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Comparison of Single and Multiple Hypotheses Test of Aggregation the "Pulses" and "Sugar and Sugar Cubes" in Urban Areas of Iran

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Abstract

The main purpose of this study was to investigate the possibility of aggregation different types of pulses as well as sugar, using the single and multiple hypotheses test. The former hypothesis tests include Composite Commodity Theorem (Leontief and Hicks) and Generalized Composite Commodity Theorem (GCCT) and the latter hypothesis tests include the Bonferroni, Simes, Holm, and Hochberg procedures and the results of mentioned methods were compared. Data of the period 2006-2018 for this study were obtained from the Statistics Center of Iran..The results of multiple tests of Bonferroni, Simes and Hochberg for different types of pulses showed that with the exception of "mixed pea and bean", other products can be aggregated into the group of Pulses. Also, based on the results of Bonferroni, Simes, Holm and Hochberg, different types of sugar can be aggregated into the group of Sugar. The results of the individual hypothesis test are not the same for different types of pulses and different types of sugar. In other words, according to Leontief method, the hypothesis of aggregate the different types of beans together was not confirmed, while according to Hicks method, this hypothesis was confirmed. Similarly, according to the Leontief method, the hypothesis of aggregate the different types of sugar together was rejected, while according to the Hicks method, this hypothesis was confirmed. The result of the GCCT showed that all types of pulses (except "other beans") can be aggregated into the Pulses group. The types of sugar can also be aggregated into the Sugar group according to the generalized composite method. Based on the results, when the number of observations is low, the use of single tests and specifically the GCCT will not show the exactly same results, which confirms Davis (2003) finding that the GCCT does not guarantee proper aggregation of goods. In these cases, multiple tests would be recommended.

Keywords: Aggregation, Multiple hypotheses test, Pulses, Single hypothesis test, Sugar
Classification JEL: C43 .D11

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Introduction

Lack of adequate information about individual behavior of consumers makes analysis of their behavior challenging. Under such circumstances, data aggregation proves to be an effective solution for this challenge (Shokoohi *et al*., 2016). In this regard, there are many cases in which the sum of the production of several products is used instead of a specific product in order to estimate a production or cost function (Salami and Kianirad, 2001). In general, aggregation and using composite goods have been considered by the researchers as an effective solution for addressing issues such as unavailability of detailed information about individual goods, higher cost of data gathering process, losing observations and data, multicollinearity problem and restrictions of degree of freedom (Shabanzadeh and Mahmoodi, 2015). As a result, data aggregation in research process is inevitable. Knowledge on optimization method for integrating individual data in consistency with the fundamental theories of microeconomics is also important (Shokoohi *et al*., 2016). In this process, proper and correct grouping of goods is extraordinary important, because incorrect grouping of goods leads to specification error and biased estimations. Additionally, incorrect grouping of goods makes an error in tests of hypotheses and consequently makes an incorrect patern of consumers' behavior as well as policy making process (Davis, 1997).

The first theory called Composite Commodity Theorem (CCT) which are introduced by Hicks (1936) and Leontief (1936). Based on this theory, if the prices of a group of goods change in the same proportion so that their ratio remains constant over time and this group of goods can be integrated together.

Assuming the separability of utility function, Leontief (1947) and Sono (1961) proposed restricting structure of consumer's preference behavior as one of the means for minimizing the number of parameters. Lewbel (1996) proposed Generalized Composite Commodity Theorem (GCCT) which imposes fewer but more acceptable constraints on goods price trend than the Hicks-Leontief Composite Commodity Theorem. According to Davis *et al*. (2000), GCCT is more important than Composite Commodity Theorem (CCT) because it facilitates establishment of connection between goods prices which is required for a consistent and compatible integration. In spite of vast application of GCCT, Davis (2003) believe under low number of observations the methods proposed by Lewbel does not necessarily guarantee the proper integration of goods. Therefore, to elevate the capability of the theorem test, Davis proposed other methods such as Bonferroni, Simes, Holm and Hochberg (Shokoohi *et al*., 2016). During the past years, numerous Iranian scholars such as Kiani Rad and Salami (2000), Salami and Kiani Rad (2001), Faryadras and Chizari (2005), Falsafian *et al*. (2006), Kiani Rad and Salami (2007), Izadimehr and Javanbakht (2013), Shabanzadeh and Mahmoodi (2015) and Shokoohi *et al*. (2016) used GCCT for goods grouping in their research. Studies by Ash *et al*. (2010) on aggregation of Swordfish imports, Frank et al. (2010) on US import demand for Swordfish, Xie and Myrland (2011) on aggregation of Salmon demand, Schulz *et al*. (2011) on aggregation of different brands of ground beef, Schulz *et al*. (2012) composite demand for ground beef in the US, Lee *et al*. (2012) on composite demand of ground beef in the US, Peterson and Myrland (2016) on aggregation of seven different fishes, and Hang *et al*. (2018) applied GCCT to test for on analyzing drinks composited demand systems such as other studies carried out test for valid aggregations using the generalized composite commodity theorem.

The review of various studies showed that the main focus of these studies was on the use of GCCT theory. While less research was on using different methods such as Leontief Theorem, Hicks Theorem, Bonferroni, Simes, Holm and Hochberg. However, it is important to compare different methods to study the aggregation of goods, which is one of the advantages of the present study over previous studies.

Indeed, aggregation test without selecting the proper method can affect the consumers' behavior analysis (Shokoohi *et al*., 2016). The main aim of this study is its comprehensive and integrity of the use of the test of single and multiple addition hypotheses.

Pulses are one of the main sources of protein as the most important source of food which conserve a special grain food in urban and rural household basket; after cereals, these products are considered (Khofi and Anvieh Tekiyeh, 2009). According to the Food and Agriculture Organization (FAO) statistics, the per capita supply of energy from pulses consumption in 2019 in Iran was equal to 49.97 kcal per day, which is lower than the world

(66.86 kcal per day) (Iranian Sugar Factories Association, 2015). Sugar and sugar cube are other important goods that have significant roles in Iranian household basket of goods. Investigating the aggregation of different types of sugar is very important for analyzing behavior of the consumers. By a 50% decrease, the annual sugar consumption of a Iranian household with four members decreases from 20 kg in 2005 to 10 kg in 2014 (Reference(s)). Also, the annual sugar cube consumption of the household decreased from 32 kg in 2005 to 21 kg in 2014 which shows 35% decrease (Iranian Sugar Factories Association, 2015). According to the FAO statistics, the per capita supply of energy from the consumption of various sugars in Iran in 2019 was equal to 280.68 kcal per day that was higher than the world by amount of 231.04 kcal per day.

Therefore, due to the importance of pulses as source of plant proteins and types of sugar in the consumer basket of Iranian households, in this study, we examined the possibility of aggregation the products including pea, split pea, pinto bean, kidney bean, other beans, soybean, mixed pea and bean, lintels, mung bean, broad bean, split bean, sprouts and other pulses in the group of "Pulses" and sugar cube, sugar granules, artificial or diet sugar, powdered sugar and types of sugar in the "Sugar" group. According to the authors' information , the aggregation tests in order to the possibility of aggregating foods or goods using different theories, has been done very rarely in Iran.

Therefore, the main objective of this study is to investigate the possibility of aggregation of different pulses, sugar and sugar cubes in groups entitled “Pulses” and “Sugar”, respectively, using single test, i.e. Leontief’s CCT& Hicks’s CCT & GCCT, and multiple test, i.e. Bonferroni, Simes, Holm procedure and Hochberg procedures.,

Materials and Methods

The following methods are common for testing the goods aggregation (Shabanzadeh and Mahmoodi, 2015):

Hicks’s Composite Commodity Theorem

Based on Hicks’s Composite Commodity Theorem, if the prices of a group of goods change in the same proportion, that group of goods behaves just as if it were a single commodity. Indeed, the relative price of the goods must remain constant during a specific period.

Leontief’s Composite Commodity Theorem

Aggregation condition of this theorem is same as the Hick’s, but the relative amounts must remain fixed during specific period. In other words, goods can be in one group whose relative value remains constant over time.

Generalized Composite Commodity Theorem (GCCT)

Lewbel (1996) provides a generalization of the CCT that is empirically useful. In this theory, goods will be aggregated into the same group if the ratio of price of each good to the group’s price index remains independent from group’s price index. In this method, assuming that there are *n* individual goods or commodities i=1,2,...,n if the objective is to aggregate them under N groups and price of individual goods and group’s price index are demonstrated respective as P_i (i=1, 2, 3 … n) and P_I (I=1, 2, . . . , N) and N<n. Then the relative price (ρ_i) and index group of interest (R_I) will be shown as follows:

$$\rho_i = \ln(\frac{P_i}{P_I}) \quad (1)$$

$$R_I = \ln(P_I) \quad (2)$$

The aggregation criterion in GCCT is the independence of ρ_i index from ρ_i index. For nonstationary prices this is equivalent to find that ρ_i and R_I is not cointegrated.

Davis’s Approach

Many of the previous empirical studies, including Lewbel’s (1996), used single testing to address the issue of small sample. In GCCT, the cointegration test is carried out between relative price of each individual good (ρ_i) and price index of the respective group (R_I). If the calculated probability values are less than the 10%, the GCCT theory is rejected.

It should be noted that the rejection of aggregation between the relative price of each commodity (ρi) and the price index of its own group (Ri) provides only the necessary condition for GCCT. A sufficient condition in this regard is to examine the hypothesis of independence between ρi and all price indices of other commodity groups. The important point in this regard is the method of testing the sufficient condition for the aggregation of goods in the conditions of low data. Davis (2003) proposed the multiple hypotheses test for this purpose. In other words, following the critique of this method (lack of cointegration between commodities of the same groups does not guarantee the lack of integration between commodities of different groups), Davis found that the GCCT could not guarantee proper aggregation of goods for a small number of observations and Therefore, suggested the use of multiple comparison testing procedures (Bonferroni, Holm, Hochberg and Simes methods). In this approach, the null hypothesis is that the price ratio of each product to the price index of the group is not correlated or co-integrated with any of the price indices.

Suppose there are N individual hypotheses H_1, H_2,…H_N each being tested at the α_I level with corresponding p-values p_1, p_2, p_N. Let H:{H_1,H_2,...,H_N} and define the family hypothesis H0 to be the intersection of all hypotheses in H (Hochberg and Tamhane, 1987; Device, 2003; Shokoohi *et al*., 2016):$H_0=\bigcap_{j=1}^{N} H_J$. The family wise error rate (FWER) is the probability of a type I error for a family hypothesis. Calculation process of family-wise error rate (FWER) will be explained bellow. As Dufour and Torres (1998) point out, multiple comparison procedures are especially useful when standard asymptotic methods are either not applicable or unreliable, which is certainly the case in this research here which we are faced with data size limitations.

Bonferroni Procedure

In this procedure, p-values are initially calculated for single hypotheses (H_0: no correlation or cointegration between ρ_i and R_I); then, critical values for the null hypothesis (H_0), which is called family-wise error rate or FWER is calculated using the following formula:

$$FWER=\alpha/N \quad (3)$$

In this procedure, α is significance level (10% for smaller samples) and N is the number of single hypotheses under N groups. If any individual p-values are less than α/N, the null hypothesis (H_0) is rejected, otherwise, it is retained (Davis, 2003; Shokoohi *et al*., 2016).

Simes Procedure

In this procedure, p-values are calculated for single hypotheses, but FWER is calculated by the following formula:

$$FWER= i\alpha/N \quad (4)$$

where *i* is order of FWER-values, α and N are defined above. In this procedure, if each of the computational p-values is less than iα/N , H_0 is rejected, otherwise, it is retained. Since significance degrees are adjusted with the ordering of the p-values, Simes procedure is more powerful than the regular Bonferroni procedure (Davis, 2003 and Shokoohi et al., 2016).

Hochberg Procedure

Hochberg (1988) developed a step-up procedure based on the Simes (1986) equality. Let order the p values $P_{(1)}$..., $P_{(m)}$ (smallest to largest) and the corresponding hypotheses $H_{(1)}$,. .. , $H_{(m)}$. Let $\alpha'_{(1)}$, … , $\alpha'_{(m)}$ be the adjusted significance levels (or FWER). If $p_{(m)} \leq \alpha'_{(m)}$, then all hypotheses are rejected; otherwise $H_{(m)}$ is retained, and $p_{(m-1)}$ is compared with $\alpha'_{(m-1)}$. If $p_{(m-1)}$ is smaller than $\alpha'_{(m-1)}$, then all the remaining hypotheses are rejected; otherwise $H_{(m\_1)}$ is retained, and P(m - 2) is compared with $\alpha'_{(m-2)}$, and so on (Davis, 2003; Shokoohi *et al*., 2016).

Holm Procedure

In this procedure, the individual p-values are first arranged in increasing order $p_{(1)} \leq p_{(2)} \ldots \leq p_{(N)}$ along with their corresponding hypotheses $H_{(1)}$,$H_{(2)}$,...,$H_{(N)}$ before the testing commences. FWER is calculated using the following procedure:

$$FWER= \alpha/(N-i+1) \quad (5)$$

Decision rule: if H_0 is accepted or rejected, the following steps are taken:

1) First, it is assumed that i=j and it is checked if the smallest p value is less than FWER. If the answer is negative, it can be resulted that none of the single hypotheses are statistically significant. Indeed, null hypothesis is retained and testing is complete.

2) If the smallest p value is less than FWER, then the comparison is statistically significant and the test proceeds. In the next step, it is assumed that i=j-1 and again, it is checked if the smallest p value is less than FWER. The decision is made same as before and the procedure continues until reaching the point that the H_0 is not statistically significant; at this point, Holm procedure is stopped and the test is not conducted on other i values (Holm, 1979; Davis, 2003; Shokoohi *et al*., 2016).

Steps of Aggregation Testing Using GCCT through Different Procedures

The followings are steps of aggregation testing using GCCT, through different procedures (Shabanzadeh and Mahmoodi, 2015):

Performing the variables unit root test (price ratio of each commodity to group's price index (ρ_i) and product group price index (R_I)): price index of each group can be calculated using Törnqvist-Theil price index.

To determine proper testing method, variables independence should be evaluated using stationary test according to Table 1.

Table 1- Type of test for determination of correlation

Row	Result		Type of Test
	ρ_i	R_I	
1	Stationary	Stationary	Correlation
2	Nonstationary	Nonstationary	Cointegration
3	Stationary	Undetermined	Correlation
4	Undetermined	Stationary	Correlation
5	Nonstationary	Undetermined	Cointegration
6	Undetermined	Nonstationary	Cointegration
7	Undetermined	Undetermined	Both of cointegration and correlation
8	Stationary	Nonstationary	None
9	Nonstationary	Stationary	None

Davis *et al*., (2000) ; Shaabanzadeh and Mahmoodi (2015)

Data Source

Required data and information of the present study, including consumption expenditures and amount of each of pulses (pea, split pea, pinto bean, kidney bean, other beans, soybean, mixed pea and bean, lintels, mung bean, broad bean, split bean, sprouts and other pulses) and Sugar group's items include of sugar cube products (sugar cube, sugar granules, artificial or diet sugar, powdered sugar) are gathered from Statistical Center of Iran, covering the period of 2006-2018.

Results and Discussion

As mentioned before, the purpose of the present study is to investigate the possibility of aggregation of different types of pulses and sugar products under respective groups, using Composite Commodity Theorem (CCT) through single aggregation Theorem (Leontief's CCT, Hicks's CCT and GCCT) and multiple aggregation Theorem (Bonferroni, Simes, Holm and Hochberg procedures). In this regard, first the results of Leontief's CCT, Hicks's CCT and GCCT for different types of pulses and sugar are presented and then the results of Bonferroni, Simes, Holm and Hochberg procedures are presented. Finally, comparison of single and multiple testing results is presented.

Results of Leontief and Hicks's CCT for Pulses

Correlation matrix and consumption ratio parity tests were used for testing the aggregation of pulses using Leontief's CCT.The results of Leontief's CCT using correlation matrix (Table 2) show that pea, split pea, kidney bean and lintels can be aggregated under the same group and pinto bean, soybean, mixed pea and bean, other beans, mung bean, broad bean, split broad bean, spouts and other pulses cannot be integrated to the mentioned group. As can be seen, a large number of products cannot be aggregated into the group of Pulses.

Correlation matrix and price ratio parity tests are also used for testing the aggregation of pulses using Hicks'CCT. The results driven from Hick's CCT using correlation matrix (Table 3) shows that except for pinto bean, kidney bean and other beans, the remaining crops can be aggregated under pulses group. Therefore, using the correlation matrix, a large number of products can be aggregated into the group of Pulses.

The results of the Leontief and Hicks's CCT test using the parity test of the consumption quantities ratio and price of different types of pulses are presented in Table 4.

Table 2- Correlation matrix of pulses consumption amount

Item	Pea	Split pea	Pinto bean	Kidney bean	Other types of beans	Soybean	Mix pea & beans	Lentils	Mung bean & the rest*
Pea	1	0.960	0.799	0.948	0.900	-0.343	0.743	0.921	0.891
Split pea	0.960	1	0.854	0.977	0.958	-0.354	0.728	0.968	0.828
Pinto bean	0.799	0.854	1	0.856	0.819	-0.291	0.465	0.797	0.671
Kidney bean	0.948	0.977	0.856	1	0.916	-0.486	0.734	0.940	0.837
Other beans	0.900	0.958	0.819	0.916	1	-0.285	0.638	0.919	0.764
Soybean	-0.343	-0.354	-0.291	-0.486	-0.285	1	-0.607	-0.291	-0.582
Mixed pea and bean	0.743	0.728	0.465	0.734	0.638	-0.607	1	0.718	0.861
Lentils	0.921	0.968	0.797	0.940	0.919	-0.291	0.718	1	0.768
Mung bean & the rest*	0.891	0.828	0.671	0.837	0.764	-0.582	0.861	0.768	1

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Table 3- Correlation matrix of pulses price

Item	Pea	Split pea	Pinto bean	Kidney bean	other types of beans	Soybean	Mix pea & beans	Lentils	Mung bean & the rest*
Pea	1	0.991	0.942	0.943	0.955	0.962	0.963	0.977	0.968
Split pea	0.991	1	0.976	0.979	0.985	0.984	0.989	0.993	0.989
Pinto bean	0.942	0.976	1	0.996	0.994	0.967	0.995	0.969	0.973
Kidney bean	0.943	0.979	0.996	1	0.998	0.981	0.997	0.981	0.986
Other beans	0.955	0.985	0.994	0.998	1	0.984	0.998	0.986	0.987
Soybean	0.962	0.984	0.967	0.981	0.984	1	0.984	0.994	0.995
Mixed pea and bean	0.963	0.989	0.995	0.997	0.998	0.984	1	0.987	0.990
Lentils	0.977	0.993	0.969	0.981	0.986	0.994	0.987	1	0.997
Mung bean & the rest*	0.968	0.989	0.973	0.986	0.987	0.995	0.990	0.997	1

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Table 4- Results of Leontief and Hicks's CCT test using parity test of pulses consumption ratio and prices

	Leontief's Composite Commodity Theorem			Hicks's Composite Commodity Theorem		
Method	df	Value	Pro.	df	Value	Pro.
Bartlett	8	89.25	0.000	8	6.75	0.56
Levene	(8, 99)	13.3	0.000	(8, 99)	2.32	0.02
Brown-Forsythe	(8, 99)	8.24	0.000	(8, 99)	1.17	0.33

References: Research findings.

As demonstrated above, significance level of the pulses consumption parity test is less than 0.05 and the H_0 hypothesis (variance parity) is rejected and pulses cannot be aggregated under the same group. In other words, pulses are not grouped according to the Leontief Theorem because the consumption of each pulses does not change in the same proportion over time. On the other hand, significance level of results of price ratio parity test is more than 0.05 and the H_0 of variance equivalency is retained; therefore, the null hypothesis (variance is equal) cannot be rejected and different type of pulses can be aggregated under the same group. In general, comparing the results of Leontief and Hicks Theorem using the methods of correlation matrix and equality of ratios indicates that there is a major difference in the grouping of pulses based on these two theories, which is mainly due to the nature of these two theories (Hicks's Composite Commodity Theorem focuses on prices and Leontief's Composite Commodity Theorem focuses on quantities). It should be noted that the results of grouping the products using the methods of correlation matrix and equality of ratios in the form of Leontief and Hicks Theorem are almost similar.

Lewbel's GCCT Test

As mentioned before, the first step for aggregation test using GCCT is to conduct stationary test on price ratio of each goods to group's price index of goods and product group price index. Price index of each group (R_I) can be calculated using Törnqvist-Theil price index. Then, independency between R and ρ must be tested based on the results of stationary test and through the proper procedure selected based on Table 1.

Results of stationary test on R and ρ variables for studying their independence are provided in Table 5.

As shown in Table 6 and by considering stationary level of R and ρ variables, co-integration test proves to be appropriate for studying independence between "split pea relative price", "kidney bean relative price", "other beans relative price", "soybean relative price", and "mixed pea and bean relative price" with the price index of pulses group. However, there is no need for conducting any test for evaluating independence of "pea relative price", "pinto bean relative price", "lintels relative price" and "mung bean, broad bean, split broad bean, sprouts and other pulses relative price" with the price index of pulses group. Summary of results of Engle–Granger cointegration test in terms of time variables and the aggregation test of pulses in urban areas by GCCT is presented in Table 6.

Based on the results of GCCT test, except for "other brans", different types of pulses can be aggregated under the same group.

Table 5- Results of stationary test on variables of Pulses and Sugar groups

Production	Variable		Generalized Dickey Fuller Statistic			Stationary	Appropriate Test
			t-Statistic	Prob.	Description		
Pulses	Pea relative price	ρ_1	-5.38	0.0023	With intercept	I (0)	None
	Split pea relative price	ρ_2	-2.18	0.2211	With intercept	I (1)	Cointegration
	Pinto bean relative price	ρ_3	-4.02	0.0636	With intercept & trend	I (0)	None
	Kidney bean relative price	ρ_4	-3.39	0.1254	With intercept & trend	I (1)	Cointegration
	Other beans relative price	ρ_5	-2.51	0.1431	With intercept	I (1)	Cointegration
	Soybean relative price	ρ_6	-3.27	0.1427	With intercept & trend	I (1)	Cointegration
	Mixed pea and bean relative price	ρ_7	-1.61	0.4451	With intercept	I (1)	Cointegration
	Lentils relative price	ρ_8	-3.21	0.0505	With intercept	I (0)	None
	Mung bean, &the rest* relative price	ρ_9	-3.08	0.0606	With intercept	I (0)	None
	Price index of group pulses	R_1	-3.05	0.1696	With intercept & trend	I (1)	-
Sugar	Sugar cube products relative price	ρ_1	-2.67	0.0127	Without intercept & trend	I (0)	None
	Sugar relative price	ρ_2	-3.06	0.1678	With intercept & trend	I (1)	Cointegration
	Price index of group sugar	R_2	-1.12	0.8751	With intercept & trend	I (1)	-

References: Research findings. *: broad bean, split broad bean, sprouts of beans and other pulses relative price

Table 6- The result of aggregation test of different types of Pulses in urban areas by GCCT method

Variable		Type of Test	Cointegration Test		GCCT
Pulses (R_1)			t-statistic	Result	
Pea relative price	ρ_1	None	-	−	Accept
Split pea relative price	ρ_2	Cointegration	-3.2 (0.2934)	Reject	Accept
Pinto bean relative price	ρ_3	None	-	−	Accept
Kidney bean relative price	ρ_4	Cointegration	-3.7 (0.1754)	Reject	Accept
Other beans relative price	ρ_5	Cointegration	-4.5(0.0656)	Accept	Reject
Soybean relative price	ρ_6	Cointegration	-4.02(0.1211)	Reject	Accept
Mixed pea and bean relative price	ρ_7	Cointegration	-3.5(0.2317)	Reject	Accept
Lentils relative price	ρ_8	None	-	−	Accept
Mung bean & the rest*	ρ_9	None	-	−	Accept

Source: Research findings. The numbers in parentheses indicate significant level.
*: broad bean, split broad bean, sprouts of beans and other pulses relative price

Comparison of the test results of Hicks, Leontief, and GCCT show that there are differences in the grouping of pulses. As Davis (2003) pointed out, one of the reasons for this could be the number of observations. In other words, the results of the study confirm Davis's finding that the GCCT does not guarantee proper aggregation of products when the number of observations is low. In these cases, Davis has proposed Bonferroni, Simes, Holm, and Hochberg procedures to increase the test capability of this theory.

Results of Single Aggregation Hypothesis Test of Sugar

A) Results of Leontief and Hicks's CCT for Sugar Products

Table 7 shows the results of Leontief and Hicks's CCT sugar products aggregation test using correlation matrix.

Results of Leontief's CCT test show that sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar cannot be aggregated in the same group. However, Hicks' CCT test on price of sugar cube and sugar products using correlation matrix show that sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar can be aggregated in the same group.

The result of the equality test of the ratio of sugar consumption (Table 8) indicates that the significance level is lower than 0.05 and H_0 is rejected; hence, sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar cannot be aggregated in the same group.

Table 7- Correlation matrix of sugar price and consumption amount

Leontief's CCT		
	Sugar cube products	Sugar
Sugar cube products	1	0.9
sugar	0.9	1
Hicks's CCT		
	Sugar cube products	Sugar
Sugar cube products	1	0.99
Sugar	0.99	1

References: Research findings.

Aggregation test of sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar using Hicks's CCT show that the significance level of the results of price parity test is more than 0.05 and the H_0 of variance equality is retained; therefore, sugar cube products and sugar can be aggregated in the same group.

b) Lewbel's GCCT

Table 5 shows the results of stationary test (Augmented Dicky-Fuller test) on relative price of sugar cube products and relative price of sugar and price index of Sugar group. According to the results, there is no need for conducting any test for studying independence between sugar cube products relative price and price index of Sugar However, co-integration test proves to be appropriate for studying independence of relative price of sugar and price index of Sugar group. Accordingly, Engle–Granger cointegration test is used for studying cointegration of the variables and by taking into account the time variable, the results show the significance level (0.24) is higher than 0.1 (10%) which indicates the variables are not cointegrated and GCCT is accepted. Results of sugar cube products and sugar cointegration test for urban areas of Iran, using GCCT are shown in Table 9. According to the results, sugar cube products and sugar products can be aggregated in the same group.

Based on the results, using the method of equality of ratios or correlation matrix to test the Leontief's CCT or Hicks's CCT has no effect on creating differences as a result of grouping different types of sugar. However, the overall result of commodity grouping varies depending on the theory used, which is probably due to the focus of Hicks's CCT on prices and Leontief's CCT on quantities.

Table 8- Results of sugar consumption and price ratio Parity Test using Leontief and Hicks's CCT

Method	Leontief's CCT			Hicks's CCT		
	df	Value	Pro.	df	Value	Pro.
F-test	(11, 11)	3.47	0.050	(11, 11)	1.25	0.715
Siegel-Tukey		-0.029	0.977		0.32	0.750
Bartlett	1	3.83	0.050	1	0.13	0.715
Levene	(1, 22)	9.55	0.005	(1, 22)	0.28	0.599
Brown-Forsythe	(1, 22)	4.08	0.055	(1, 22)	0.25	0.619

References: Research findings.

Table 9- Results of Cointegration Test on Sugar Cube and Table Sugar products in urban areas of Iran Using GCCT

Variable		Type of Test	Cointegration Test		GCCT
			Tau-Statistic	Result	
Sugar (R_2)					
Sugar cube products	ρ_1	none	–	–	accept
Sugar	ρ_2	cointegration	-3.46 (0.24)	reject	accept

References: Research findings. The number in parenthesis indicate significant level.

Results of Multiple Aggregation Hypothesis Test

The probability value resulting from Engle – Granger co-integration test between relative price of each product and price index of the respective group and price index of other groups is considered in order to using multiple test methods and calculated p values are compared to FWER.

The FWER is chosen to be 0.10 to compensate for the low power of the cointegration tests (Davis, 2003; Shokoohi *et al.*, 2016). The results of Bonferroni, Holm, Hochberg and Simes procedures are presented and compared. Significance levels driven from Engle – Granger cointegration test are presented in Table 10.

Bonferroni Procedure

In this study, FWER values were calculated using Bonferroni procedure based on α=0.1 and N=2 which results shown in Table 12. According to multiple testing results driven from Bonferroni procedure, all calculated p values, ("mixed pea and bean" excluded), are higher than 0.05 and H_0 (indicating independence of relative prices of the products and price indices of two groups) is accepted. Indeed, except for "mixed pea and bean", not only all pulses can be aggregated in "Pulses" group but also all types of sugar can be aggregated under "Sugar" group.

Holm Procedure

Initially, p values (values driven from Engle–Granger cointegration test between relative price of each commodity and price index of the related group and price indices of the other groups) are calculated for each single hypothesis; then, the calculated values are ordered from smallest to larges (Table 11).

Critical values are demonstrated in Table 12. In this procedure, the lowest values are compared to highest critical value (0.1). In the first step of Holm procedure, as shown in the result, except for "mixed pea and bean" & "other beans", all calculated values are higher than 0.1 and hypothesis of independence between relative prices of split pea, kidney bean, soybean and sugar with price index of the groups is accepted. As for "mixed pea and bean" and "other beans", the next step must be taken and their values must be compared to the second critical value; indeed, values of "mixed pea and bean" and "other beans" which are respectively 0.231 and 0.453 must be compared to 0.05. Subsequently, the results show that independence hypothesis between relative price of the products and price index of the groups is accepted.

Hochberg Procedure

The Hochberg procedure uses the same criterion for each hypothesis as does the Holm procedure but tests hypotheses with larger p-values first. If any of the calculated p-values is less than their respective FWER, H_0 is rejected.

By considering significance levels provided in Table 11, it can be concluded that:

For sugar, calculated p-values are higher than the second FWER (0.1), the hypothesis of independence is accepted. Indeed, sugar cube products and sugar can be aggregated in "Sugar" generic group.

For all products except for "mixed pea and bean" which the first calculated value is higher than the first FWER (0.05), the hypothesis of independence between relative price of products and price indices of the groups is accepted. Therefore, except for “mixed pea and bean”, all pulses can be aggregated in “Pulses” generic group.

Comparison of the results shows that findings of Hochberg procedure are same as the findings of Bonferroni procedure.

Table 10- Results of Engle–Granger Cointegration Test (significance level)

ρ_i		Pulses Price Index(R_1)	Sugar Price Index(R_2)
Production	**Stationary**	**Stationary: I (1)**	**Stationary: I (1)**
Pea	I (0)	–	–
Split pea	I (1)	0.293	0.629
Pinto bean	I (0)	–	–
Kidney bean	I (1)	0.175	0.227
Other beans	I (1)	0.065	0.453
Soybean	I (1)	0.121	0.279
Mixed pea and bean	I (1)	0.231	0.039
Lentils	I (0)	–	–
Mung bean, the rest*	I (0)	–	–
Sugar cube products	I (0)	–	–
Sugar	I (1)	0.126	0.24

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Table 11- Significance level of Cointegration test in order from minimum to maximum

Production	**Probability Value**	
	Ordered p-value (R_1)	**Ordered p-value (R_2)**
Pea	No Comparison	No Comparison
Pinto bean	No Comparison	No Comparison
Lentils	No Comparison	No Comparison
Mung bean, the rest*	No Comparison	No Comparison
Sugar cube products	No Comparison	No Comparison
Mixed pea and bean	0.039	0.231
Other beans	0.065	0.453
Soybean	0.121	0.279
Sugar	0.126	0.24
Kidney bean	0.175	0.227
Split pea	0.293	0.629

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Simes Procedure

The decision-making rule of this procedure is same as the Hochberg’s and the only difference is in calculation of critical values. According to the results provided in Table 11 and Table 12, except for “mixed pea and bean” which the corresponding calculated p-value in the step one (R_1) is larger than FWER (0.05), the hypothesis of independency between relative price of other products and price indices of the groups is accepted. Therefore, “mixed pea and bean”, cannot be aggregated in “Pulses” group. All calculated p values in step two (R_2) are higher than FWER(0.1), so the H_0 is accepted.

Therefore, sugar cube products and sugar can be aggregated under “Sugar” group. As it is evident, the results of Simes procedure are consistent with the results from Bonferroni and Hochberg procedures.

Table 12- Family-Wise Error Rate (FWER) values

Simes	Holm, and Hochberg	Bonferroni	Group Ordered
0.05	0.05	0.05	1
0.1	0.1	0.05	2

References: Research findings.

Conclusion and Recommendations

The general purpose of the this study was to investigate the possibility of aggregating the different types of pulses as well as types of sugar in groups called "Pulses" and "Sugar", respectively, using the single hypothesis test (Leontief Composite Commodity Theorem, Hicks Composite Commodity Theorem, and the Generalized Composite Commodity Theorem) and multiple hypothesis test (Bonferroni, Simes, Holm, and Hochberg methods) and comparing the results of different methods together. The following results were obtained:

Leontief's Composite Commodity Theorem: 1- It is not possible to aggregate the different types of pulses together. 2- It is not possible to aggregate the different types of sugar together.

Hicks's Composite Commodity Theorem: 1- It is possible to aggregate the different types of pulses together. 2- It is possible to aggregate the different types of sugar together.

Generalized Composite Commodity Theorem: 1- All types of pulses except "other beans" can be aggregated in one group called Pulses. 2- All of the types of sugar can be aggregated in a group called Sugar.

Bonferroni method: according to this method, aggregation types of pulses (except "mixed pea and bean") in the group of "Pulses" and types of sugar in the group of "Sugar" is possible.

Holm method: The results of this method showed that the hypothesis of independence between the relative prices of products and the price index of groups is accepted and the aggregation of types of pulses in the group of "pulses" and types of sugar in the group of "Sugar" is possible.

Hochberg method: The aggregation test based on this method indicates that the aggregation of different types of pulses except *for "mixed pea and bean"* in the "Pulses" group is possible and it is also possible to aggregate different types of sugar in the "Sugar" group. The result of this test is similar to the result of Bonferroni test.

Simes method: The study of aggregation of the studied products using the Simes method showed that it is not possible to aggregate "mixed pea and bean" in the group of Pulses. The result obtained in this method confirms the results of Bonferroni and Hochberg methods.

According to the results of the Bonferroni, Simes and Hochberg multiple hypothesis testing for types of pulses & sugar, are the same.

Based on the results of this study, the use of consumption values (according to Leontief's CCT) for grouping the products, offers different results. The use of product price values (according to Hicks's CCT, GCCT, multiple hypothesis testing) provides closer results. Moreover, using the single tests, and specifically the GCCT does not show exactly the same results, which is in line with Davis (2003) finding that the GCCT does not guarantee proper aggregation when the number of observations is low. In this case, the importance and necessity of performing the test of sufficient condition of aggregation using multiple tests (Bonferroni, Simes, Holm, and Hochberg methods) is emphasized. According to the research results, in studies on the consumers behavior of pulses including pea, split pea, pinto bean, kidney bean, other beans, soybean, mixed pea and bean, lintels, mung bean, broad bean, split bean, sprouts and other pulses in Iran's urban communities, considering all pulses except "mixed pea and bean" will provide reliable and compatible results. Among the possible reasons for not including "mixed pea and bean" in the group of Pulses, we can mention the existence of different types of beans (pinto bean, kidney bean, other beans) and pea in the group of Pulses. In other words, the presence of the main groups of these products in the group of Pulses has probably led to the non-inclusion of the mixture of these products in the group of Pulses.

Also, considering the different types of sugars including sugar cube, sugar granules, artificial or diet sugar, powdered sugar with the types of sugar in one group called "Sugar" in studying the behavior of urban consumers in Iran, will provide compatible results.

One of the important cases to provide more accurate results is the expansion of the study period along with increasing the number of studied product groups. In addition, it is suggested that in studding consumer behavior in order to increase the validity of the results, in the aggregation test, in addition to using the single hypothesis test (Leontief Composite Commodity Theorem, Hicks Composite Commodity Theorem, and the Generalized Composite Commodity Theorem), multiple hypothesis tests (Bonferroni, Simes, Holm, and Hochberg methods) also be considered.

It should be noted that the rejection of aggregation between the relative price of each commodity (ρi) and the price index of its own group (Ri) provides only the necessary condition for GCCT and sufficient condition in this regard is to examine the hypothesis of independence between ρi and all price indices of other commodity groups using multiple hypothesis tests (Bonferroni, Simes, Holm, and Hochberg methods). The important point in this regard is the method of testing the sufficient condition for the aggregation of goods when data is low. Therefore, similar to the results of the study of Shokoohi *et al.* (2016), the results of the present study also emphasize the importance of not paying enough attention to the sufficient condition of goods aggregation and the number of observations can lead to incorrect aggregation of goods.

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مقاله پژوهشی

جلد ۳۶، شماره ۲، تابستان ۱۴۰۱، ص ۱۹۵-۱۸۳

مقایسه آزمون فرضیه انفرادی و چندگانه جمع‌پذیری انواع حبوبات و قند و شکر در مناطق شهری ایران

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چکیده

هدف کلی مطالعه حاضر، بررسی امکان تجمیع انواع حبوبات و همچنین انواع قند و شکر در گروههایی به ترتیب با عنوان "حبوبات" و "قند و شکر" با بهره گیری از آزمون فرضیه انفرادی و چندگانه است. آزمون فرضیه انفرادی شامل قضیه کالای مرکب (لئونتیف و هیکس)، و قضیه کالای مرکب تعمیم یافته و آزمون فرضیه چندگانه شامل روش‌های بن فرونی، سیمز، هولم، و هاچبرگ می‌باشد. همچنین نتایج حاصل از روش‌های مذکور با هم مقایسه شده است. داده‌های مورد نیاز مطالعه از مرکز آمار ایران برای دوره ۱۳۸۵ تا ۱۳۹۷ اخذ گردید. نتایج آزمون‌های چندگانه بن فرونی، سیمز و هاچبرگ برای انواع حبوبات نشان داد که به استثنای " نخود و لوبیا مخلوط"، سایر محصولات در گروه حبوبات قرار می‌گیرند. همچنین بر اساس نتایج روش‌های بن فرونی، سیمز، هولم و هاچبرگ، انواع شکر و انواع قند در گروه قند و شکر قابل تجمیع می‌باشند. نتایج آزمون فرضیه انفرادی درخصوص انواع حبوبات و انواع قند و شکر، یکسان نیستند. به عبارت دیگر، بر اساس روش لئونتیف، فرضیه جمع‌سازی انواع حبوبات با یکدیگر تایید نشد در حالی که بر اساس روش کالای مرکب هیکس، این فرضیه مورد تایید قرار گرفت. به طور مشابه، بر اساس روش لئونتیف، فرضیه جمع‌سازی انواع قند و انواع شکر با یکدیگر رد شد در حالی که بر اساس روش کالای مرکب هیکس، این فرضیه مورد تایید قرار گرفت. نتایج آزمون فرضیه کالای مرکب تعمیم یافته نیز نشان داد که همه انواع حبوبات به جز "سایر انواع لوبیا"، قابل تجمیع در یک گروه تحت عنوان حبوبات می‌باشند. انواع قند و شکر نیز مطابق روش کالای مرکب تعمیم یافته قابل تجمیع در یک گروه تحت عنوان قند و شکر هستند. بر اساس نتایج، هنگامی که شمار مشاهدات کم باشد، استفاده از آزمون‌های انفرادی و به طور مشخص آزمون کالای مرکب تعمیم یافته، نتایج یکسانی را نشان نخواهند داد که این نتیجه تاییدی است بر یافته‌های دیویس (۲۰۰۳) مبنی بر اینکه آزمون کالای مرکب تعمیم یافته تضمین کننده تجمیع مناسب کالاها در زمان کم بودن تعداد مشاهده‌ها نیست. در این شرایط انجام آزمون‌های چندگانه نیز پیشنهاد می‌شود.

واژه‌های کلیدی: حبوبات، قند و شکر، مرکب‌سازی تعمیم یافته

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