CHEMICAL ENGINEERING TRANSACTIONS
VOL. 46, 2015

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Peiyu Ren, Yancang Li, Huiping Song

ISBN 978-88-95608-37-2; **ISSN** 2283-9216 DOI: 10.3303/CET1546073

Equilibrium Analysis of the Supply Chain of Special Agricultural Products in Hunan Province - A Case Study of the Citrus Industry

Xin Lei

Dept. of Economy & Trade. Hunan Vocational College of Commerce, Shangsha, 410205, China
502141050@qq.com

This paper carries out a case study of the industrial supply chain of citrus, the main agricultural product in Hunan province, employs the traditional Walrasian Equilibrium Model to evaluate the development of the citrus supply chain industry, uses the systematic equilibrium model and all layers of equilibrium models to analyze the independent decision-making behavior of yield, price and total output value as well as their interaction, and finally verifies the rationale behind the location choice of the citrus supply chain.

1. Introduction

As the main cash crop of Hunan province, citrus has, due to various factors, maintained a relatively high price in the market from the statistical data of the citrus industry over the years. Since the Walrasian Equilibrium Model reflects the basic idea of general equilibrium analysis, it will be more targeted to use this model to analyze how location factors lead to the differences of the industrial development. Therefore, it will be helpful to improve the competitiveness of Hunan citrus industry through using this idea to analyze this industry's comparative advantages and evaluate its competitiveness.

2. Walrasian equilibrium model

Suppose there is an auctioneer who will organize transactions in the market. The exchange of goods begins with the auctioneer's bidding, proceeds with the adjustments of the bidding price and ends when the demand is equal to the supply. The first bidding is random, but afterwards the transaction proceeds on the basis of constant biddings when supply is compared with demand. If supply is not consistent with demand, the second bidding will, according to the actual condition between supply and demand, improve the price of the goods when demand exceeds supply and lowers the price when supply exceeds demand, and gradually approaches the equilibrium.
The condition of Walrasian Equilibrium is that the citrus yield allocation should make the price level be consistent with its price. It is assumed that the environment has little impact on the spare time, thus the relative environment price of citrus has no impact on its absolute price. However, these two aspects are relevant to the interest at the relative price of citrus. Therefore, as long as these two relative price levels are chose to the price of citrus, the supply of citruses will be totally controlled by the department whose sales price is high and the low-price department will supply near on citruses unless there is a well-planned distribution mechanism. This equilibrium condition can be expressed in the following equation:

$$W_p = W_m = W \tag{1}$$

Likewise, the equilibrium condition in the quantity regulation market and the non-quantity regulation market is

$$p_p = p_m = p \tag{2}$$

Please cite this article as: Xin L., 2015, Equilibrium analysis of the supply chain of special agricultural products in hunan province - a case study of the citrus industry, Chemical Engineering Transactions, 46, 433-438 DOI:10.3303/CET1546073

For an economic organization, the actual price of citrus will be of particular interest since it is the actual price that determines the industrial distribution. Therefore, under the state of Walrasian Equilibrium, the citrus productivity decided by the non-production departments is exactly equal to the common price level in the market of the high-price citrus production area. The Walrasian Equilibrium in the citrus market of citrus-producing areas can be expressed as the following equation:

$$L_p^s(W_p, W_m) = \alpha\beta K_p^* \tag{3}$$

$$L_m^s(W_p, W_m) = L - \alpha\beta K_p = \Phi_1(K_m^*, \omega) \tag{4}$$

$$C^d(R_i, \overline{M}_i, p) + I_g^* + \tilde{E} = \beta K_p^* + F(K_m^*, L - \alpha\beta K_p^*) \tag{5}$$

Here, $C^d = C_p^d + C_m^d$ (6)

The most critical variable of citrus industry is the industrial economy of fixed capital. Because the citrus industry is particularly abundant, it can be changeable. That is to say, the citrus industry is relevant with condition on the majority of economic development restraints. Therefore, with the market-oriented reform in rural area and the development of citrus industry, the role of planning tools will be greatly undermined and finance and taxation will become increasingly prominent economic means of the citrus industry. As a reference, Walrasian Equilibrium just describes an ideal state, which is hard to be presented in reality. When the citrus industry is under various non-equilibrium states, different policies should be carried out to reduce the degree of non-equilibrium. Moreover, the existence of quantity configuration excludes the possibility of the Walrasian Equilibrium state described above. The most basic relationship in the model is that the price of quantity configuration goods is lower than the market price whereas the price of quantity configuration citrus is generally higher than its market price.

$$W_p > W_m, \qquad p_p < p_m$$

The Walrasian Equilibrium state of citrus is that under the condition of Wp>Wm and pp<pm, what non-Walrasian Equilibrium states the citrus industry may be in, what features these non-equilibrium states have and what macroeconomic policies and suggestions can be offered to reduce the macro non-equilibrium phenomenon. One common feature shared by the following non-equilibrium states is that the two aspects about transactions of the quantity sector are always in a non-equilibrium state. In the former, the supply exceeds the demand; in the latter, the demand exceeds the supply.

$$L_p^s(W_p, W_m) > \alpha\beta K_p \tag{7}$$

$$C_p{}^d = (R_i, \overline{M}_i, p_p, p_m) + I_g > \beta K_p \tag{8}$$

Equilibrium can only be obtained after quantity configuration,

$$C_p^* + I_g^* = \beta K_p \tag{9}$$

$$L_p^* = \alpha\beta K_p \tag{10}$$

On the premise of quantity configuration, there are probably three different equilibrium or non-equilibrium states in the market.
The market-oriented production department has been under the state of equilibrium in two markets.

$$L_m^* = \Phi_1(K_m, \omega) = L - \alpha\beta K_p \tag{11}$$

$$Y_m{*} = G(K_m, \omega) = C_m{}^d(R_i, \overline{M}_i, p_p, p_m, \overline{C}_p) + \tilde{E} \tag{12}$$

Here, the quantity price and the product price of citrus differ from the market price and the citrus market price because the effective price mechanism has maintained a state of equilibrium on the premise of complete distribution. On the basis of the above analysis, such a balance should be built on the premise that the bottleneck restraint of investment, a popular quantity restraint in the citrus industry, does not exist, and therefore the production area allocation can be assigned by the non-production department according to the actual citrus price. In the rural area where the citrus industry enjoys a vast market, the actual citrus price in the non-production department exactly equals to the difference between the citrus supply and the market equilibrium price on the premise of complete distribution. Through giving full play of the price mechanism, the product supply market realizes the complete distribution of the total demand, and the citrus industry has reached the maximum supply level of complete distribution in a short period of time. Any macroeconomic policy can do nothing about enhancing the citrus industry economy, since this industry has reached the supply level of complete distribution during a short period of time. The policy of increasing taxation to increase investment can only produce a crowding out effect to the consumption demand in a short time. Equilibrium can be realized through the price adjustment in the market, yet unemployment can arise from the restraint of bottleneck investment in the rural citrus market.

$$L_m{}^* = \Phi_2(K_m, \frac{\overline{R}_m}{y_m}) < L - \alpha\beta K_p \tag{13}$$

$$Y_m{}^* = \frac{\overline{R}_m}{y_m} = C_m{}^d(R_i, \overline{M}_i, p_p, p_m, \overline{C}_p) + \tilde{E} \tag{14}$$

According to the signal of market price, to expand distribution and improve the level of citrus industrialization, the local government has adopted the expansionary macroeconomic policy (demand management policy) to promote the level of distribution. The structural adjustment of citrus industrial economy, which is also an issue of quantity price adjustment, is related to its long-term performance. The restraint of bottleneck investment of products on the economic activity of citrus industry is a result of the long-term implementation of quantity price.

The excess supply in the non-quantity regulation market coexists with the unemployment in the rural citrus market of citrus production area,

$$L_m^* = \Phi_2(K_m, Y_m^d) < L - \alpha\beta K_p \tag{15}$$

$$Y_m{}^* = F(K_m, L - \alpha\beta K_p) > Y_m^d = C_m{}^d(R_i, \overline{M}_i, p_p, p_m, \overline{C}_p) + \tilde{E} \tag{16}$$

Within a short period of time, since the market price and price level are assumed to move downward due to the rigid demand, the excessive aggregate demand will be tightening all of a sudden and the production capacity of non-production department will greatly affect the surplus of the production department. On the contrary, the supply and price reform of some excess industries can't be totally decided by the quantity price in reality. After the quantity price is released, the non-production market regulation department will transform to be the production department. To meet the market demand of the production department, the yield of citrus will increase substantially. Under the unequilibrium condition, all the Keynesian expansionary fiscal and monetary policies will have a positive impact on the citrus industry, thus promoting the economic activity and enhancing the distribution level.

3. Empirical analysis

3.1 The selection of research sample

This paper selects the citrus industry data of 14 cities in Hunan province in 2003, which is very representative and typical. All the original data in this sample comes from Hunan Statistical Yearbook, thus guaranteeing the accuracy and authority of data source. The original data is shown in the following table:

Table 1: Original Data

city	yield	price	total output value
Changsha	696.0	5.9	130.41
Zhuzhou	738.5	5.7	25.06
Xiangtan	826.5	5.7	50.14
Hengyang	1027.9	4.8	58.05
Shaoyang	1116.8	5.3	64.87
Yueyang	1154.4	5.5	62.86
Changde	1357.0	5.8	65.34
Zhang Jiajie	1655.3	4.6	68.88
Yiyang	1957.0	4.6	79.11
Chenzhou	2366.2	4.6	99.89
Yongzhou	2808.6	4.4	92.67
Huaihua	3251.6	4.3	99.77
Loudi	3239.5	4.3	76.25
Xiangxi	3606.3	4.3	69.38

3.2 Regression analysis

As can be seen from the above analysis, three sub-dimensions which affect regional distribution of the citrus industry have a positive correlation with the industrial decision-making and the correlation is relatively significant. To have a further understanding of the change of their quantitative relationship, a stepwise multiple linear regression analysis is carried out. During the process of stepwise regression analysis, qualified predictive variables will enter the regression equation and testify it immediately whereas unqualified variables will be eliminated.

Table 2: Multiple Regression Model Parameters of Regional Distribution of the Citrus Industry

Model	R	R2	Adjust R2
1	.704a	.495	.494
2	.673b	.453	.452
3	.635c	.403	.403

R refers to the correlation coefficient between the independent variable and the dependent variable; R2 stands for the coefficient of determination of the regression analysis, which reflects the closeness between the regression curve and the scatters formed by independent variable and dependent variable; Adjust R2 represents the a new R2 which has been adjusted when enough independent variables are eliminated to realize the goodness whether that is fit of the model or not.△R2 means the proportion that regression model errors account for of the total errors. It shows that the regression model matches the data very well.

a. Predictive variable: constant, yield

b. Predictive variable: constant, yield, price

c. Predictive variable: constant, yield, total output value

As shown by the data in Table 3.2, R2 in Model 3 is 0.403, which suggests that the regression equation can explain 40.3% of the total variation. That is to say, three sub-dimensions of geographical distribution of the citrus industry have collectively explained 40.3% of the variation of industrial decision-making, indicating that these relevant sub-dimensions can explain well the industrial decision-making. The three sub-dimensions of yield, price and total output value can respectively explain 30.3%, 7.4% and 2.6%.

Table 3: Statistical Table of Variance

Model	Sum of squares	df	Mean Square
1	Regression	88.131	3
	Residual	89.835	996
	Total	177.966	999
2	Regression	80.675	2
	Residual	97.291	997
	Total	177.966	999
3	Regression	72.222	1
	Residual	106.854	1003
	Total	179.076	1004

a. Predictive variable: constant, yield
b. Predictive variable: constant, yield, price
c. Predictive variable: constant, yield, total output value

The above table is about variance analysis, which contains variance source, sum of squares, degree of freedom (df), the value of F and significance level. As can be seen from the table, F is 677.920, the accompanied probability value is 0.000, which is smaller than 0.01, reflecting that the model's regression effect is significant.

Table 4: Table of Regression Coefficient

Model		non-standardized coefficient		standardized coefficient	T	Sig.
		B	standard error	trial version		
1	(constant)	.787	.072		11.005	.000
	yield	.728	.028	.635	26.037	.000
2	(constant)	.625	.071		8.844	.000
	yield	.567	.032	.496	17.975	.000
	price	.228	.024	.263	9.507	.000
3	(constant)	.033	.094		.352	.725
	yield	.505	.031	.442	16.238	.000
	price	.329	.036	.231	9.092	.000
	total output value	.469	.024	.195	7.053	.000

As can be seen from the table, accompanied probability of yield and price and total output value have reached the level of significance, and all the three factors have entered the regression equation successively. According to the multiple regression model $y=b0+b1X1+b2X2+b3X3+…+bjXj+e$, the non-standardized coefficient B is substituted in the model equation, then we can get the regression equation as $y=0.033+0.505X1+0.329X2+0.469X3$. In this equation, y is the dependent variable, namely the industrial decision-making index; X1, X2 and X3 represent the relevant sub-dimensions of geographical distribution of the citrus industry: respectively the yield, price and total output value.

As the equation suggests, all the three factors have positive influence on the dependent variable. To be specific, the more support the overall supply chain has for geographical distribution of the citrus industry, the more benefit it will bring to the industrial decision-making. These factors' correlation coefficients are close, which proves that the independent variables (relevant dimensions of geographical distribution of the citrus industry) selected in the research hypothesis can be regarded as the main influence factors of the dependent variable (the relevant dimension of industrial decision-making), and they have different features in terms of their influence conditions of industrial decision-making. Meanwhile, it can be noted that price and total output value have a greater variable slope, namely that these two variables have a greater impact on industrial decision-making than yield. And this is consistent with the result of relevant analysis.

A significance test is carried out on the regression equation.

As can be learned from Model 3 in the table of variance analysis, F is 677.920 and the significance level is 0.000, therefore the correlation of regression equation is very significant. Through the regression and other relevant analyses, yield, price and total output value, the three dimensions of geographical distribution of the citrus industry, have a significant linear correlation. Besides, when they increase by a unit at the same time, the industrial decision-making increases respectively by 0.305, 0.529 and 0.469. In other words, during the process of industrial decision-making, price and total output value can exert a greater impact. These three factors can be ranked in terms of their influence on industrial decision-making from the greatest to the least: price, total output value and yield.

3.3 Result analysis and evaluation of empirical analysis

On the macro level, in the overall market of the citrus industry, there is no obvious change about the number of technically and efficiently pioneering industries after eliminating the environment variable and random variable, which indicates that the overall efficiency of our country's citrus market is rarely affected by the environment. Meanwhile, the efficiency value of domestic citrus market is very low. After the adjustment of Gross Regional Product, this industry's efficiency value averages to be 1, which suggests that its internal management efficiency and scale efficiency have reached a relatively high level, can cope very well with the external influence and maintain high operation efficiency under different economic environments.

On the micro level, there are obvious regional differences on individuals. Due to the influence of geographical location and transportation, the citrus price and total output value will change significantly, which can lead to the fact that some areas which enjoy convenient transportation will have unique advantages over high price and yield areas thanks to their logistics benefits. Within the internal logistics area, logistics can develop at a close degree in different places whereas the logistics in different logistics areas can develop very differently. Besides, these areas can make full use of their logistics advantages to further process the citrus industry so as to improve the product's added value.

4. Conclusions

As can be found from the empirical analysis, some high-yield areas fail to achieve a satisfying sales effect and the scale economics effect due to its geographical restraint and transportation limitation. This situation can be improved from the following aspects. First, these areas should follow a path of product deep processing. Citrus enterprises in inconvenient areas should, starting from their own needs for development, actively introduce new technologies, new products, new techniques and new facilities, vigorously develop intensive processing, expand the industrial chain, emphasize upon improving the product quality, create the agricultural brand, expand the management scale and enhance the comprehensive efficiency and level of agriculture. Second, these areas should accelerate the construction of agricultural product logistics distribution centers. They should build a number of global and pivotal logistics infrastructure, innovate and construct a number of modern warehouses and distribution centers, strengthen the level of logistics management so as to meet the needs for constant and rapid economic development.

References

Duan C.W., 2007, Study of Key Issues of Supply Chain Competitive Advantages. Beijing Jiaotong University, 7.

Gui L.J., 2005, Study of Supply Chain Cost Management and Integrating Methods. Nanjing University of Science and Technology.

Hong Y.X., 1998, The balanced and unbalanced analysis of economy operation, Shanghai Sanlian Bookstore.

Sui M.G., 2000, Study of Supply Chain Inventory Costs and Its Development Trend. Modernization of Management, 5.

Yi Y.N., 1999, Unbalanced Chinese economy, Guangdong Economy Press.

Yuan Z.G., 1994, Unbalanced growth theory study and its practical significance, Journal of Fudan University, 5.

Zhou W.Y., 2009, Ma Tianshan. Application of Zero Inventory Control Theory in Manufacturing Enterprises Logistics Technology, 28, 8.

Zhu J.M., 1988, Unbalanced growth, Shanghai Sanlian Bookstore.