ECONOMETRIC CONSUMPTION DEMAND ANALYSIS – MULTIPLE LINEAR REGRESSIONS

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Abstract
Econometric consumption demand analysis comprises a sphere of applied econometrics that expresses the maximum connectivity between the economic theory (consumption demand theory) on one side, and mathematics and statistics on the other, which yields in rather significant results for applied econometrics, through the use of respective methods and models.
The two-dimensional regression method is based on the Alfred Marshall and Ernest Engel models respectively, and represents the basis of the statistics-econometric models used for empirical analyses of consumption demand. In addition to the linear regression, the multiple linear regressions play a significant role in the econometrical analysis of consumption demand, respectively on the determination of the demand for concrete products and assumption of the trends of such demand for the upcoming years.
Consumption demand analyses may be expressed through linear and non-linear functions. Below, we have strived to transform the non-linear functions into linear functions, by utilizing adequate transformation methods, mostly logarithmic. The utilization of linear functions facilitates the calculation of the model's parameters, assumptions and economic interpretation of the consumption demand. If the use of these three very significant demand analysis elements was correct, this means that we have accomplished the three basic scientific purposes of econometrics: a) determination of the adequate demand model, b) calculation of demand model parameters, c) assumption of the consumption demand for concrete products.
Keywords: Multiple Linear Regression, Consumption Demand Analysis, Product Price, Consumer Income, Demand Elasticity Coefficient, Partial Derivatives.

1. The determination of consumption demand based on the Sluck – Hicks – Allen (S.H.A.) theoretical Model

According to the Sluck – Hicks – Allen (S.H.A.) theoretical model, the demand for concrete product (let's say Q) depends from the consumer incomes, **(m)**, from the observed concrete product price **(p_1)**, and from all other consumption product prices, ($p_1, p_2, \ldots, p_n$), this means that we can now write it as:

$$q_1 = (m, p_1, p_2, \ldots, p_n$$

The basic issue in empirical analysis of consumption demand based on the S.H.A. model is the selection of regression function form **(f)**, which in the observed period of time, expresses in the best possible way the dependence of the demand for concrete product from the consumer income, from that product price, and also from the other product prices.
In this case it is desirable that the selected parameters of the form of regression model to have a concrete statistic – economic meaning, so that their evaluation to be done very easy then, and their gained quality to be known.
For this reason, in the empirical analysis of demand created on the S.H.A. model where the regression model is most frequently used as in the following form:

$$q_1' = \alpha_1 + \beta_{10}m + \beta_{11}p_1 + \beta_{12}p_2 + \cdots + \beta_{1n}p_n$$

$$q_1' = \alpha_1 m^{\beta_{10}} p_1^{\beta_{11}} p_2^{\beta_{12}} \ldots p_n^{\beta_{1n}}$$

2. The interpretation of linear and power model parameters

The economic- statistic interpretation of the parameters of a linear function (1), the power function (2), respectively of the linear-logarithmic demand model (2) is very simple. E.g. parameter β_{12} in the model (1) presents the first partial derivative of the variable q_1 for p_2 that it means

$$\beta_{12} = \frac{\partial q_1}{\partial p_2}$$

It shows for how many units on average the demand for concrete product will change, where the product price Q_2, increases for a unit, whereas all other product prices, and the consumer incomes to be remained unchanged
Parameter β_{12} in the second regression equation (2), presents demand elasticity coefficient Q_1 regarding the price Q_2

$$\beta_{12} = \frac{p_2}{q_1}\frac{\partial q_1}{\partial p_2} = e_{12}$$

And it shows for how many percentages (%) the observed product demand Q_1 will change if the product price Q_2 increases for 1 %. The consumer incomes and all other product prices remain in the same level (so unchangeable).

3. The parameters evaluation in multiple linear regressions of demand

We evaluate the basic community parameters, $\alpha_1, \beta_{10}, \ldots, \beta_{1n}$ based on the occasional sample, by T observations, respectively based on the statistic- time series, offering us the data on movement – conduct of the demand, incomes and prices for the period of T years. Hereupon, based on the samples of T observations where we gain the evaluations $a_1, b_{10}, \ldots, b_{1n}$, of unknown parameters $\alpha_1, \beta_{10}, \ldots, \beta_{1n}$, so that we can write the evaluation of the linear regression model (2) in this form.

$$q_1' = a_1 + b_{10}m + b_{11}p_1 + b_{12}p_2 + \cdots + b_{1n}p_n$$

The parameters evaluation in multiple linear regressions of demand (2) is based on the same assumption we have mentioned also to the parameters evaluation of the two-dimensional regression Model:

1. We determine, calculate the evaluations based on the sample of T observations $(q_{jt}; m_t, q_{jt}, ..., p_{nt}), t = 1, 2, ..., T$, where we assume, that the independent variable $m, p_j, p_2, ..., p_n$ are not occasional variables.
2. the values of dependent variable (respectively the volume of demand for product Q_1) in the year t is equal to the sum of systematic component $\alpha_j + \beta_{10} m + \cdots + \beta_{nj} p_n$ and occasional component (ε),this is

$$q_{1t} = \alpha_1 + \beta_{10} m_t + \beta_{11} p_{1t} + \cdots + \beta_{1n} p_{rt} + \varepsilon_t \quad t = (1, 2, ..., T)$$

……… (4)

3. occasional variables $(\varepsilon_1, ..., \varepsilon_T)$ are independent between them, and are normally distributed, arithmetic averages of these variables are equal to zero, whereas variances finally and equal between them.
4. Variables $m, p_1, ..., p_n$, are independent between them Hereupon in this case, we are not going in the techniques and the methods of the parameters determination (the method of least squares), their standard errors, hypothesis testing and prediction based on the multiple linear regressions, but there are many similarities and common techniques and methods of this demand model with the two-dimensional regression model.

4. The transformation from the non-linear regression model to the linear model

We notice that if we make the logarithmic transformation in the equation (2), we will gain the linear function form

$$q'_1 = \alpha_1 + \beta_{10} m + \beta_{11} p_1 + \beta_{12} p_2 + \cdots + \beta_{1n} p_n$$

(2') / log

$$\log q'_1 = \log \alpha_1 + \beta_{10} \log m + \beta_{11} \log p_1 + \beta_{12} \log p_2 + \cdots + \beta_{1n} \log p_n$$

(2 `)

so that we estimate the parameters of this model completely in the same manner as the model parameters (1).

For the sake of great advantages that the model (1), (2) have, respectively model (2), are used very often in the empirical analysis of demand.

First, in the model (2) the demand elasticity regarding the consumer incomes and the individual product prices are constant in all income and price levels, what we do not have this case with the model (1).

Second, empirical researches of consumer demand have shown that Heteroscedasticity can be removed considerably with logarithmic transformation of variables, which it is often present in the demand regression analysis based on the statistic time series.

5. The results of R Stonea's research in the field of demand analysis.

The results of R Stonea's and other Econometricians' research in the field of demand analysis has shown that the model (2)

$$q'_1 = \alpha_1 m^{\beta_{10}} p_1^{\beta_{11}} p_2^{\beta_{12}} \dots p_n^{\beta_{1n}}$$

… **(2)**

is very suitable for the demand analysis based on the time series, when a product or a group of relative homogenous product is observed or noticed that it means on the occasion of the evaluation of model parameters (2), respectively on the occasion of verification of the empirical results of the demand analysis, the certain relations-results of the S.H.A. theoretical model can be used.

6. Theoretical results of the S.H.A. Model

Theoretical results of the S.H.A. Model, explain that the evaluation of demand regression equation must be homogenous, zero level of homogeneity regarding (in proportion to) incomes or prices. This condition will be satisfactory if the sum of all incomes and prices elasticity is equal to zero, that it means:

$$\sum_{j=0}^{n} \beta_{1j} = 0$$

Since the demand projection, is often created – based on waiting for changes in the real population incomes, then it is necessary to include the real incomes instead of the nominal incomes in the model (2). Deflation of the nominal incomes (m) with general price index of consumption products (P) model (2) we can write in the form:

$$q_t = \alpha'_1 \mu^{\beta_{10}} p_1^{\beta^*_{11}} p_2^{\beta^*_{12}} \dots p_n^{\beta^*_{1n}}$$

.. (5)

where it is:

$$P = \prod_{j=1}^{n} p_j^{w_j}, \quad w_j = \frac{p_j q_j}{m}, \quad \mu = \frac{m}{p}$$

Parameters $\beta^*_{1j} (j = 1, 2, ..., n)$ now express the net price elasticity of demand

7. Heteroscedasticity

One of the assumptions of linear regression model was that the stochastic error $\varepsilon_1, \varepsilon_2, ..., \varepsilon_T$ has the same (constant) variance.

The cases when stochastic errors have the same (constant v) variances is known as homoscedasticity, whereas the case when the variances of stochastic errors are different then we are dealing with the phenomenon of heteroscedasticity (heteroscedasticity of variances)

If the method of least squares (MLS) is used directly in the original data in the conditions of heteroscedasticity of stochastic errors, we will have two main consequences:

First, the incorrect evaluation of variances of the regression parameters is noticed

Second, the evaluation of variances of the regression coefficients overestimates or underestimates the actual size of their variances.

If the variances of stochastic errors are positively correlated with the values of independent variables, which happen often in the empirical analysis, then the evaluation of variances of the regression parameters gained through the general method of least squares shall underestimate the true value of their variances.

In order to remove these consequences (and others) in that way that inequality of variances be removed (avoid) to the parameters of regression model in the heteroscedasticity case, it must be evaluated through the implementation of generalized method of least squares, this means that firstly the transformation of the original variables is performed according to the heteroscedasticity type, then we apply the general methods of least squares in the transformed variables.

In special cases, when the variances of stochastic errors are positively correlated with the independent variables, then as we have mentioned earlier, the heteroscedasticity consequences can be removed considerably through the logarithmic transformations in the original variables.

8. Conclusion

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It is analysed by the Sluck – Hicks – Allen theoretical Model (S.H.A .), and it is done the determination of the consumer demand for concrete product **Q**. The interpretation of linear and power model parameters shows clearly the relevant factors that impact in the level of consumption demand. The parameters evaluation in multiple linear regressions of demand is necessary to do the measurement of demand as the researched economic phenomenon. We gave the indispensable explanations how in the demand analysis is done the transfer from nonlinear regression model to linear model. We saw the concrete results of R Stonea's and other econometricians' research in the field of consumption demand analysis for the concrete product Q. Theoretical results of the S.H.A. Model, explain that the evaluation of demand regression equation must be homogenous, zero level of homogeneity regarding (in proportion to) incomes or prices. And in the end we looked the Cases when the stochastic error have the same (constant) variances then the phenomenon is known as homoscedasticity, whereas the case when the variances of stochastic errors are different then we are dealing with the phenomenon of heteroscedasticity (heteroscedasticity of variances).

MULTIPLE LINEAR REGRESSIONS, except the form explained in the paper, can be presented in the Record forms, or Matrix form, both of these forms of multiple linear regressions give the same results of model parameters, but the second form can present a small problem for the non-expert of matrix bases.

Aware for the complexity of this demand analysis, and the limitation of the paper in the number of words and pages, we had to determine the paper's framework only in thick lines, so only to explain the procedures and steps in such analysis, but, without having possibility to present the research of a case until the end. Whereas we can completely present this in annex for interested persons, respectively as annex of this scientific paper, by the two possible forms of multiple linear regression.

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