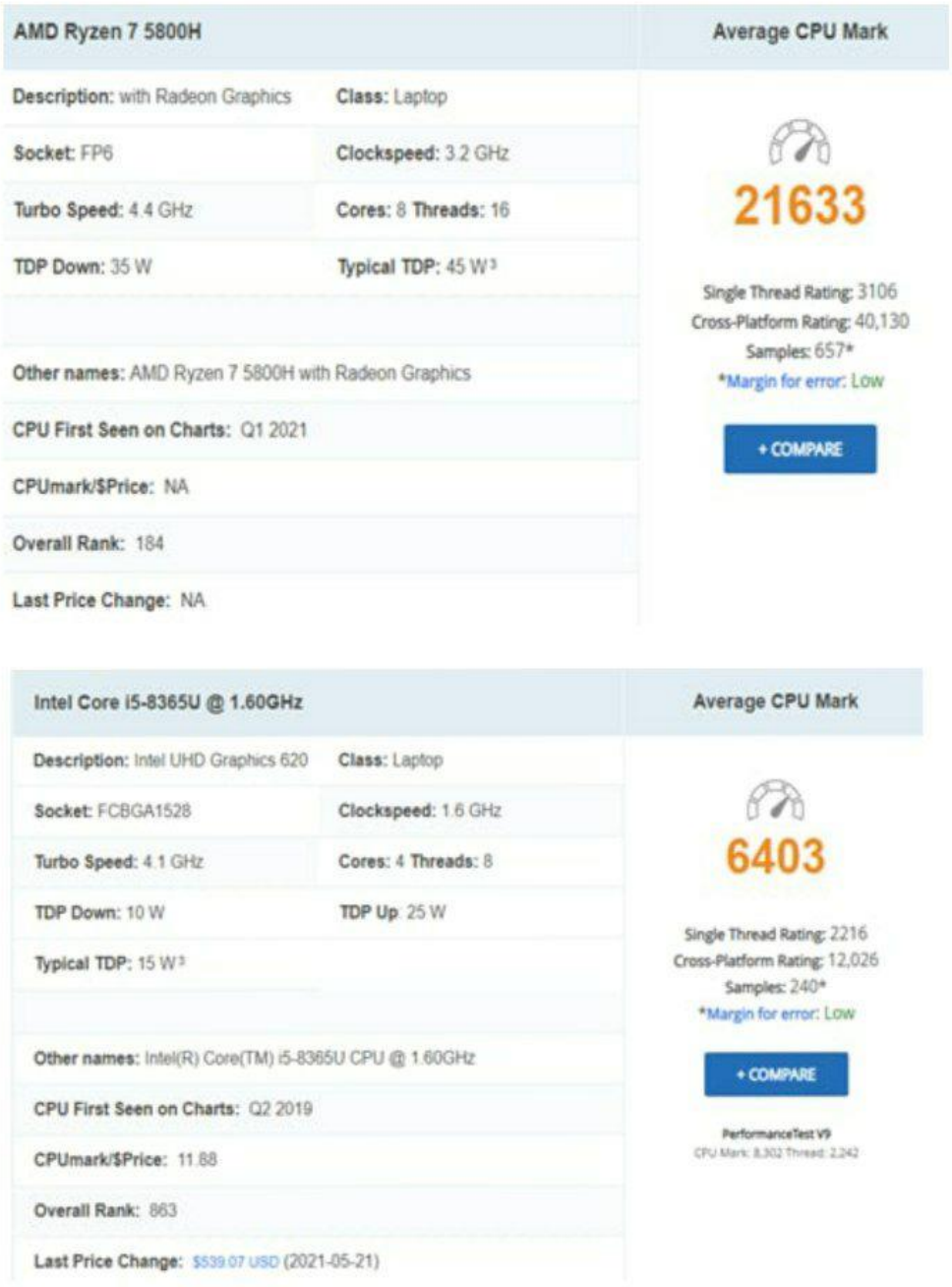
APPENDIX E

Figure 15. Asus Vivobook Pro and Dell Latitude 7300 from "Rozetka"



Source: rozetka.com.ua

Figure 16. Comparison of CPU AMD Ryzen 7 5800H and Intel Core i5-8365U



Source: passmark.com

Table 5. Laptops' characteristics

Characteristics	Asus Vivobook Pro	Dell Latitude 7300
Seller	Rozetka	Rozetka
Screen size	14" (2880x1800)	13.3" (1920x1080) Full HD
Screen type	OLED	-
Screen refresh rate	60 Hz	90 Hz
Built-in camera	720 p	-
CPU	8 Cores AMD Ryzen 7 5800H	4 Cores Intel Core i5-8365U
OS	Windows 10 Home	Linux
Intel generation	-	8th Whiskey Lake
Language choice	English, Russian, Ukrainian	-
RAM	16 GB	16 GB
Number of slots for RAM	-	2
RAM type	DDR4	DDR4
Storage volume	512 GB SSD	512 GB SSD
GPU	Integrated	Integrated
Color	Blue	Black
Weight	1.4 kg	1.25 kg
Sound system	Harman/Kardon	-
Battery capacity	63 WH	60 WH

Source: rozetka.com.ua

APPENDIX F

Figure 17. MSI Prestige 15 and Asus Vivobook Pro 15 from "Rozetka"

Ноутбук MSI Prestige 15 (A11SC-009XUA) Carbon Grey

3 отзыва

42 999₴

Заканчивается

Экран 15.6" IPS (1920x1080) Full HD, глянцевый с антибликовым покрытием / Intel Core i7-1185G7 (3.0 - 4.8 ГГц) / RAM 16 ГБ / SSD 1 ТБ / nVidia GeForce GTX 1650 Max-Q, 4 ГБ / без ОД / Wi-Fi / Bluetooth / веб-камера / DOS / 1.69 кг / темно-серый

Ноутбук Asus Vivobook Pro 15 OLED K3500PH-L1083T

Оставить отзыв

42 999₴

Есть в наличии

Экран 15.6" OLED (1920x1080) Full HD, глянцевый / Intel Core i7-11370H (3.3 - 4.8 ГГц) / RAM 16 ГБ / SSD 1 ТБ / nVidia GeForce GTX 1650 Max-Q, 4 ГБ / без ОД / Wi-Fi / Bluetooth / веб-камера / Windows 10 Home / 1.65 кг / синий

Source: rozetka.com.ua