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Testing Geographical Aggregation Consistency Across Agencies in Agriculture Sector of Iran

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Abstract: Theory of the firm investigates the behavior of individual producers; however, in many cases researchers inevitably use aggregated data in empirical studies since disaggregated data are not available or are costly to collect. In addition, working with aggregated data in modeling producer's behavior is easier and more desirable, particularly in policy analysis. Despite the attractive features of aggregated data, using these data in aggregate econometrics models results in biased parameter estimates and depicts unrealistically producers' behavior and consequently lead to unreliable inferences. In this study, we examine the aggregation consistency condition for price and quantity aggregation across 6 large paddy producer provinces and also 24 wheat producer provinces, resorting to the Generalized Composite Commodity Theorem (GCCT). Results indicate that group quantity and price indices are respectively independent from relative quantities and prices for wheat and paddy across all provinces. Consequently, consistent geographic aggregation was supported for each price and quantity data at the country level.

Key words: Consistent aggregation · Generalized composite commodity theorem · Wheat · Paddy · Iran

INTRODUCTION

Theory of firm consider the behavior of individual producer or firm but in many empirical production analysis aggregate data is used extensively due to several factors. Most of the time, disaggregated data not available or may be more costly to collect than aggregate data. Moreover, modeling producer's behavior can be simplified with using aggregate data. Also, Hellerstein [1] believe that aggregate model can be estimate with more suitable functional forms. Despite the aggregate data preferences, where consistent aggregation conditions are not satisfied aggregate models can result in spurious parameters and consequently lead to unreliable policy inferences [2]. For this reason, consistent aggregation conditions were investigated in many research articles. On the basis of these studies, Hicks composite commodity theorem, Leontief composite commodity theorem, seperability and generalized composite commodity theorem (GCCT) are sufficient conditions for consistent commodity – wise aggregation. When all prices of individual commodity in the group move in fixed proportions, the Hicks composite commodity theorem will be satisfied. According to Leontief composite commodity theorem, sufficient condition for aggregation consistency is that quantity of individual commodity in the group move in fixed proportion. The seperability theorem requires that marginal rate of substitution between each elements of group be independent of all commodity that are not elements of their group. The aforementioned conditions have some weakness. Two first conditions are rarely satisfied in real world's data set. Also, separibility imposes restriction on technology or utility.

For these reasons, Lewbel [3] introduced the generalized composite commodity theorem as a sufficient condition for consistent aggregation. According to this theorem, price ratio can be varied over the data set on condition that the distribution of the ratio of individual prices to their group prices is independent of the distribution of group price.

The GCCT has often been used to test aggregation consistency across commodity and researchers have rarely been paid attention to consistent geographic aggregation. Recently, Liu and Shumway [4], in a new approach, have applied GCCT as a sufficient condition for firms and geographic aggregation.

Because of widely aggregate province data usage in agricultural economics studies, in this paper GCCT was

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used to test consistency of price and quantity aggregation across geographic units for wheat and paddy outputs. In the next section, GCCT and the necessary conditions for its application, as a valid sufficient condition for consistent aggregation over firms and geographic units will be briefly discussed. Finally, empirical results and conclusion will be illustrated.

MATERIALS AND METHODS

Lewbel [3] proved that GCCT is a sufficient condition for commodity – wise aggregation when: a) consumers maximize their utility; and b) the distribution of ratio of individual prices to their group price is independent from the distribution of group prices.

For test assumption two, let Pi be prices of individual commodities i=1,2,…,n. Also let PI be vectors of group price indices, where I identify groups of commodities. Define ρi to be the logarithm of the ratio commodity i's price to group's price, ρi = log (Pi /PI). Furthermore, define RI to be the logarithm of the group price index, RI =log (PI) and let ρ and R be respectively the vectors with ρi and RI elements. According to Lewbel's approach, it is necessary that vector ρ be independent from vector R to satisfy latest assumption.

Davis [5], as a new approach to GCCT, belief that independence relative prices of their group price index do not guarantee the independence between groups then independence relative price of other group price index (RJ, i∉J) must be tested, too.Testing independence ρi of RI performs in three stages. At first, stationary of log relative price ρi and log group price RI must be tested. For this purpose, augmented Dickey- Fuller (ADF) can be used. Then, if both ρi and RI were stationary, a correlation test such as Spearman's rank correlation test would be used to test independence ρi from RI. If both ρi and RI were found to be nonstationary, a cointigeration test would be used. If one of them is stationary and the other is nonstationary, linear independence would be acquired without any additional test. Finally, multiple - comparison test procedures, such as Simes test, must be applied to determined independence inference.

After introducing GCCT, this theorem has widely been used to test for consistent aggregation of commodity prices; however, consistent geographic aggregation has been investigated in few studies [6]. It is seem that very restrictive characteristic of the sufficient technology conditions for consistent firm–wise aggregation has been dissuaded researchers from this test [5]. Chambers [7] explained sufficient technology condition for aggregation across firms. In the short-run aggregation consistence requires that each firm-level marginal cost equal aggregate marginal cost but only identical constant return technologies satisfies linear aggregation in the long-run. Furthermore, in the case of nonlinear aggregation, it is necessary that the aggregate cost function exhibit quasi-homotheticity.

When all prices are homogenous, the Hicks composite commodity theorem and consequently consistency of aggregation would be satisfied but even in competitive industries prices may be heterogeneous, due to transportation and search costs. Liue and Shumway [4] belief that when prices are heterogeneous, the GCCT can be used as a sufficient condition for consistent aggregation across firms. They declare that when each firm maximizes its profit and the distribution of ratio of firm prices to their group prices is independent from the distribution of group price then sufficient condition for consistent firm-wise aggregation would be satisfied. Under these circumstances the theoretical properties of individual supply function namely homogeneity; symmetry and positive semi definiteness are retained in aggregate supply function. In the present study, we assume that each province is a firm that maximizes its profit. When the distribution of ratio of province prices to the national-level price is independent from the national-level price, consistent geographic aggregation would be supported across all provinces.

Empirical Results: In the present study consistent province – wise aggregation was tested for wheat and paddy outputs. For this purpose, 24 provinces for wheat and 6 provinces for paddy were separately aggregated into one hypothesized group. Price and quantity data was collected from Ministry of Jihad-e-Agriculture and Statistical Center of Iran. This data set contains annual data for the period 1983-2005 for wheat and 1983-2002 for paddy.

National –level price and quantity were created as Laspeyres, Pacheh, Fisher and Tornqvist indices. Results of the ADF tests for log relative prices of wheat ρi are reported in Table 1. The results show that nonstationary hypothesis was rejected in most provinces at 1% significance level. The only exceptions were in East Azarbayjan, Boshehr, Fars, Kordestan, Lorestan for all indices. Also, nonstationary could not be rejected in Semenan for Laspeyres and Tornqvist indices and in Kerman for Pacheh, Fisher and Tornqvist indices. By inspection of Table 3, log group prices RI appear nonstationary for all indices. According to these findings, independence of ρi from RI was investigated. As already mentioned, linear independence of nonstationary series RI

Table 1: T-test statistics of ADF test (wheat price)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT *	T **	NT	T	NT	T	NT	T
East Azarbayejan	-2.30	-1.69	-2.16	-1.58	-2.23	-1.63	-2.31	-1.71
West Azarbayejan	-3.99	-3.62	-4.06	-3.74	-4.03	-3.68	-4.11	-3.69
Esfahan	-3.75	-3.62	-2.89	-2.98	-3.06	-3.05	-4.04	-4.00
Ilam	-3.03	-3.06	-3.18	-3.11	-3.09	-3.07	-3.18	-3.19
Boshehr	-2.46	-3.08	-2.61	-3.09	-2.53	-3.08	-2.56	-3.06
Tehran	-3.30	-3.89	-3.00	-3.18	-3.13	-3.27	-3.19	-3.36
Charmahal & Bakhtiari	-3.38	-3.30	-3.75	-3.63	-3.55	-3.45	-3.53	-3.43
Khorasan	-5.05	-4.35	-4.54	-3.93	-4.48	-4.08	-5.61	-4.91
Khozestan	-4.46	-6.58	-5.42	-7.06	-5.02	-6.86	-5.01	-6.59
Zanjan	-3.61	-4.53	-3.75	-4.84	-3.59	-4.69	-3.42	-4.33
Semnan	2.31-	-2.20	-3.59	-3.73	-3.70	-3.96	-2.10	-2.15
Sistan & Balochestan	-4.03	-4.02	-3.22	-2.82	-3.23	-2.78	-3.26	-2.85
Fars	-2.30	-2.69	-2.23	-2.51	-2.26	-2.59	-2.33	-2.76
Kordestan	-1.73	-1.48	-1.90	-1.62	-1.80	-1.54	-1.70	-1.48
Kerman	-2.86	-2.83	-2.16	-2.74	-2.21	-2.78	-2.60	-2.90
Kermanshah	-4.27	-3.93	-4.01	-3.67	-4.15	-3.80	-4.11	-3.80
Kohkeloyeh & Boyer Ahmad	-3.92	-3.72	-1.40	-1.81	-1.58	-1.97	-3.79	-3.61
Gilan	-3.48	-3.78	-3.47	-3.74	-3.47	-3.75	-3.51	-3.81
Lorestan	-1.70	-2.18	-1.66	-2.23	-1.67	-2.20	-1.49	-1.92
Mazandaran	-1.91	-1.19	-2.72	-2.78	-1.92	-1.24	-1.67	-1.17
Markazi	-3.76	-3.62	-3.87	-3.73	-3.78	-3.63	-4.03	-3.87
Hormozgan	-2.98	-3.54	-2.96	-3.43	-2.97	-3.48	-3.01	-3.57
Hamedan	-4.51	-4.53	-4.51	-4.30	-4.54	-4.45	-4.13	-4.08
Yazd	-2.83	-4.14	-2.35	-3.61	-2.57	-3.86	-2.43	-3.95

* Regression equation without trend and ** Regression equation with trend

Table 2: T-test statistics of ADF test (paddy price)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT*	T**	NT	T	NT	T	NT	T
Esfahan	-5.14	-5.21	-5.06	-5.62	-5.12	-5.43	-5.33	-5.32
Khozestan	-3.47	-3.35	-3.49	-3.39	-3.49	-3.37	-3.49	-3.37
Fars	-3.42	-3.53	-3.84	-3.82	-3.62	-3.66	-3.44	-3.60
Kohkeloyeh & Boyer Ahmad	-1.15	-1.43	-1.26	-1.37	-1.21	-1.40	-1.11	-1.44
Gilan	-2.42	-2.58	-2.09	-2.43	-2.22	-2.48	-2.47	-2.58
Mazandaran	-3.46	-4.43	-3.62	-3.64	-2.68	-3.28	-3.10	-3.95

* Regression equation without trend and ** Regression equation with trend

Table 3: T-test statistics of ADF test (price indices)

	Wheat		Paddy	
Index/Ouput	NT*	T**	NT	T
Laspeyres	-0.03	-2.91	-0.32	-1.81
Pacheh	-0.09	-2.94	-0.22	-1.89
Fisher	-0.06	-2.95	-0.27	-1.88
Tornqvist	-0.05	-2.98	-0.34	-1.81

* Regression equation without trend and ** Regression equation with trend

Table 4: T-test statistics of cointigeration test (wheat price)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT*	T**	NT	T	NT	T	NT	T
East Azarbayejan	-1.45	-2.98	-1.58	-1.36	-1.51	-2.90	-1.54	-2.95
Boshehr	-0.69	-3.22	-0.28	-3.16	-0.66	-3.19	-0.64	-3.26
Semenan	-0.64	-1/32	-	-	-	-	-0.18	-1.30
Fars	-0.25	-3.05	-0.28	-2.95	-0.26	-2.99	-0.36	-3.01
Kordestan	-0.73	-3.16	-0.34	-3.12	-0.37	-3.14	-0.68	-3.13
Kerman	-	-	-0.04	-3.10	-0.02	-3.16	-	-
Lorestan	-0.78	-3.26	-0.61	-3.21	-0.71	-3.23	-0.73	-3.15
Mazandaran	-0.43	-3.05	-0.40	-3.05	-0.42	-3.04	-0.29	-3.06
Yazd	-0.44	-1.44	-0.69	-3.69	-0.66	-3.77	-0.67	-3.76

* Regression equation without trend and ** Regression equation with trend

Table 5: T-test statistics of cointigeration test(paddy price)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT*	T**	NT	T	NT	T	NT	T
Kohkeloyeh & Boyer Ahmad	-1.44	-1.67	-1.29	-1.64	-1.36	-1.68	-1.47	-1.68
Gilan	-1.40	-1.95	-1.60	-1.92	-1.51	-1.93	-1.30	-1.95

* Regression equation without trend and ** Regression equation with trend

Table 6: T-test statistics of ADF test (wheat quantity)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT*	T**	NT	T	NT	T	NT	T
East Azarbayejan	-2.64	-2.60	-2.58	-2.52	-2.61	-2.56	-2.46	-2.43
West Azarbayejan	-2.79	-3.01	-2.87	-3.01	-2.83	-3.04	-2.83	-3.08
Esfahan	-1.13	-2.28	-1.09	-2.22	-1.11	-2.25	-1.06	-2.28
Ilam	-1.42	-1.65	-1.43	-1.64	-1.42	-1.65	-1.44	-1.65
Boshehr	-1.53	-2.44	-1.55	-2.46	-1.54	-2.45	-1.54	-2.47
Tehran	-2.29	-2.50	-2.28	-2.47	-2.29	-2.48	-2.26	-2.47
Charmahal & Bakhtiari	-7.40	-6.55	-7.39	-6.55	-7.40	-6.55	-7.24	-6.32
Khorasan	-3.46	-3.70	-3.33	-3.65	-3.39	-3.67	-3.45	-3.68
Khozestan	-1.29	-1.70	-1.30	-1.68	-1.30	-1.69	-1.32	-1.66
Zanjan	-0.78	-1.33	-0.79	-1.32	-0.79	-1.32	-0.81	-1.33
Semnan	-0.62	-1.21	-0.63	-1.31	-0.62	-1.26	-0.72	-1.35
Sistan & Balochestan	-1.87	-2.11	-6.08	-2.09	-1.85	-2.10	-1.85	-2.09
Fars	-2.77	-2.52	-2.73	-2.46	-2.75	-2.49	-2.70	-2.49
Kordestan	-3.45	-3.40	-3.55	-3.52	-3.50	-3.45	-3.59	-3.53
Kerman	-3.05	-3.12	-2.96	-3.05	-3.00	-3.09	-3.02	-3.08
Kermanshah	-2.80	-3.48	-2.83	-3.47	-2.81	-3.48	-2.82	-3.53
Kohkeloyeh & Boyer Ahmad	-2.84	-2.82	-2.85	-2.81	-2.85	-2.81	-2.85	-2.83
Gilan	-1.67	-2.25	-1.67	-2.24	-1.67	-2.24	-1.62	-2.21
Lorestan	-1.92	-2.88	-1.84	-2.83	-1.88	-2.85	-1.95	-2.85
Mazandaran	-2.61	-2.54	-2.61	-2.54	-2.61	-2.54	-2.58	-2.52
Markazi	-1.35	-2.79	-1.37	-2.81	-1.36	-2.80	-1.40	-2.80
Hormozgan	-2.13	-2.42	-2.10	-2.39	-2.12	-2.41	-2.11	-2.42
Hamedan	-3.26	-3.52	-3.45	-3.67	-3.35	-3.59	-2.10	-2.76
Yazd	-1.54	-0.31	-1.54	-0.23	-1.54	-0.27	-1.62	-0.29

* Regression equation without trend and ** Regression equation with trend

Table 7: T-test statistics of ADF test (paddy quantity)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT*	T**	NT	T	NT	T	NT	T
Esfahan	-1.91	-2.71	-5.06	-5.65	-5.12	-5.43	-5.33	-5.32
Khozestan	-2.11	-0.97	-3.49	-3.39	-3.49	-3.37	-3.49	-3.38
Fars	-3.88	-5.03	-3.84	-3.82	-3.62	-3.66	-3.44	-3.60
Kohkeloyeh & Boyer Ahmad	-1.61	-2.44	-1.27	-1.37	-1.21	-1.39	-1.11	-1.44
Gilan	-1.03	-3.26	-2.09	-2.43	-2.22	-2.48	-2.47	-2.58
Mazandaran	-2.56	-3.10	-3.62	-3.64	-2.68	-3.28	-3.10	-3.95

* Regression equation without trend and ** Regression equation with trend

Table 8: T-test statistics of ADF test (quantity indices)

	Wheat		Paddy	
Index/Ouput	NT*	T**	NT	T
Laspeyres	-1.38	-2.49	-2.25	-3.01
Pacheh	-1.30	-2.42	-2.42	-3.02
Fisher	-1.33	-2.45	-2.33	-3.02
Tornqvist	-1.37	-2.46	-2.41	-3.07

* Regression equation without trend and ** Regression equation with trend

Table 9: T-test statistics of cointigeration test(wheat quantity)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT*	T**	NT	T	NT	T	NT	T
East Azarbayejan	-	-	-	-	-	-	1.47-	2.62-
Esfahan	-2.32	-2.56	-2.30	-2.50	-2.31	-2.52	-2.32	-2.53
Ilam	-1.61	-2.62	-1.53	-2.55	-1.58	-2.58	-1.62	-2.63
Boshehr	-1.57	-2.43	-1.46	-2.43	-1.51	-2.43	-0.81	-2.49
Tehran	-2.83	-2.68	-2.85	-2.63	-2.84	-2.56	-2.90	-2.64
Khozestan	-2.12	-3.01	-2.03	-2.95	-2.07	-2.98	-2.11	-2.99
Zanjan	-2.56	-2.59	-2.52	-2.54	-2.54	-2.56	-2.53	-2.58
Semenan	-2.23	-2.62	-2.12	-2.54	-2.22	-2.57	-2.20	-2.57
Sistan & Balochestan	-1.42	-2.43	-1.40	-2.40	-1.41	-2.42	-1.44	-2.44
Gilan	-1.53	-2.84	-1.52	-2.84	-1.52	-2.83	-1.52	-2.87
Lorestan	-2.58	-2.64	-2.62	-2.56	-2.60	-2.60	-2.58	-2.63
Markazi	-2.58	-2.49	-2.56	-2.93	-2.57	-2.95	-2.55	-2.95
Hormozgan	-1.99	-2.61	-1.90	-2.52	-1.94	-2.56	-2.00	-2.58
Yazd	-2.53	-2.50	-2.45	-2.45	-2.49	-2.48	-2.53	-2.45

* Regression equation without trend and ** Regression equation with trend

from stationary series ρi are acceptable without applying any additional test. Therefore, log relative prices of wheat were independence from log group prices in West Azarbayjan, Esfahan, Ilam, Charmahal & Bakhtiari, Khorasan, Khozestan, Zanjan, Sistan & Balochestan, Kermanshah, Kohkeloyeh & Boyer Ahmad, Gilan, Markazi, Hormozgan and Hamedan for all indices and in Semenan for Pacheh and Fisher indices and in Kerman for Laspeyres and Tornqvist indices. If ρi was nonstationary, the cointegeration test has been applied to examine independence of ρi from RI. Results of cointegration test revealed that also nonstationary ρi are independent from RI.

In Esfahen, Khozestan,Fars and Mazandaran provinces contrast with Kohkeloyeh & Boyer Ahmad and Gilan log paddy prices were stationary relative to all indices. As log group prices were nonstationary, independence of ρi from RI was accepted for stationary series ρi without any additional test and for nonstationary series ρi from cointigeration test results (Table 5).

Table 10: T-test statistics of cointigeration test (paddy quantity)

	Laspeyres		Pacheh		Fisher		Tornqvist	
Province/Index	NT*	T**	NT	T	NT	T	NT	T
Esfahan	-3.69	-3.46	-	-	-	-	-	-
Khozestan	-4.19	-3.82	-	-	-	-	-	-
Kohkeloyeh & Boyer Ahmad	-3.04	-3.08	-1.29	-1.64	-1.36	-1.68	-1.47	-1.68
Gilan	-	-	-1.60	-1.92	-1.52	-1.93	-1.30	-1.95
Mazandaran	-3.45	-3.45	-	-	-	-	-	-

* Regression equation without trend and ** Regression equation with trend

Consequently, GCCT was satisfied and consistent geographic aggregation of province-level data to national-level was supported for both wheat and paddy prices. Table 6 gives the results of nonstationary test for log relative quantity of wheat.

According to these findings, ρi series were stationary in West Azarbayejan, Charmahal & Bakhtiari, Khorasan, Fars, Kordestan, Kerman, Kermanshah, Kohkeloyeh & Boyer Ahmad, Mazandaran and Hamedan for all idices and East Azarbayejan for Laspeyres, Pacheh and Fisher indices, whereas nonstationary hypothesis could not be reject in other provinces. Log relative quantity of paddy ρi was stationary in Fars province for all indices, in Esfahan, Khozestan and Mazandaran for Pacheh, Fisher and Tornqvist indices and in Gillan for Laspeyres index (Table 7). Also log group quantity indices were found to be nonstationary for both outputs. Therefore, cointegeration test was established to investigate independence nonstationary ρi from RI for each output (Tables 9 and 10), whereas stationary series ρi were independent from RI. The cointigeration test results verified independence ρi from RI for each output and all indices except to Laspeyres index for paddy. Then the GCCT test conclusions are similar prices data. On the other hand, aggregated quantity data with all indices would be consistent for wheat and also paddy (except with Laspeyres index).

CONCLUSIONS

Aggregate consistency is an important issue in empirical production analysis. When consistent geographic aggregation is achieved, aggregated models give reliable inferences about the behavior of individual geographic units. In this paper, the generalized composite commodity theorem was used to test consistent geographic aggregation for price and quantity of wheat and paddy outputs. Consistent geographic aggregation with all indices was supported with the GCCT test for price and quantity of each output, except for paddy quantity data that aggregated with Laspeyres index [7-9].

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