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# **Quality Adjustment of Goods Price Index Using Hedonic Regression Model**

(Personal Computers Case)

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## Introduction

One of major problems in calculation of price indexes is ignoring the quality changes in goods whose price is collected over time. In general, the quality changes in the household's consumer basket occur in such goods as personal computers, audiovisual equipment, automobiles, etc. These continuous changes create errors in calculation of price index of each group of such goods. Thus, separation of the net effects for price index can be effective in accurate estimation and adjustment of the level of prices. In this research effects of the quality change of personal computers on their price index have been studied with the application of Hedonic Regression Model.

### *1- Quality changes concept*

Identification of quality changes in goods may seem to be difficult, though subjective it is in most cases. The change measured in the consumer price index is the change in the "real" price or the change in "the sum received from the customer" in which the consumer goods quality is not considered. The real price change does not correspond with the quality change. If the quality improvement is not adjusted, it will result in overstating the real price change, and if there is deficiency in quality and it is not adjusted it will result in understating the price change rate.

Changes in a physical characteristic like the size of a good, the change in safety that might be compulsory (strengthening car's windshield), as well as changes irrelevant to the customer's choice known as "compulsory" price changes are all regarded as the quality changes.

In addition to goods, the quality change may occur to services too. Generally, it is simpler to define the quality changes in goods than in services. The quality of services depends on many factors and on the particular purposes when rendering them.

### *2-Methods for goods quality control*

In order to overcome problems caused by the quality changes it is necessary to retain the quality of goods to the extent possible so that the subjective adjustment of the index be reduced. That is to say, the price of the same goods in each season can possibly be collected. In order to provide the consumer price index for overcoming quality control problems, different criteria such as identification of the goods, selection of the goods and the determination of quality changes are to be considered.

### *3-Quality control methods*

There are several methods for adjustment in the price indexes some of which are introduced as follows:

- Direct Comparison Method
- Unit Price Comparison Method
- Overlap Method
- Hedonic Regression Method
- Production Cost Method
- Imputation Method

In methods other than hedonic regression method, the data collector's and retailer's knowledge are subjective.

#### **4- Overview of data**

The method used in this research to collect price of desktop personal computers is described as follows:

- a. The establishments have deliberately been selected without any sampling. Rather, considering the studies carried out about the wholesalers' market share, the efforts were made to visit establishments willing to cooperate and having the most data with them during the reference time.
- b. The practical sale prices collected from the wholesalers (Data Processing Company and Isiran Institute) and also from retailers in Tehran market have been employed. Also, discounts on the practical sale prices have been taken into account. Therefore, the price quality adjustment is net from effects of discounts, etc.
- c. Considering the fact that data collected from newspapers usually have some theoretical and practical problems for use in hedonic regression model, these prices have been employed only as witness without incorporating them into the regression model. In addition, the integration of the newspapers data with those of the aforementioned sources is theoretically problematic.

#### **5- Data collection sources on the desktop computers**

Data on prices collected for personal computers relate to the period from 1999 to 2002. These data have been collected from the two sources, wholesalers and retailers.

#### **6- Regressions**

In this part, hedonic price index of personal computers has been calculated for the 1999-2002 period. In order to measure quality changes of goods and services, there are different recommended methods of which the hedonic classic linear regression model is one of the most prevalent. In this study, the fundamental model variables, price, the characteristics of each type of goods, different brands in the market, and residuals are presented as:

$$\ln P_i = \alpha + \sum_{j=1}^n \beta_j \ln X_{ij} + \sum_{k=1}^k \delta_k d_{ik} + u_i$$

where  $P_i$  is price of the goods,  $\alpha$  is constant variable,  $X_{ij}$  indicates  $j^{th}$  characteristics of goods in the  $i^{th}$  period,  $d_{ik}$  is dummy variable, and  $u_i$  residuals.

To apply the hedonic indexes, it is first necessary to select the basic functional form. To suit this purpose, such various tests of functional forms as linear, semi-logarithm and log-log forms have been administered using the residuals. Studying and testing of residuals will determine the functional form of the model (particularly for cross-sectional data) in addition to indicating the existence or non-existence of heteroscedasticity of variances and autocorrelation. Reviewing the functional form of the regression model with the use of regression specification error testing in different time periods made it clear that log-log form seems to be significantly inappropriate. The linear form will, to a great extent, understate forecasts. On the other hand, in testing the linear form versus linear-log form,

the latter is regarded to be more appropriate. Accordingly, the following model has been employed for estimation:

$$(2) \quad LPT_i = \alpha_0 + \alpha_1 LCPU_i + \alpha_2 LRAM_i + \alpha_3 LHD_i + \alpha_4 D_i + U_i$$

in which LPT stands for logarithm of price, LCPU for the logarithm of the CPU speed, LRAM for logarithm of main memory, LHD for logarithm of hard disk, and D for dummy variables. Therefore, all regressions will embrace the three main characteristics of computers, CPU, RAM, and HD and the characteristic of the processor is also included in the regressions as a dummy variable. Pentium II is regarded as a measure for the years 1999 and 2000, Pentium III for 2001 and Pentium IV for 2002. Other characteristics of the computer such as CD-ROM and Fax-Modem, etc. are included in regressions as dummy variables. Model (2) has been estimated using the Ordinary Least Squares Method. The table below introduces the coefficients of the main characteristics applied in hedonic regression models during 1999-2002. As it is seen, all coefficients are significant at one percent level. Sign of all variables' coefficients (excluding the coefficient of the secondary memory variable or hard disk in 2000 and 2001) has been positive during the years under study indicating increase in total price of computers as a result of increase in either of the aforementioned characteristics.

*Coefficients of main characteristics and their standard errors in hedonic regressions*

<i>Variable</i>	<i>1999</i>	<i>2000</i>	<i>2001</i>	<i>2002</i>
<i>Intercept</i>	12.16 (0.19)	12.89 (0.56)	12.21 (0.27)	12.34 (0.45)
<i>Speed (MHz)</i>	0.29 (0.04)	0.53 (0.11)	0.56 (0.06)	0.24 (0.05)
<i>Main memory (MB)</i>	0.4 (0.01)	0.18 (0.07)	0.06 (0.04)	0.29 (0.04)
<i>Hard disk (GB)</i>	0.23 (0.03)	-0.46 (0.08)	-0.19 (0.03)	0.05 (0.09)

Source: Computer outputs

Since the variables have been inserted into the regression model in a logarithm form, the coefficients are indicative of proportional elasticity or sensitivity of the dependent variable to the changes in either of the independent variables. Accordingly, the presented coefficients display rate of price sensitivity to the changes in each of the main computer characteristics. The results reveal that the speed variable has left the highest effect on the price of computers purchased since 2000.

As it is evident some of  $R^2$  (goodness of fit) are smaller than normal level. The reason is that in many studies carried out for calculation of hedonic price index of personal computers the unobserved characteristics are not included.

Regression of squared residuals over the square fitted values has been employed to identify heteroscedasticity. Also, The weighted least squares method has been applied to remove heteroscedasticity of variances in the above-mentioned models. It is necessary to note that the distribution of the residuals follows the normal distribution.

## **Conclusion**

The application of the modern technologies in manufacture of goods particularly electronic goods has brought about considerable changes in quality of such products in recent decades. This study attempts to identify and measure the changes occurred in prices of goods due to changes in their quality in a specific duration.

The data collected on the personal computers in this study cover the 1999-2002 duration, and have been extracted from the wholesalers and retailers' invoices.

By calculating the hedonic price index of the desktop personal computers it is observed that the index has had a decreasing trend so that it has declined continuously from 100 in 1999 to 68 in 2002. In addition, the downward trend of the index has also been diminishing, namely it has declined from 17 percent in 2000 to 9 percent in 2002.