Appendix 1 Calculation of the price indices for PCs and cameras by hedonic approach

The hedonic approach is one of the methods to adjust quality. This approach is used to identify the qualitative aspect causing price differences between products quantitatively by analyzing the relationship between characteristics (e.g. HDD memory capacity, built-in memory capacity and use of bundled software in case of PCs) and the price of a product using a statistical technique called the multiple linear regression analysis on the assumption that the quality of a product can be broken down to a multiple number of characteristics (performance) that collectively compose the product, and the performance determines the price.

A method to directly evaluate the quality-adjusted price movement through the hedonic approach is used in the CPI for three items having a very short product cycle due to rapid upgrading of quality. These are “Personal computers (desktop),” “Personal computers (notebook)” and “Cameras.” A significantly large amount of data on the price, quantity and characteristics of a large number of products is required to make the multiple linear regression analysis highly objective and reliable. Scanner data on sales prices, sales volume and characteristics of all models from the POS information[43] are used in the hedonic approach when applied to analyze these items.

The indices of “Notebook PCs” and “Tablet terminals” are calculated and formulated to apply to “Personal computers (notebook).” Similarly, the indices of “Compact digital cameras,” “Single-lens reflex digital cameras” and “Mirror less interchangeable lens cameras” are calculated, and formulated to apply to “Cameras.”

1 Calculation of link indices using the hedonic approach

(1) For each of personal computers (desktop), notebook PCs, tablet terminals, compact digital cameras, single-lens reflex digital cameras and mirror less interchangeable lens cameras, a semi-log regression model is formulated with the average sales price of each model as the explained variable, and memory capacity, display size, and optical zoom ratio and other characteristics, and sales period of each model as the explanatory variable[44].

Multiple linear regression formula for two consecutive months (t - 1, *t*)

$$\ln p_T = \alpha_t + \beta_t \delta_{T,t} + \sum_k \gamma_{t,k} x_k$$

p_T : Sales Price T: Month = t - 1, t k: Characteristics used as explanatory variables

α_t , β_t , $\gamma_{t,k}$: Partial regression coefficient x_k : Variables representing characteristic

$\delta_{T,t}$: Dummy variables for sales period $\begin{cases} 0 \text{ when } T = t-1 \\ 1 \text{ when } T = t \end{cases}$

[43] Monthly average sales price for each model. The averages of sales prices for each model for one week in the middle of a month are used for the preliminary figures for the Ku-area of Tokyo.

[44] The explanatory variable is revised in time within a year. The details of the regression model such as the explanatory variable are explained in the Annual Report on Consumer Price Index published every spring.

(2) All models sold[45]current month (t) and the previous month (t-1) are subject to regression calculation using the regression model in (1) with the total sales volume of each sold model as the weight to determine the monthly price estimation formula.

(Previous month) $\ln \hat{p}_{t-1} = \hat{\alpha}_t + \sum_k \hat{\gamma}_{t,k} x_k$

(Current month) $\ln \hat{p}_t = \hat{\alpha}_t + \hat{\beta}_t + \sum_k \hat{\gamma}_{t,k} x_k$

(" ^ " (hat) means estimated value.)

(3)The link index referred to the previous month is calculated with the above price estimation formula in (2).

$$I_{t,l}^{(L)} = \frac{\hat{p}_t}{\hat{p}_{t-1}} = \frac{\exp\left(\hat{\alpha}_t + \hat{\beta}_t + \sum_k \hat{\gamma}_{t,k} x_k\right)}{\exp\left(\hat{\alpha}_t + \sum_k \hat{\gamma}_{t,k} x_k\right)} = \exp\left(\hat{\beta}_t\right)$$

l : Personal computers (desktop), notebook PCs, tablet terminals, compact digital cameras, single-lens reflex digital cameras and mirror less interchangeable lens cameras

2 Formulation of indices

(1) The weighted average of the link index for each item calculated in 1 (3) (notebook PCs and tablet terminals for "Personal computers (notebook)," and "Compact digital cameras," "Singles-lens reflex digital cameras" and "Mirror less interchangeable lens cameras" for "Cameras") is calculated on based on the ratio of sales amount (W). The ratio of sales amount is revised in a suitable frequency (τ) within a year.

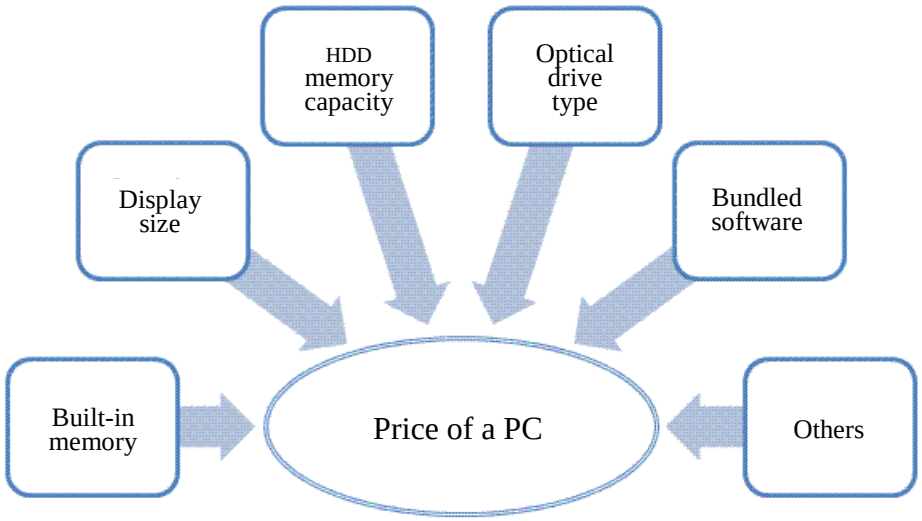
$$I_t^{(L)} = \frac{\sum_l I_{t,l}^{(L)} W_{\tau,l}}{\sum_l W_{\tau,l}}$$

(2) The link index calculated in (1) is multiplied by the index of the previous month (t - 1) (2015 = 100) to find the chain index of current month (t).

$$I_t^{(C)} = I_{t-1}^{(C)} \times I_t^{(L)}$$

[45] The models sold until the previous month, and the models sold from current month are included.

<Example of quality adjustment using hedonic approach (personal computers)>



1) Correlations between characteristics and price are analyzed using a large amount of PC sales data.

2) For example, a relation of “1 TB increase of HDD memory capacity makes a 5.0% rise of the price of PC” can be estimated.

3) When a new PC having 1 TB larger HDD memory capacity is marketed, comparison is made by reducing the price of the PC by 5.0 percent.