International Food and Agribusiness Management Review
Volume 20 Issue 4, 2017; DOI: 10.22434/IFAMR2016.0160

Received: 28 September 2016 / Accepted: 13 February 2017

Is dairy complex a solution to milk safety? A comparison of farmers' perceived and realized food safety effects

RESEARCH ARTICLE

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Abstract

This study explores the major reasons for Chinese small dairy farms to accept the new organization structure, dairy complex (DC), and the discrepancies between the actual effect and farmers' perceptions. Our results show that the frequency of milk refusal, herd scale and farmers' age contribute to farmers' decision in accepting DCs, while sale price and disease prevention do not have significant influence. Independent farmers' perceived effects and the actual effects of DCs in improving raw milk safety and price are consistent, but there exists misperception of DCs' effect in disease prevention.

Keywords: dairy complex, food safety, perceived and actual effects, misperception
JEL code: Q12, Q18

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1. Introduction

The 2008 infamous scandal that Chinese tainted infant formula killed and sickened thousands of babies shocked the world and impacted the Chinese dairy industry dramatically (Ortega *et al.,* 2012). Illegal chemicals are added to milk by dairy producers and milk collectors to make the milk appear to have high protein component, but can cause severe health problems to consumers. One important factor leading to such milk safety problems is the highly fragmented production sector (Calvin *et al.,* 2006; Ortega *et al.,* 2011), which is a common situation in developing countries. The Chinese government has taken a series of regulatory measures that call for stronger control over milk producer, collectors, and processors. One strategy has been to encourage small-scale farmers to move their cows into the communal dairy complex (DC) in each village.

Dairy complexes, *yangzhixiaoqu* in Chinese, is also translated as farming communities, cooperative dairy farms, or cow hotels. They are usually co-funded by local governments, agribusiness firms and individuals and centrally planned, managed and constructed under the guidance of local governments, according to the 'White paper on China dairy' (Li, 2014). In general, DCs are constructed outside villages and managed by a single manager who owns the DC or is hired to manage it. The small, backyard dairy producers in the village or nearby are encouraged to check their cows into the DC. In a DC, individual farmers still own their cows and assume the primary responsibilities of feeding and providing other inputs. The cows are milked in the DC-owned milking parlor, and vaccination and breeding are managed by the DC. Small sample of milk is kept from each farmer until the whole batch of milk is accepted by the processor after inspection. If rejection occurs due to quality or safety reasons, the causes can be traced to individual farmers who will be held responsible, with the help of the samples. The government provides subsidies and uses other measurements to promote DCs in an attempt to provide a transitional model as the dairy industry shifts gradually into modern large scale production.

Farmers are allowed to join a DC on a voluntary basis, although the government promotes hard. Many farmers are reluctant to join, because entry is not free and some DCs are far away from farmers' homes that they can't commute several times a day to feed, milk and take care of the cows (Mo *et al.,* 2012). Most importantly, a large number of individual farmers consider that DCs are simply gathering cows into a centralized location with little effect on improving raw milk safety, raw milk price, and cow health.

DC policy is one of the most important production polices after the 2008 scandal and has significant impact on the development of China's dairy industry (Jia *et al.,* 2012). There exists rich literature about farmers' understandings and perceptions of a new program and their effect on farmers' willingness to participate in it (Buckley *et al.,* 2012; Leftley and Mapfumo, 2006; Patt *et al.,* 2010; Vanslembrouck *et al.,* 2002; Wossink and Wenum, 2003). Most of these studies investigated the effects of farmers' evaluation or the adoption of the program by using their subjective attitude toward a public good, say the environment, or their own perceptions of program attributes directly as explanatory variables in their models, and thus the accuracy of the perception measurement is crucial in such methods. Given that farmers' answers to the perception questions in surveys are often inaccurate and even endogenous, studies that avoid using such explanatory variables are needed.

Further, there exist a limited number of studies on Chinese dairy production and policy and they mainly focus on impact of policy on farmers' production (Jia *et al.,* 2012; Mo *et al.,* 2012; Zhong *et al.,* 2014). Little analysis has been found trying to explain small scale farmers' motivation to move their cows into DCs from the milk safety and quality angles. There is also hardly any literature on the actual milk safety and quality effect comparison between independent farms and DCs.

In this paper, we conduct an empirical analysis on the Chinese DCs in the dairy production to explore whether DCs can help improve the milk safety and quality. We first check the farmers' willingness to join the DCs, which is fundamental for DCs to be the milk safety solution. To avoid using inaccurate perceptions

as independent variables directly, we employ measurements of independent small scale farmers' actual factors to explain their willingness to enter the DCs. The linkage between such actual factors outside DCs and the willingness to enter DCs implies farmers' perception and expectations of the DCs' effect on these factors. Milk safety measurements are considered among these factors. Then we also present the real effect of DCs on milk safety, economic and ecological factors. Finally, we will give some suggestion about how to improve the effectiveness of policy.

Whether the DC policy can be implemented smoothly depends not only on local governments' executive power but also farmers' acceptance, while the latter mainly depends on their endowments and comprehension of DCs' actual effects. This paper, using the randomly survey data in the main production areas in China, aims to fill this gap. In this study, we will compare farmers' perceived and actual effects of DCs on the improvement of raw milk safety, raw milk price, and cow health, the three primary goals of the government's DC promotion policy.

2. Data and variables definition

A survey was conducted in the summer of 2012 by graduate student from China Agricultural University in a face to face interview method for dairy farms in three major dairy production areas of China that supply milk to leading dairy processors. Ten villages were chosen in Tangshan district of Hebei province, seven villages in Weifang district of Shandong province, and six villages were chosen in Shuangcheng district of Heilongjiang Province. In each village we randomly selected dairy farmers from a name list with the help of the local government. The questionnaire was pre-tested in Tangshan before the formal survey started. Finally, we obtained 164 observations, among which, 48 are currently independent farms, and 116 are those who used to be independent farms but have moved to DCs. The proportion of farms in DCs in our sample is 71%, much higher than independent farms, which can attribute to the strong DC promotion by local governments.

Since we are interested in evaluating farmers' attitude toward DCs, we ask a question explicitly to the independent farmers whether they are willing to enter (WTE), and assign value 1 to the binary variable *WTE* if the answer is yes. This question was not asked to farmers already in DCs, because they are not the program target and also because they are mostly willing if not all.

The three primary goals of the DC policy are the improvement of raw milk safety, raw milk price received by farmers, and cow health, and thus, we focus on farmers' actual effects of DCs on these three aspects. The variables, *RefFreq*, *Sprice* and *DisPre,* representing the frequency of raw milk being rejected in the previous year, the sale price of raw milk in the current year, and the dummy indicator for farms with the presence of some disease this year, respectively, are included in the model as the key independent variables. Notice, all these three variables are actual instead of perceptional. We expect the variable *RefFreq* and *DisPre* positively affect the WTE to a DC, because farmers with larger frequency of refusal and the occurrence of cow diseases will be more likely to check their cows into DCs, as the cows are managed with better techniques in terms of disease prevention and sanitation, and better guidance in feed nutrition. *Sprice* is expected to be negative, because farmers experience low prices may count on DCs to have more market power and better quality reputation to receive better price. Notice, there is no government regulation on raw milk price in China, and farmers can sell their milk in open market to small collectors, and to processors with and without a contract.

In order to capture farmers' production and external monitoring situation, we also include variables about herd-scale and governments' supervision. The variable *HerdScale* is the number of cows a farmer has, and it is reasonable to assume that larger (no more than a few dozens of cows) dairy farms are more likely to join, because they can benefit more after checking into DCs and they are the government's targets (Mo *et al.,* 2012). The variable *GovSup* is a dummy variable and equals to 1 if local government official rigorously examines the safety of raw milk and sanitation of production environment in previous three months. Farmers who are supervised rigorously are more likely to enter the DCs, because it is harder and harder for small independent farms to meet the continuously improvement of sanitary requirement. In addition, farmers'

demographic characteristics variables, *age*, *gender* and *education level* are also included. The definition and descriptive statistics of variables in the model are present in Table 1.

Same questions except WTE are asked to farmers in the DCs to capture the factual differences in milk safety and price. The descriptive statistics will be discussed in the result section because they contribute to the results.

Additional questions are asked to farmers in DCs to explore their behavioral and environment changes. Twelve questions are asked. Behavioral questions include, after moving into the DC, whether they have changed their production style, whether they use better technologies, whether they pay more attention to milk safety measurements, whether they obtain higher quality feed, whether they experience reduced refusal frequencies, whether they improve milk protein content, whether they receive higher price, whether the price is more stable, whether they reduce production cost, and whether they receive dramatic profit increase. Questions about environmental change include whether they have better production environment, and whether they receive better disease prevention support. In order to obtain more accurate responses, farmers are asked to give one or two examples if the answer is yes to a question and we bench mark their answers with the examples provided. Corresponding variables are assigned the value one to the yes answers and zero to the no answers.

3. Method

We first conduct *t*-tests for the three factual variables, *RefFreq, Sprice, and DisPre*, between the farms in and outside DCs. The null hypothesis is that the means of the two populations for each variable is the same. The alternative hypothesis can be directional in one-tailed tests for variables if we have a clear expectation of the signs, or non-directional in two-tailed tests for those no sign is expected at *a priori.* These results give us indications that whether DCs can improve milk safety.

We then employ a logistic regression model to check the impact from actual factors of milk safety, profitability and other economic attributes on farmers' willingness to enter the DC. These impacts on WTE reflexes farmers' perception of the corresponding factors can help them in DCs. For example, if a particular factor contributes to WTE positively, it means that independent farmers with higher level of this factor are more

Table 1. Descriptive statistics of variables in the model.[1]

Variables	Definition	Independent farms				DC farms	*t*-test[2]
		Mean	SD	Max	Min	Mean	
WTE[3]	Willingness to enter a DC, equals 1 if the farmer is willing, 0 otherwise	0.44	0.50	1	0	N/A	N/A
RefFreq	Frequency of raw milk refusal in the previous year	0.35	0.79	3	0	0.34	-0.07
Sprice	Sale price of raw milk in the current year	2.97	0.05	3.05	2.8	3.08	5.38***
DisPre	Occurrence of disease, =1, if there are some diseases this year, 0 otherwise	0.75	0.44	1	0	0.29	-5.9***
GovSup	Government supervision, =1, if it is very rigorous, 0 otherwise	0.68	0.47	1	0	0.84	1.96*
HerdScale	The number of cows the farmer has	16.25	10.1	60	5	31.44	6.92***
Age	Years of farmer's age	41.6	8.34	59	27	49.44	6.0***
Male	Gender dummy, male=1, female=0	0.83	0.38	1	0	0.69	-2.07**
Edu	Years of farmer's schooling	7.31	2.48	12	0	7.82	1.14

[1] Two refusals caused by inappropriate behavior and disobeying the dairy complex's regulation rather than safety or quality issues are excluded.

[2] **, and *** indicate statistically significant at 5 and 1%, respectively.

[3] WTE = willing to enter.

likely to join a DC. If we know this factor is a 'bad' one, then, it implies farmers expect the factor can be reduced in a DC. This way farmers' perception and expectations are examined. We expect the good factors to be negative and bad factors to be positive intuitively.

Logistic regression is a common method for binary dependent variables.

$$Y^* = X\beta + e \quad (1)$$

$Y^*$is a latent variable measuring farmers perceived benefits of entering the DCs, if $Y^* > 0$, farmers will express willingness to enter, and *WTE*=1. *X* is the matrix of explanatory variables, as explained in Table 1.

$$P(Y^* > 0) = P\,(X\beta + e > 0\,) = F(X\beta) \quad (2)$$

We assume the error term in Equation 1 is distributed as the logistic function, then:

$$F(X\beta) = P = \frac{1}{1 + e^{-X\beta}} = \frac{e^{X\beta}}{1+e^{X\beta}} \quad (3)$$

where *P* is the probability that the observed variable, *WTE* takes value 1. Thus, we can get the marginal effect of each variable:

$\frac{\partial P}{\partial X_j} = P\,(1 - P)\,\beta_j$ from Equation 3.

Our third analysis is to study the behavioral change before and after farmers entering DCs, and their perceived condition differences. This analysis is only conducted for farmers already in DCs.

4. Results

Factual results from comparison

From Table 1 we see that the mean of *WTE* is 0.44 among independent farmers, which means 56% of independent farmers prefer to feed their cows in their backyards, rather than checking into DCs. This value indicates that DCs are not accessible or conveniently ready to some farmers who are willing to join, and it also indicates that for the remaining independent farmers, a large portion are unwilling.

The mean of *RefFreq* in independent farms is 0.35, only slightly higher than their counterpart in DCs, 0.34. Giving that some farms receive 3 refusals in a year, the majority of farms, about 70% or more have never been rejected. The safety of raw milk in DCs is a little better than independent farms, but not very significant as shown in the *t*-tests. Notice, the rejections are not all due to safety reasons such as bacteria measures, but also due to nutritional quality reasons such as protein content. The latter is individually determined as farmers in DCs still manage their feed and feeding operation. Another reason is that DCs receive more rigorous government supervisions as shown next, and such supervisions include more careful inspection at the processing firm receiving end resulting in refusals. A third reason is that the statistics are from two different samples. There may be a self-selection effect that farmers who had historically higher refusal frequency tend to join DCs. This factor alone cannot conclude whether DCs have advantages in milk safety.

Farmers in DCs receive significantly higher prices than the independent ones, although by a small margin, 7 cents or about 2%. The raw milk variation is not big among the three provinces across farmers. The likelihood of disease occurrence is significantly lower for cows in DCs and outsides, with the former being only 40% of the latter. Healthy cows produce safer and better milk. This factor shows the advantages of DCs.

The mean of *GovSup* in DCs and independent farms is 0.84 and 0.68 respectively, that farms in DCs receive significantly more rigorous government supervisions. The average of *HerdScale* in DCs is 31.44, much larger than independent farms at 16.25, ranging from 5 to 60. This result corresponds well to our expectation that larger farms are more likely to check into DCs. Demographic variables show that farmers entering DCs are significantly older, for about 8 years, are more likely to be females. The average education levels are about seven years for both groups.

Results of perceived effects

The regression results for WTE are presented in Table 2. These results confirm that the milk refusals made by processors contribute to farmers' decision of moving to DCs. The marginal effect of *RefFreq* is 0.705, indicating that if the number of refusal increases by 1 in a year, the probability of the farmer's willingness to enter a DC will increase by 0.71. This is a strong support that farmers do link the DCs with better milk quality and safety and resulting fewer refusals. The variables *Sprice* and *DisPre* are insignificant. This means, although the signs are as expected, there is no significant evidence showing that independent farmers connect DCs with higher raw milk prices or low chance for cow disease, which meets our expectations. Or in other words, DCs' effects on improving sale price and disease prevention as shown in Table 1 have not been perceived by farmers.

Other factors like production scale and farmers' age also contributed to such decisions. One more cow an independent farmer owns will lead to 0.079 increases in her/his probability of entering the DC. This result is accordance with our expectation and that in Table 1. Chinese farmers live in villages with farm houses closely constructed to one another, which makes it difficult for their casual barns in backyards to hold more than a few cows. As the number increases, they need to consider the space in DCs. Local governments also target the relatively larger farms for the DC promotion. The younger independent farmers are more likely to enter the DCs than their older counterparts. This is different to the age comparison between the independent farms and those already in DCs. They are from different samples, and there is no strong economic reason for one way or the other.

Table 2. Logit model: factors influencing farmers' willingness to send their cows to dairy complexes.[1]

Variable	Coefficient[2]	*z*-statistic	Marginal effect on WTE[3] probability
Constant	13.748	0.317	
RefFreq	2.834**	2.196	0.705
Sprice	-6.038	-0.434	-1.503
DisPre	0.904	0.295	0.215
GovSup	2.441	1.249	0.512
Age	-0.151*	-1.653	-0.037
Male	3.340	1.022	0.553
Edu	-0.126	-0.469	-0.031
HerdScale	0.318***	2.681	0.079
No. of observations	48		

[1] McFadden R-squared: 0.62; LR statistic: 40.88. The partial effect are calculated when we set variables to their means.

[2] *, **, and *** indicate statistically significant at 10, 5 and 1%, respectively.

[3] WTE = willing to enter.

Results of realized effect

Using the survey data from producers who used to operate on their own farms but have moved to DCs, we can observe real effects of DCs on the same group of people through the changes they experience. Questions about whether they experience particular changes are asked to these farmers. The sample average of the binary variable represents the percentage of yes answers for each question. We conducted *t*-test to check each mean against zero. The results are listed in Table 3.

Results show that all estimates are significant, except for the cost reduction question. 47% of DC farmers have changed they production style, and adopted better technology. Over 90% of them paid more attention to food safety of raw milk, used higher quality feed, and improve their milk protein content. 85% experienced a lower milk refusal frequency. However, only 27% of farmers in DCs realized their sale price increased consistent to the small price difference reported by farmers in and outside DCs in Table 1, although 58% of them received more stable prices. So the DCs' effect of improving sale price is very limited. DCs do not help lower feed cost, because farmers still manage their own feed independently, not taking advantage of DCs' collective bargaining power in feed purchasing, and they also use better quality feed. Therefore, only 21% realized that their profit has increased dramatically. 91% of DC farms have better production environment and better disease prevention support in DCs. These are actual changes experienced by the same people before and after moving to DCs. Although we don't have third party record for these variables rather stated by farmers themselves, we have good faith about their honesty and accuracy as we take extra measures or validating their answers during the face to face interview.

Comparison of perceived and realized effects

We can conclude from the Logit model that independent small farmers do link the DCs with better milk safety and quality. At the same time, 85% of once independent farmers realized that their frequency of milk refusal decreased after moving into the DCs. So it is consistent in the perceived and realized effects of DCs in improving milk safety.

The effects of DCs on improving milk price and disease prevention are not perceived by most of the independent farmers from the results of the Logit model. Although 58% farmers agree with DCs effects on stabilizing

Table 3. Realized effects of dairy complexes from famers currently operating in dairy complexes who used to be independent.[1]

Variables	Average	*t*-value[2]
Change of production style	0.47	10.18***
Using better technology	0.47	10.18***
Paying more attention to food safety of raw milk	0.96	50.53***
Obtaining higher quality feed	0.91	34.91***
Reduction of refusal frequency	0.85	25.88***
Improved quality with higher protein content	0.94	42.32***
Receiving higher price	0.27	6.48***
Price is more stable	0.58	12.54***
Profit increased dramatically	0.21	5.48***
Cost reduction	0.03	1.75
Having better production environment	0.91	34.91***
Better disease prevention	0.91	34.91***
Number of observations	116	

[1] Null hypothesis of *t*-test is $\mu=0$; alternative hypothesis is $\mu\neq0$.

[2] *** indicate statistically significant at 1%.

price, only 27% expressed that their price increased significantly. That is a critical issue we have found in the survey, that most farmers' perception of DCs lack of effects on improving price is also consistent with its actual effects. This may hamper farmers' willingness to enter DCs as they need to pay extra space cost without receiving higher price. The only economic gain is through refusal reduction.

Disease prevention is an important issue, which directly contributes to milk quality and safety. Most of independent farmers worry about the disease prevention in DCs. They do not trust the DCs have great performance in disease prevention, which has also been supported by Logit model. However, 47% of DC farmers expressed that they had changed their production style after moving into DCs, and 91% agreed that they had better production environment and better disease prevention. So we can conclude that independent farmers have misperceptions about DCs' effect of disease prevention.

5. Summary and conclusions

This study has explored the connection between acceptance of DCs by independent farmers and specific milk safety, quality and other economic factors, examined the behavioral and production environmental change for farmers in DCs before and after they join, and also compared the safety and quality measurements across the two groups. We find factors contributing to farmers' willingness to enter DCs, and the discrepancies between the actual effect and some of farmers' misperceptions about these factors. Frequency of refusal for milk from independent farms, herd scale and farmers' age contribute to farmers' decision in moving into DCs, while milk price and disease prevention do not have significant influence. Independent farmers' perception and the actual effects of DCs in improving the safety of raw milk and price are consistent, but there is misperception of DCs' effect on disease prevention among independent farmers. Therefore, it is very important for DC promoters to educate independent farmers from disease prevention point of view.

The empirical results are based on a limited survey sample. However, the survey was conducted during the special window right after the 2008 severe milk safety scandal and the government reacted with promoting the DCs as a policy. Because DCs play a limited role in increasing price received by farmers, an obvious obstacle of moving independent farms into DCs, how to increase sale price of raw milk and further increase farmers' profit is the critical issue of effectiveness of the DC policy.

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