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ORIGINAL PAPER

Comparison of two milk pricing systems and their effect on milk price and milk revenue of dairy farms in the Central region of Thailand

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Abstract A study was conducted to investigate determinates of how milk pricing system, farm location, farm size, and month and year affected farm milk price (FMP), farm milk revenue (FMR) and loss in FMR of dairy farms in the Central region of Thailand. A total of 58,575 milk price and 813,636 milk yield records from 1034 farms were collected from November of 2004 to June of 2006. Farms were located in the districts of Muaklek, Pak Chong, Wang Muang, and Kaeng Khoi. A fixed linear model was used to analyze milk price of farms. Two pricing systems were defined as 1 = base price plus additions/deductions for milk fat percentage, solids-non-fat, and bacterial score, and 2 = same as 1 plus bulk tank somatic cell count (BTSCC). Farm size (small, medium, and large) was based on the number of cows milked per day of farms. Results showed that FMP were lower ($P<0.05$) in pricing system 1 than pricing system 2. Most small farms had higher ($P<0.05$) milk prices than medium and large farms across both pricing systems. Large farms lost more milk revenue due to deductions from bacterial score and BTSCC than small and medium farms.

Keywords Dairy farms · Milk price · Milk revenue · Thailand

Abbreviations

BTSCC	bulk tank somatic cell count
FMP	farm milk price
FMR	farm milk revenue
FMY	farm milk yield

Introduction

Historically cattle in Thailand were primarily used for draft and meat production purposes, consequently until the 1950's there had been no tradition of consuming dairy products in Thailand (Suzuki 1998). However, beginning in the 1960's the Thai government, in cooperation with the United Nations, began a school milk program, whose purpose was to increase nutritional levels in children, and mothers and infants by providing powdered and fresh milk. As the demand for milk and other dairy products increased, the Thai government began to promote

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dairy programs aimed at generating income opportunities for small farmers and reducing the dependency on milk imports from other countries (Suzuki 1998). Currently, most dairy farms in Thailand are considered small size farms, with an average herd size of twenty animals, and they are typically members of a local dairy cooperative (Garcia et al. 2005). Thai dairy cooperatives serve similar roles as dairy cooperatives in other countries, where cooperatives purchase, and market milk from farms, as well as provide technical assistance to farms. Milk prices are determined by the Thai government, and during the time of this study (2004–2006) milk price was 12.5 baht per kilogram (Moran 2005). Even though milk prices are set by the government, they still differ across cooperatives due to additions or deductions assigned by the cooperative. Typical additions/deductions specified by cooperatives to farms are based on milk components such as milk fat, solids-non-fat, and milk quality factors such as bacterial score and BTSCC. Through these additions and deductions, farms can either lose or gain milk revenue that may determine whether they make a profit in a given year. Milk yield, milk composition, and milk quality depend on health, nutrition, and herd management. Consequently, herd health, nutrition of animals and other management factors play an important role in influencing revenues of dairy farms. For example, farms with good sanitation practices that control mud and water in pens and resting areas of cattle may have milk with low levels of bacteria and fewer cows with mastitis, benefiting from additions in milk price due to low bacterial scores and low BTSCC.

The objectives of this study were 1) to determine the effect of pricing system, month and year, district of farm, and farm size on milk price, and 2) to calculate FMR and losses in FMR due to deductions in milk price based on milk fat percentage, bacterial score, and BTSCC of dairy farms in the Central region of Thailand.

Material and methods

Data

Data were from 1034 farms located in the provinces of Saraburi and Nakhon Ratchasima in Central Thailand. All farms were members of the Muaklek dairy cooperative. The Saraburi province contained 786 dairy farms, of which 28 were in the Kaeng Khoi district, 737 in the Muaklek district, and 21 in the Wang Muang district. The Nakhon Rachasima province had 248 farms, all in the Pak Chong district. There were 58,575 FMP records collected every ten days from November 1, 2004 to June 30, 2006, and 813,636 FMY records collected daily from November 1, 2004 to February 28, 2006. Data were collected by Muaklek dairy cooperative personnel at milk collection centers.

Data on FMY and FMP included day, month, and year of collection date, district where the farm was located, and farm identification. A farm size variable was created to group farms into three size categories and it was based on the number of cows milked per day in each farm in January of 2005. The number of cows milked per farm was not regularly recorded, thus it was assumed to have remained constant throughout the duration of this study. Farms size groups were classified as follows: 1 = small (less than 10 cows milked per day), 2 = medium (between 10 and 19 cows milked per day), and 3 = large (20 or more cows milked per day). There were 517 small, 362 medium, and 155 large farms.

The Muaklek dairy cooperative used two separate pricing systems for FMP over the duration of this study. A pricing system variable was created to account for changes in the calculation of FMP. The two Muaklek dairy cooperative pricing systems were calculated using a base price of 11 baht/kg, plus additions/deductions based on components and quality of milk (Table 1). The two pricing system groups were defined as: 1) standard base price of 11.0 baht/kg plus additions/deductions for milk fat percentage, solids-non-fat, and bacterial score, and 2) standard base price of 11.0 baht/kg plus additions/deductions for milk fat percentage, solids-non-fat, bacterial score, and BTSCC. Pricing system 1 was in place from February 2004 to September 30, 2005, and pricing system 2 from October 2005 to June 2006. The maximum milk price that farms could have received in pricing systems 1 and 2 were 11.7 baht/kg and 11.8 baht/kg, respectively.

Statistical analysis

FMP

The FMP data was not normally distributed. Thus, data were normalized using a logistic transformation.

Table 1 Rules for milk price based on additions and deductions from milk fat percentage, solid non-fat, bacterial score, and bulk tank somatic cell count (BTSCC) of the Muaklek dairy cooperative

Factor	Grade	Effect on price	Price (baht/kg)
Milk fat percentage	Less than 3.5%	Deduction	0.2
Solid non-fat	Less than 8.4%	Deduction	0.1
Bacterial score	1	Addition	0.7
	2	Addition	0.5
	3	–	0
	4	Deduction	1
	Previous test was 4	Deduction	2
	Two previous tests were 4	Deduction	3
BTSCC (cells/cm3)	Less than 200,000	Addition	0.1
	200,001 to 1,000,000	–	0
	1,000,001 to 1,500,000	Deduction	0.05
	1,500,001 to 2,000,000	Deduction	0.1
	2,000,001 to 2,500,000	Deduction	0.15
	2,500,001 to 3,000,000	Deduction	0.2
	More than 3,000,000	May reject milk until the quality is better	

Results from the statistical analysis were back transformed to the original scale of the data. FMP was analyzed using the GLM procedure of SAS (SAS 2004). The FMP model included the fixed effects of pricing system, month nested within year of collection date by pricing system subclass, farm district by farm size by pricing system subclass, and residual. The model can be represented as follows:

$$y = Xb + e$$

where

- y vector of FMP records,
- b vector of fixed effects of pricing system, month nested within year of collection date by pricing system subclass, and farm district by farm size by pricing system subclass
- X incidence matrix relating FMY records to elements of b,
- e vector of residual effects.

Residual effects were assumed to have mean zero and a common variance σ_e^2. Least squares means for fixed effects and differences between subclasses within fixed effects were compared using a t-test at an $\alpha=0.05$ level.

Farm milk revenue

Farm milk revenue was calculated as the product of the average FMY and the average FMP the farm received during that period. Maximum FMR was calculated by taking the product of the maximum achievable milk price (pricing system 1: 11.7 baht/kg; pricing system 2: 11.8 baht/kg) by the average FMY a farm received during that period. Loss in FMR was the difference between maximum FMR and actual FMR. Losses in FMR were summed across all months, years, and within farm districts, to compute the average loss in FMR per district. Subsequently, average district FMR losses were added to obtain total average loss in FMR for the Muaklek dairy cooperative during the time of this study.

In order to determine the causes of loss in FMR, histograms of loss in milk revenue were created for milk price observations during each pricing system. Causes for losses in FMR during pricing system 1 were due to lower milk fat, solids-non-fat, and higher bacterial score (Table 1). Causes of loss in milk revenue during pricing system 2 were due to discounts from higher bacterial score, BTSCC, or a combination of higher bacterial score and BTSSC. Deductions due to milk fat percentage and solids-non-fat were found to have negligible effect on losses is FMR during pricing system 2, thus, they were not included.

Results

FMP

Pricing system, month nested within year by pricing system subclass and farm district by farm size by pricing system effects were important sources affecting FMP ($P<0.0001$). In pricing system 1, FMP (11.68 baht/kg) was lower ($P<0.05$) than FMP in pricing system 2 (11.71 baht/kg; Table 2). All months within year across pricing system 2 were greater ($P<0.05$) for FMP than all months within year for pricing system 1 (Fig. 1). Within pricing system 1, the FMP for June, July, and August of 2005 were similar, but they were lower than in April and May of 2005 ($P<0.05$). In pricing system 2, FMP in December of 2005 was higher ($P<0.05$) than all months within year for FMP, while May of 2005 was lower ($P<0.05$) than all other months within year.

When comparing FMP for farm size within each district and pricing system, all farm sizes in each farm district had lower ($P<0.05$) for FMP in pricing system 1 than pricing system 2 (Table 2). In pricing systems 1 and 2, there were no differences among farm sizes for FMP in Kaeng Khoi. In Muaklek, all farm sizes were different from one another ($P<0.05$) for FMP, with small farms having the highest FMP and large farms the lowest FMP, in both pricing systems. Small farms in Pak Chong and Wang Muang had greater ($P<0.05$) FMP than medium and large farms during pricing system 1, whereas medium and large farms had similar FMP ($P=0.79$). During pricing system 2 in Pak Chong large farms had lower ($P<0.05$) FMP than small and medium size farms, which in turn were not different from one another. Small farms had greater ($P<0.05$) FMP than both medium and large farms under both pricing systems in Wang Muang.

Table 2 Least square means (LSM) and standard errors (SE) of farm milk price by pricing system, and farm district–farm size subclass for pricing system 1 and 2

Effect		Pricing system 1		Pricing system 2	
		LSM (baht)	SE	LSM (baht)	SE
Pricing system		11.689	0.044	11.715	0.045
Farm district	Farm size[a]				
Kaeng Khoi	small	11.695	0.119	11.729	0.124
Kaeng Khoi	medium	11.697	0.179	11.741	0.187
Kaeng Khoi	large	11.697	0.281	11.706	0.286
Muaklek	small	11.693	0.026	11.741	0.027
Muaklek	medium	11.692	0.031	11.728	0.031
Muaklek	large	11.691	0.045	11.705	0.045
Pak Chong	small	11.694	0.043	11.729	0.044
Pak Chong	medium	11.691	0.054	11.724	0.055
Pak Chong	large	11.691	0.085	11.683	0.087
Wang Muang	small	11.687	0.163	11.760	0.165
Wang Muang	medium	11.653	0.163	11.650	0.168
Wang Muang	large	11.570	0.281	11.581	0.300

[a] Farm size was defined as the number of cows milked per day of farms. Categories were: small = less than 10 cows milked per day; medium = between 10 and 19 cows milked per day; and large = more than 20 cows milked per day.

Farm milk revenue and loss in farm milk revenue

Results for FMR are presented in Fig. 2. Across all months and within each year, farms in Muaklek had the highest milk revenues, while farms in Kaeng Khoi had the lowest. Farms in Wang Muang had the highest loss in milk revenue in every month within each year, whereas farms in Kaeng Khoi had the lowest (Table 3). Farms in each district had lower losses in milk revenue during pricing system 1, and higher losses in milk revenue during pricing system 2. Across farm sizes, large farms had the largest amount of losses in FMR in every month and year, whereas small farms had the lowest (Fig. 3). Total losses in milk revenue from November 2004 through February 2006 were 4,038.7, 9,940.7, 7,887.9, and 19,122.6 baht for farms in Kaeng Khoi, Muaklek, Pak Chong, and Wang Muang, respectively. The combined loss in FMR of all farms including both pricing systems was 40,990.0 baht.

During pricing system 1, 79.23 % of milk price observations were at the maximum milk price of 11.7 baht, while 13.2 % were between 11.69 and 11.50 baht (Fig. 4). Additionally in pricing system 1, 20.2 % of milk price observations received deductions due to bacterial score, compared to 0.4 % due to milk fat, solids-non-fat. During pricing system 2, 22.8 % of FMP were at the maximum price 11.8 baht, while 49.93 % of FMP were between 11.79 and 11.7 baht (Fig. 5). All FMP between 11.79 and 11.7 baht were from deductions due to BTSCC. A total of 19.9 % of FMP observations were between 11.69 and 11.5, of which 12.33 % and 7.28 % where from deductions

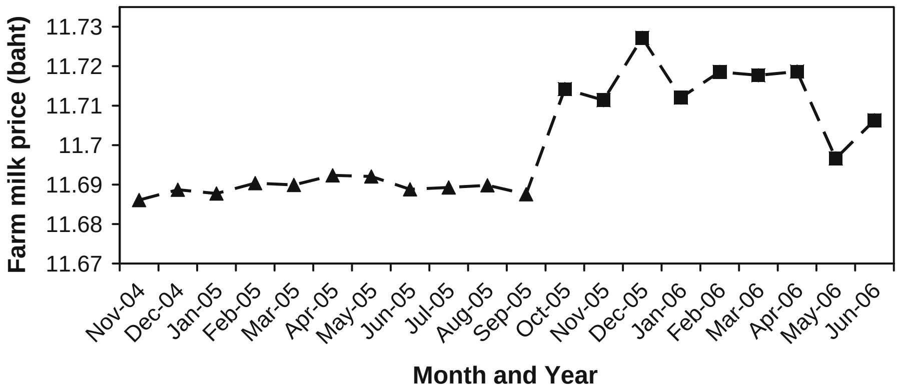

Fig. 1 Least square means for farm milk price by pricing system 1 (▲) and 2 (■) and month and year

due to a combination of bacterial score and BTSCC and BTSCC only, respectively.

Discussion

Results for monthly total FMR for all districts were much higher than previous annual milk revenues of 342,876 baht (milking an avg. of 8.5 cows/day) in dairy farms of the Thaluang dairy cooperative in Central Thailand (Suzuki 1998). This large difference in revenue was primarily due to an increase in milk price over the past 10 years. However, this increase was also due to an increase in average milk yield per cow from previous years, as seen in small farms in Muaklek district that had an average milk yield of 15.76±0.63 kg per day (Rhone et al. 2007). The higher milk revenues of farms in Muaklek and Pak Chong, compared to Wang Muang and Kaeng Khoi, were due to higher FMY and average milk yields per cow, as reported in Rhone et al. (2007). A longer history of commercial dairy production in the Muaklek region, where farms have more productive animals and operations, may have contributed to these higher milk yields (Chantalakhana and Skunmun 2001).

The higher FMP during pricing system 2 (11.71 baht) versus pricing system 1 (11.68 baht) suggest that there were farms in the Muaklek cooperative that were benefiting from additions in FMP due to low BTSCC (less than 200,000 cells/cm3) under pricing system 2. This statement is supported by the fact that during pricing system 2, 22.8 % of FMP achieved the maximum price of 11.8 baht, while 72.7 % were at or above 11.7 baht (Fig. 5). Since the majority of small farms during both pricing systems had higher FMP ($P<0.05$; Table 2) than medium and large farms, it is clear that small farms were benefiting economically from having lower bacterial scores and BTSCC compared to medium and large farms. Conversely, the lower FMP of medium and large farms were due to higher ($P<0.05$) bacterial scores and BTSCC than

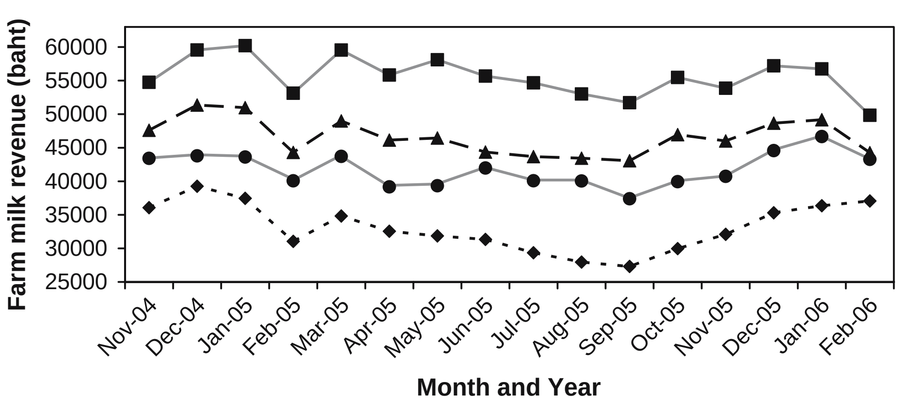

Fig. 2 Farm milk revenue of farms in Muaklek (■), Kaeng Khoi (♦), Pak Chong (▲), and Wang Muang (●) by month and year

Table 3 Averages loss in farm milk revenue due to deductions in milk price by farm district, and across months and years and pricing systems

Category	Farm district			
	Kaeng Khoi loss (baht)	Muaklek loss (baht)	Pak Chong loss (baht)	Wang Muang loss (baht)
Pricing system 1				
Nov-04	92.74	424.41	286.54	793.48
Dec-04	168.50	669.18	398.19	1792.34
Jan-05	193.11	623.99	572.70	1744.73
Feb-05	133.28	458.02	343.45	1199.42
Mar-05	119.49	565.24	422.34	837.70
Apr-05	224.14	432.84	237.85	681.18
May-05	109.31	400.10	400.46	753.81
Jun-05	161.55	480.03	459.61	1256.23
Jul-05	278.56	566.56	338.57	2281.10
Aug-05	144.11	549.33	336.75	945.98
Sep-05	117.22	581.06	371.25	1634.79
Total loss in pricing system 1 (baht)	1742.01	5750.76	4167.71	13920.76
Pricing system 2				
Oct-05	569.27	1005.01	768.41	1437.88
Nov-05	441.17	834.46	874.24	809.72
Dec-05	240.98	786.36	668.86	768.43
Jan-06	373.56	879.02	761.73	1134.22
Feb-06	671.73	685.08	647.03	1051.66
Total loss in pricing system 2 (baht)	2296.71	4189.93	3720.27	5201.91
Combined total loss (baht)	40990.06			

small farms (Rhone et al. 2007). These lower FMP of medium and large farms account for the greater losses in FMR during pricing system 2. This statement is substantiated by farms having a combined total of 77.2 % of FMP that were at or below 11.7 baht/kg during pricing system 2, indicating that the majority of farms had a BTSCC greater than 200,000 cells/cm^3 (Fig. 5). If farms under pricing system 2 can maintain a BTSCC of less than 1,000,000 cells/cm^3, farms will be able to achieve or exceed the maximum milk price (11.70 baht/kg) from pricing system 1. However, the current situation of most medium and large dairy farms is that they are struggling to maintain low bacterial scores and BTSCC and, as a result, they are receiving lower FMR and profits.

Overall results here showed that high bacterial scores and BTSCC were linked to lower economic performance of farms. In many instances low produc-

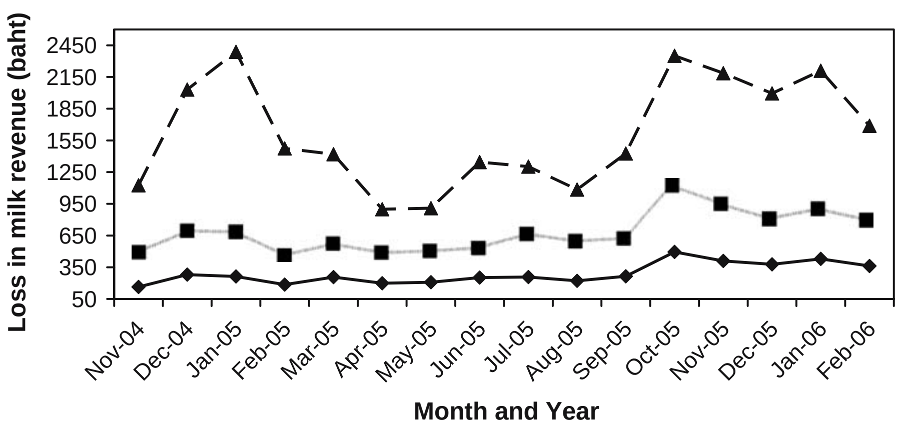

Fig. 3 Loss in farm milk revenue due to deductions in milk price by month and year, and small (♦), medium (■), and large (▲) size farms

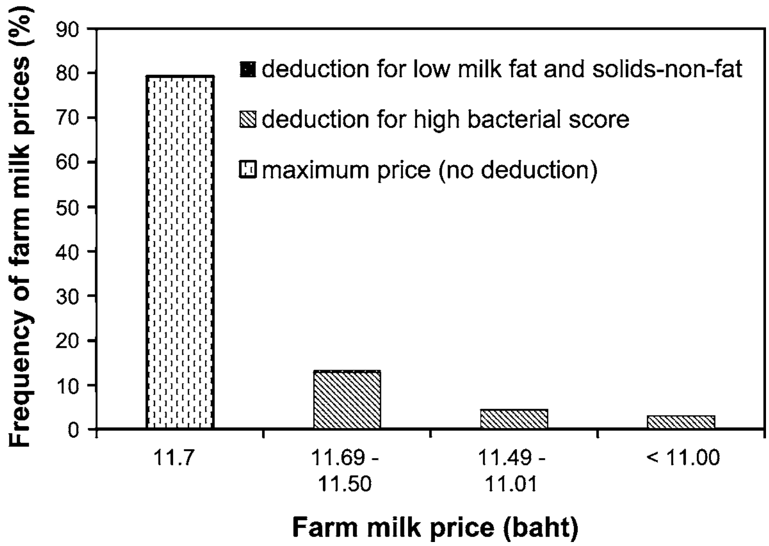

Fig. 4 Histogram of percentage of farm milk price observations in pricing system 1 by milk price and by farms that achieved maximum milk price or deductions in milk price from milk fat percentage (milk fat), solids-non-fat, and bacterial score

tion performance alone may not provide enough incentive for farmers to adopt improved management practices. However, linking low production performance to lower economic gains has been shown to motivate farmers to adopt improved practices at the farm level (King and Rollins 1995). Although in this study specific farm management data were unavailable, muddy resting areas of cattle, cleaning of milking equipment, and proper cooling of milk are factors that have been found to affect bacteria in milk and mastitis in cows (Yhoung-Aree 1999). Consequently, future work is needed to determine specific factors affecting high bacterial scores and BTSCC of farms. Once these factors have been identified, information from this study can be used to help design and implement a program to train and motivate farmers to adopt desirable farm management practices that will improve quality of milk and decrease mastitis levels of cows.

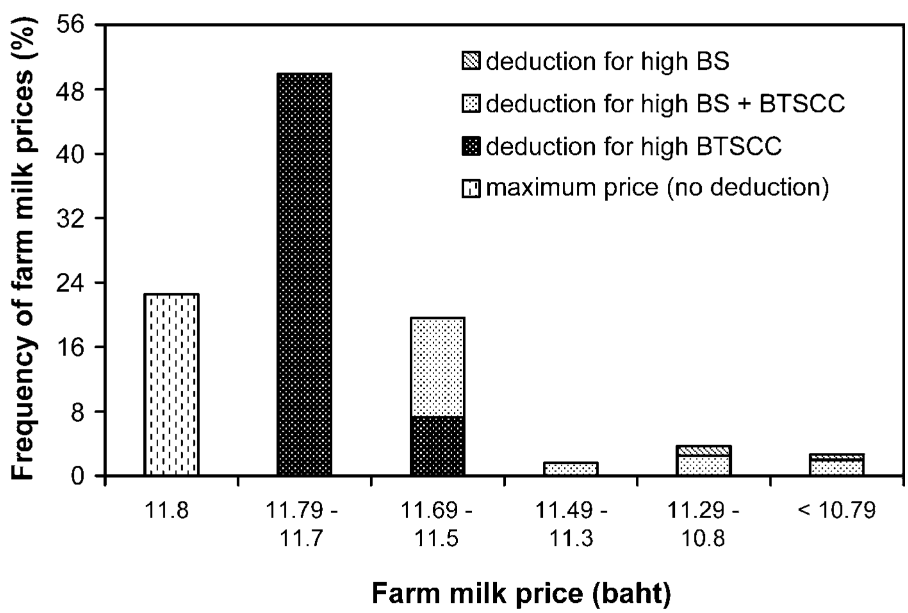

Fig. 5 Histogram of percentage of farm milk price observations in pricing system 2 by milk price and by farms that achieved maximum milk price or deductions in milk price from bacterial score (BS), bulk tank somatic cell count (BTSCC), or a combination of BS and BTSCC

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