Coordination of Agricultural-super Docking Supply Chain Based on policy of government

SU Yingsheng, Southwestern University of Finance and Economics; YUAN Xigang., Southwestern University of Finance and Economics; WU Jiang, Southwestern University of Finance and Economics ; ZHANG Wen, Ping'An Bank of Chongqing; JI Pengfei, Ben Xi Statistical Bureau

Abstract

Based on Buyback agreement of Stackelberg Game, this article analyzed the impact of sharing buyback cost for optimal production and different choices of supermarkets and farmer professional cooperatives in distribution model and direct model for agricultural-super docking supply chain in china. At the same time, this article designed a buyback agreement model and explores the nature of buyback agreements. We found that the buyback agreement under the direct model is the best choice for supermarket; while the best choice depends on the circumstances for farmer professional cooperatives. In this case, appropriate subsidies of Government play an important role for agricultural super docking.

Introduction

In china, the price of agricultural products has been one of the main issues concerned by government and residents. In the last ten years, there exists a great contradiction between supply and marketing in the prices of agricultural products. On one hand, consumers bear the high prices of agricultural products, on the other hand, the purchase price of the agricultural products is very low, on average, only 1/8 terminal market prices. The main reason is that from production to the market, the supply chain has experienced too many intermediate links, such as buyers, multistage wholesalers, sellers and so on. Too many intermediate links lead a great difference between origin and sale prices. Thus, reduction of intermediate links is important for the balance of agricultural prices. The agricultural-super docking is an effective supply chain which can reduce marketing links.

Agricultural-super docking means the intent agreement signed by farmers or farmers' cooperative organizations and businesses, a new circulation pattern which supply agricultural products to supermarkets, vegetable market and convenience store directly by famers or farmers' cooperative organizations. Agricultural-super docking is not only a special case in China, but it also occurrence in emerging economies in Asia and other countries. For example, most of the supermarket in Tokyo has implemented the "direct selling" model, with the help of the local association, the supermarket sign contract with the local farmers, directly. The implementation of the agricultural-super docking improved the situation of Japan's high prices. On the other hand, the products circulation mode in American agricultural including "production straight hanging" mode dominated by the farm-

ers and "direct selling" model dominated by the supermarket. The agricultural production regionalization degree is higher in American, producers are all the farmers, all these factors determine the agricultural production is concentrated in American. Farmers have the ability and strength to find the demander for agricultural products, and provide a large number of fresh agricultural products, directly. In some developed countries, agricultural super docking has had for decades. In china, because of the development of supermarkets and farmers' cooperative organizations, agricultural super docking is a new supply chain. It connects supermarkets and farmer professional cooperatives directly, farmer professional cooperatives and supermarkets sign the intent agreement which can dock production and sale effectively and realize the marketing effect of leading production direct to market. Implementation of agricultural super-docking has a significant impact on the entire agricultural supply chain, especially on fresh product supply chain. In a sense, agricultural super-docking is a reconstruction of the agricultural supply chain, reduces intermediate links, so that agricultural products reach the hands of consumers faster. Through this model, supermarkets get cheap agricultural products which form a price advantage. At the same time, supermarkets can put the profits of intermediate businesses to farmers and farmers benefit. In addition, agricultural product is one of the highest frequencies of buying goods which closely related to daily life. Consumers' requirement of health and safety food directly contributed to the development of agricultural super docking, and pollution food, green food, organic food began to be sold in supermarkets. Agricultural super docking is a win-win situation for agricultural products circulation patterns.

From December 2008, the Ministry of Commerce and the Ministry of Agriculture Farm in China began to carry out experimental work in nine companies, to the year 2011, "the Directive opinion of Ministry of Commerce and Ministry of Agriculture about promoting Agricultural Super Docking " means comprehensive development of the agricultural super-docking period is coming. After four year pilot study, agricultural super-docking has achieved initial effects in cost reduction (about 20%), stabilizing prices, resolving conflicts and other aspects. However, because of the limited agricultural cooperative organizations, poor management and the incomplete infrastructure, agricultural super-docking coverage is still very narrow (currently covers only about 15 %, while in the Asia-Pacific region, the proportion is more than 70%, the U.S. 80%); Meanwhile, due to the lacks of ability

to resist risks and necessary bargaining chips, agricultural cooperative organization cannot bring the surplus profits to famers and promote their income. In addition, the supermarkets face the bottleneck of demanding, and the perishable characteristics of agricultural products resulted in the turnover per unit area is lower than the average turnover of supermarkets and other complex factors greatly hampered breadth and depth of agricultural super docking. After all, there are some blind spots in market regulation, then the government stood a global perspective to guide the production, introduce relevant policies and guide the risks which can make agricultural super docking more healthy and harmonious proceed. Yu Gutai (2009) believed that the Government's promotion will bring the agricultural super docking more motivation, and the three parties of agricultural super docking, supermarket and government are all necessary. Under the guidance of the "visible hand" of government, the agricultural super docking will have a bright future.

In terms of coordinating the supply chain, Zhang Guo Quan (2013) built an action choice evolutionary game model in the process of agricultural super docking by using evolutionary game theory and analyzed factors which can promote the better development of agricultural super docking. The result shown that it has a positive correlation between choose positive strategy probability and docking income, it has a negative correlation between docking risk coefficient and risk cost. Liu Lei (2012) contrast the price of agricultural product and the quality of demand when two sides in the competition and cooperation in the agricultural super docking model by using non-cooperative game and cooperative game theory. They draw a conclusion that the cooperative game model is better than that of the non-cooperative game model. Fei Wei (2013) built a model in which farmers can participate, and the supermarket want to protect the quality of agricultural products based on the principal-agent theory. They put forward effective suggestions and policy guidance. Li Xin Jian (2013) studied the cooperative relationship between supermarkets and farmers based on the principal-agent theory, the incentive mechanism model is constructed in the paper, and they give some suggestions to optimize supply chain. Zhang Fang (2015) built the supermarket incentive model for farmers in information asymmetry based on the principal-agent theory. The result shows that it can reduce the supermarket agent cost by improving the farmers' output coefficient, reducing the cost of farmers' effort coefficient and decreasing the farmers' aversion degree. At the same time, it can increase the expected utility of supermarket and the farmers' expectation income.

In terms of buyback contract involving the supply chain, Pasternack (1985) did the first study about buyback contract, he used a newsboy model with seasonal sales of stochastic demand and insufficient or excess cost conditions, and pointed out that the right choice of parameters can guide retailers to choose the right orders in order to make the entire supply chain to achieve optimal, while allowing the profits of suppliers and retailers to achieve Pareto optimality. Mantrala and Raman (1999) studied a buyback contract between a supplier and two retailers considering whether there is a relationship between the demands of the two retailers, after conducting numerical analysis, they found that the risk attitude of retailers is determined by supplier, and the demand variables have no effect on the retailer's optimal decision. Emmons and Gilbert (2000) used multiplicative model of retail price to discuss demand variable, and verify that in the uncertainty situation, manufacturers will increase their profits through repurchasing the products which are not sold. Xiaohang and Raghunathan (2007) studied the situation that buyback strategy makes the benefit of the whole supply chain higher than the benefit of the supply chain without buyback strategy in the case of asymmetric information. Brown, Chou and Tang (2008) studied the buyback agreement about multi-product in IT industry. Compared with non-joint repurchase contract, the expected profit of supplier may increase or decrease which will guide supplier to decide when to use joint buyback contract. Chen Jing and Peter C. Bell (2011) designed a contract which included two buyback prices, one for unsold inventory and one for customer returns, and shown that this contract can achieve perfect supply chain coordination and be a win-win for both manufacturer and retailer. Chen Jing (2011) considered a single period problem in a supply chain in which a Stackelberg manufacturer suppliers a product to a retailer who faces customer returns and demand uncertainty. They show that the manufacturer incurs a significant profit loss with and without a buyback policy if it failed to account for customer returned in the wholesale price decision. Biao Zhang, Song Feng Lu, Di Zhang and Kun Mei Wen (2014) introduces the interval as the demand of production into the model of supply chian. They represent uncertain and fuzzy demand by a fuzzy random variable in a supply chain system based on a two-level buyback contract for a newsvendor model with a single cycle. Stephan Sluis and Pietro De Giovanni (2016) identified the key factors in selecting a buyback contract in a supply chain by investigating their performance, supply chain orientation, and supply chain integration.

This paper attempts to add the role of government in the secondary supply chain and explore the impact of sharing repurchase cost on optimal production and the choices of supermarkets and farmers' professional cooperative organizations. This paper focuses on the buyback agreement - farmer professional cooperatives repurchase supermarket sales of agricultural products which are not sold at the end of the quarter, and farmer cooperatives bear only a certain percentage of the buyback cost, the remaining cost was taken by the government. This article chapters are distributed as follows: The first chapter introduces the concept and current satiation of agricultural-super docking, and then reviews literature on agricultural super-docking and buyback agree-

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ments; Chapter II introduces symbols and assumptions of the model, and then points out the specific form and some properties; Chapter III makes a comparative analysis with examples; Chapter IV makes a brief summary of this paper.

Model and Solution

A.   Symbols and assumptions

Symbols in the model will be discussed in details below.

P: Unit retail price in supermarket；

q_1: Production of farmer professional cooperatives；

q_2: Supermarket orders at farmer professional cooperatives；

c_u: Unit loss of reputation of supermarket with insufficient inventory；

c_0: Unit save cost with the excess inventory；

s_r: Unit wholesale price of farmer professional cooperatives；

c: Unit production cost of farmer professional cooperative；

c_r: Unit buyback price of products which are not sold at the end of the quarter;

c_s: Unit residual value of buyback products；

γ : The percentage of the buyback cost taken by farmer professional cooperatives ($0 \leqslant \gamma \leqslant 1$), the percentage of buyback cost taken by government is $1 - \gamma$；

x：Actual market demand；

There are basic assumptions as follows.

(1) Farmer professional cooperatives and supermarket both are rational, and then they will choose to maximize their expected profits；

(2) Products are perishable goods and supermaekets can order one time in a sales cycle time;

(3) Farmer professional cooperatives can sell the buyback products which are not bad at a low price as livestock feed and organic fertilizer；

(4) Farmer professional cooperatives know the sale price, demand distribution, the loss of reputation with less inventory, and holding cost with excess inventory;

(5) The market demand x is normal distribution $x \sim N(\mu, \sigma^2)$,the normal distribution function is $F(x)$, the normal density function is $f(x)$;

(6) Without loss of generality, $s_r > c_r > \dfrac{c_s}{\gamma}$;

Meanwhile, normally $p \geq s_r > c$, c_u and c_0 both are very small；

This article only considers the supply chain with one farmer professional cooperative and one supermarket, and there is no sales promotion in supermarket.

We assume that the farmer professional cooperative can meet the needs of supermarket;

B. The buyback agreement in distribution model

In china, 60% supermarkets take the distribution model. In this model, at the beginning of the sale season, the farmer professional cooperative sells all the products with unit price s_r to the supermarket. At the end of the sale season, the farmer professional cooperative repurchases the products which are not sold with unit price c_r from the supermarket. In order to encourage the supermarket to promote the sale of agricultural products, the buyback price should be lower than the wholesale price. As a vigorously advocated project of government, government will share the buyback cost, and the percentage of sharing buyback cost is $1-\gamma$。For the supermarket, when the demand x is less than the output q_1, the supermarket will get c_r (q_1-x) because of the resale of excess products，but at the same time, the supermarket will bear the cost of saving the excess part of the products c_0 (q_1-x); When the demand x is not less than the output q_1, then the supermarket have to face the loss of reputation because of low stocks.

The agricultural professional cooperative sell all the products to the supermarket with the unit price s_r, at the end of the sale season, repurchase the unsold products with the price c_r. Meanwhile, government will share the buyback cost with the percentage. When the demand is between [0, q_1], the supermarket has unsold products, and then the farmer professional cooperative will repurchase the unsold products; But when the demand is between [q_1,∞], the farmer professional cooperative does not need to take buyback cost. We can write down the profit of the farmer professional cooperative as follow:

$$\pi_S = \begin{cases} (s_r - c)q_1 - \gamma c_r(q_1 - x) + c_s(q_1 - x), & x < q_1; \\ (s_r - c)q_1, & x \geq q_1. \end{cases}$$

(1)

At this time, the expected profit is

$$E_G[\pi_S] = (s_r - c)q_1 - \int_0^{q_1} (\gamma c_r - c_s)(q_1 - x)f(x)dx$$

(2)

The first and second order partial derivatives of q_1 is:

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$$\frac{\partial E_G[\pi_S]}{\partial q_1} = s_r - c - (rc_r - c_s)F(q_1)$$
(3)

$$\frac{\partial^2 E_G[\pi_S]}{\partial q_1^2} = -(rc_r - c_s)f(q_1) < 0$$
(4)

Because the second order partial derivatives of q_1 is less than 0, $E_G(\pi_S)$ is a concave function on q₁, and then we can get the maximum value of $E_G(\pi_S)$; When $\frac{\partial E_G[\pi_S]}{\partial q_1} = 0$, we can calculate the best q₁, and put q₁ into $E_G(\pi_S)$, and then we can get the maximum expected profit of the agricultural professional cooperative. Because $F(x)$ is an normal distribution function, and then $F(x)$ has an inverse function, we can find

$$q_1^* = F^{-1}\left(\frac{s_r - c}{\gamma c_r - c_s}\right).$$

At the beginning of the sale season, the farmer professional cooperative sell all the products to the supermarket, and at the end of the season, it will repurchase the unsold products. Thus, the supermarket does not determine the orders. So the profit of the supermarket can be expressed as:

$$\pi_R = \begin{cases} px - s_r q_1 + c_r(q_1 - x) - c_o(q_1 - x), & x \le q_1; \\ pq_1 - s_r q_1 - c_u(x - q_1), & x > q_1. \end{cases}$$
(5)

The expected profit is:

$$E_G[\pi_R] = \int_0^{q_1}[px + (c_r - c_o)(q_1 - x)]f(x)dx + \int_{q_1}^{\infty}[pq_1 - c_u(x - q_1)]f(x)dx - s_r q_1$$
(6)

We have already calculated the optimal production q_1^*, and the supermarket knows the wholesale price and buyback price. Thus, the expected profit of the supermarket is only related with the retail price. From (6), we can find $E_G(\pi_R)$ increases with the increase of retail price, in other words, the supermarket maximizes the expected profit when the retail price is the maximum. When the market price is exogenous variable, in the distribution model, the supermarket is a passive recipient of buyback agreement of agricultural-super docking.

C. The buyback agreement in direct model

In the direct model, at the beginning of the sale season, the supermarket order the number q_2 of agricultural products

from farmer professional cooperative; at the end of the sale season, the supermarket sell the unsold products to the farmer professional cooperative with the unit price c_r. In this buyback agreement, the buyback price is not a fixed value; it depends on the market demand x-to-orders q_2 ratio. We assume $c_r = \frac{x}{q_2}s_r$. When $c_r = \frac{x}{q_2}s_r$, the less the quantity of the unsold products $q_2 - x$ is, the closer the buyback price is to the wholesale price. Thus, it will encourage the supermarket to decide the orders carefully in order to minimize the loss. Next, we will discuss the decisions faced by the farmer professional cooperative and the supermarket.

The supermarket orders the agricultural products from the farmer professional cooperative with the unit price s_r, and sells the unsold products with the unit price c_r to the farmer professional cooperative. Under the above assumptions, the profit of the supermarket is：

$$\pi_r = \begin{cases} px - s_r q_2 + c_r(q_2 - x) - c_o(q_2 - x), & x \le q_2; \\ pq_2 - s_r q_2 - c_u(x - q_2), & x > q_2. \end{cases}$$

$$= \begin{cases} px - s_r q_2 + (\frac{x}{q_2}s_r - c_o)(q_2 - x), & x \le q_2; \\ pq_2 - s_r q_2 - c_u(x - q_2), & x > q_2. \end{cases}$$
(7)

The expected profit is：

$$E_M[\pi_r] = \int_0^{q_2}[px + (\frac{x}{q_2}s_r - c_o)(q_2 - x)]f(x)dx$$
$$+ \int_{q_2}^{\infty}[pq_2 - c_u(x - q_2)]f(x)dx - s_r q_2$$
(8)

So, the supermarket focuses to maximize the expected profit, $\max E_M[\pi_r]$.

From(8), we can find that obtaining the express of q_2^* is very difficult，because(8)involves the inverse function of q_2 (This article assumes the existence of an inverse function of the normal distribution, and if you encounter the other situation which does not exist an inverse function of the distribution, it will be more complex to obtain the express of q_2^*) and q_2 contains a ceiling of calculus. We will discuss the related properties of the optimal orders through the analysis of the example in section 3.

At the beginning of the sale season, the farmer professional cooperative provides agricultural products to the supermarket at the unit price s_r; and at the end of the sale season, it repurchases the unsold products at the price c_r, the buyback products have residual value c_s. Thus, the profit of the farmer professional cooperative is:

$$\pi_s = \begin{cases} (s_r - c)q_2 - (\dfrac{x}{q_2}s_r - c_s)(q_2 - x), & x < q_2; \\ (s_r - c)q_2, & x \geq q_2. \end{cases} \quad (9)$$

Like the case of the supermarket, the expected profit of the farmer cooperative is:

$$E_M[\pi_r] = \int_0^{q_2} [px + \left(\frac{x}{q_2}s_r - c_0\right)(q_2 - x)]f(x)dx + \int_{q_2}^{\infty} [pq_2 - c_u(x - q_2)]f(x)dx - s_r q_2 \quad (10)$$

The farmer cooperative focuses to maximize the expected profit $\max E_M[\pi_s]$. In this function, q_2 is determined by Formula(8). So the farmer professional cooperative decides the wholesale price and buyback price to maximize the orders of the supermarket, then the profit of the whole supply chain is optimal- a win-win situation.

Numerical Models

In this part, we set the related parameters values of the repurchase agreement, and then compare the different buyback agreements in distribution mode and direct mode. Finally we will discuss how to choose the right buyback agreement to maximize the profits. (In order to express briefly, we record the buyback agreement in distribution model as P1, the direct model as P2)

We assume that a farmer cooperative cooperated with a supermarket in area A, this paper takes kiwifruit of the farmer cooperative as an example to study the buyback agreements. At the beginning of the sale season, the farmer cooperative provides kiwifruit to the supermarket or the supermarket buys the kiwifruit from the farmer cooperative. At the end of the sale season, the farmer cooperative repurchases the unsold kiwifruit from the supermarket. The wholesale price, retail price, the mean and variance values of demand are shown in Table 1 (per unit of the price is yuan, the unit orders is kg):

Table1 Assignment of parameters in model

Variables	Value	Variables	Value
p	6	s_r	2.5，3，3.5
c_u	0.50	c	$0.55 s_r$
c_o	0.50	c_r	[0,3.85]
μ	300	c_s	3
σ	10，20，30	γ	0.85

Source Description: Simulating the actual situation, we assign the parameters in the model. Based on different risk （σ=10,20,30）, we will discuss the choices of buyback agreements..

Through computing, in different wholesale price and different standard deviations, we can obtain the optimal buyback price(in P1),the optimal orders(or production), the optimal profits of the supermarket and the farmer professional cooperative as follow:

Table 2 Calculation of Optimum value

Whol esale price	Optimum value	P1			P2		
		$\sigma = 10$	$\sigma = 20$	$\sigma = 30$	$\sigma = 10$	$\sigma = 20$	$\sigma = 30$
$s_r = 2.5$	c_r	1.1	1.1	1.1			
	q^*	326.2	352.4	378.5	309.7	318.1	328.2
	$\max E[\pi_R]$	420.4	503.2	586.1	1040.3	1027.3	1012.9
	$\max E[\pi_S]$	1001	951.9	902.9	355	374.2	397.1
	$\max\{E[\pi_R] + ...\}$	1421.4	1455.1	1489	1395.3	1401.5	1410
	$\max E[\pi_R]/\max$	0.420	0.529	0.649	2.930	2.745	2.551
$s_r = 3$	c_r	1.4	1.4	1.4			
	q^*	382.1	464.2	546.3	308.2	316	323
	$\max E[\pi_R]$	667.9	930.8	1139.7	890.4	877.7	861
	$\max E[\pi_S]$	723.5	547	377.4	418.3	433.5	449.3
	$\max\{E[\pi_R] + E...\}$	1391.4	1447.8	1517.1	1308.7	1311.2	1310.3
	$\max E[\pi_R]/\max$	0.923	1.702	3.020	2.129	2.025	1.916
$s_r = 3.5$	c_r	1.6	1.6	1.6			
	q^*	327.3	354.6	380.1	307.8	313.2	319.4
	$\max E[\pi_R]$	560.8	649	736.6	740.4	727.3	712.5
	$\max E[\pi_S]$	683.9	617.8	553	481.1	491.3	503.3
	$\max\{E[\pi_R] + E...\}$	1244.7	1266.8	1289.6	1221.5	1218.6	1215.8
	$\max E[\pi_R]/\max$	0.820	1.051	1.332	1.539	1.480	1.416

In the case of different standard deviations in the same wholesale price, the optimum orders increases as σ increasing. In P1, the profit of the supermarket is increasing, but profit of the farmer professional cooperative is decreasing. However, the total profit of supplier and seller is increased. This may be due to the buyback price in P1 is a constant, the orders of the supermarket (the production of the farmer cooperative) is determined by the farmer cooperative. When the fluctuation in demand is larger (σ is larger), the farmer professional cooperative will take more risks, and the expected profit of the farmer professional cooperative will be reduced. In P2, the profit of the supermarket is reduced, the profit of the farmer professional cooperative has increased, but the total profit of both supplier and sellers is reduced. In P2, the buyback price is determined by the demand, when the fluctuation in demand is large, the loss borne by the supermarket may become larger.

In the case of different wholesale prices with the same standard deviation: In P1, the buyback price increases as s_r increasing, and the total profit of supplier and seller is declined, but the optimal production, the profits of the farmer professional cooperative and the supermarket are not appeared as increasing decreasing or unchanged. In P2, as s_r increasing, the orders is gradually reduced, but changes a little; the profit of the farmer professional cooperative is increased, the profit of the supermarket is declined and the total profit of both supplier and seller is also reduced. In P2, due to the increase in the wholesale price, the cost of the supermarket is increased, so the profit of the supermarket is reduced, and then the farmer professional cooperative appears to increase.

We use $\max E[\pi_R]/\max E[\pi_S]$ to analyze the distribution of the supply chain: in the case of the same σ, as s_r increasing, in P1, $\max E[\pi_R]/\max E[\pi_S]$ is increased, but in P2, $\max E[\pi_R]/\max E[\pi_S]$ is declined; in the case of the same s_r, in P1, $\max E[\pi_R]/\max E[\pi_S]$ is increasing as σ increasing, in P2, $\max E[\pi_R]/\max E[\pi_S]$ is decreasing as σ increasing. In other words, if the total profit of both supplier and seller compared to a cake, the farmer professional cooperative can share more cake with the change of buyback strategy and not just by changing the wholesale price and production.

Conclusions

This article established two kinds of buyback model of agricultural-super docking; and gave mathematical relationship of the optimal order decision (or output decisions) in these two modes. Through numerical analysis of examples，we can conclude that: The choices of two buyback agreements for agricultural cooperatives and supermarkets depend primarily on who take the risk and the level of the risk. In the distribution model, the quantity of agricultural products sold by supermarkets is higher than the quantity under the direct model. Therefore, supermarkets are not willing to take the direct model; especially there is relatively large fluctuation in market. In order to promote agricultural super-docking, government should give some tax relief to subsidize the gap. In the direct mode, the agricultural cooperatives are the main bearers of risk. When the fluctuation in demand is small, agricultural cooperatives and supermarkets are willing to adopt this approach. If the fluctuation in demand is large, the profit of agricultural cooperatives decline rapidly, or even negative profits. Government should take consideration to subsidize agricultural cooperatives.

This paper only considers the case of a farmer cooperative with a supermarket. For a number of farmer cooperatives and a supermarket or a case with one farmer cooperative and a number of supermarkets, this needs further study. And repurchase models in this paper are established under conditions of symmetric information. This is a question worthy of further exploration if the information is asymmetry.

Acknowledgments

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Biographies

YINGSHENG SU received the B.S. degree in Electrical Engineering from the University of Sichuan, Chengdu, China, in 2002, the M.S. degree in Management Science from the University of Sichuan, Chengdu, China, in 2006, and the Ph.D. degree in Management Science from the University of Sichuan, Chengdu, China, in 2009, respectively. Currently, He is an associate Professor of Management Science at Southwestern University of Finance and Economics. His teaching and research areas include supply chain management, control systems and system design. Professor SU may be reached at suys@swufe.edu.cn