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Counter-sanctions, milk production efficiency and scale: how are they interrelated?

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Abstract. The counter-sanctions imposed in 2014 by the Russian government have led to an artificial reduction in competition through the reduction of competitive pressure from foreign milk and dairy producers. Conditions of supply shortage led to a change in the behavior of milk producers both in terms of production volumes and the quality of the products. This paper describes changes of the Russian milk market on the example of the Moscow Region and the impact on this change of counter-sanctions, market conditions and scale of production.

1. Introduction

The introduction of counter-sanctions [1] on the supply of dairy products, primarily from European countries and the USA, stimulated the development of milk production as part of import substitution. In 2017, there was a positive trend in the production of milk, primarily due to production in peasant farms. At the same time, the rate of decline in the number of cows decreased from 0.97769 in 2014 to 0.99543 in 2017, with a significant increase in the number of cows in the peasant farms, where in 2014-2017, the average increase was 4%.

Similar trends are typical for the Moscow region, which holds the fifth place in Russia for milk production and the first place in the Central Federal District, according to Dairy News [2]. The introduction of counter-sanctions has reduced the competitive pressure from foreign producers of milk and dairy products. And the ban on the supply of cheeses from European countries has led to the emergence of an unfilled niche in the market.

As a result of favorable conjuncture in 2015, a reduction in milk production in the Moscow region was stopped. In 2017, the increase in production was 6.55% if comparing to 2015. Similar changes in milk production are typical for agricultural organizations, while peasant farms showed a steady increase in milk production during 2013-2017. In 2017, the peasant farms of the Moscow Region produced 1.8 times more milk in comparison with 2013. In 2017, agricultural organizations stabilized the number of cows, with the stable growth of cow livestock in the peasant farms in 2013-2017.

The described changes are quite peculiar. Peasant farms usually are smaller than agricultural organizations, and also tend to use less profound technologies. Larger agricultural organizations experience economies of the scale [3] and can invest in technological advancements. In 2000s, these factors caused almost complete extinction of smaller forms of milk production. In 2010's, these trends reversed, and there were a the rapid growth in peasant farms sector and quite moderate growth in



agricultural organizations. We will examine official records of agricultural organizations from 2002 to 2017 and try to explain these trends.

2. Data and Methods

The Moscow region is located in the Central-European part of Russia, has a well-developed transport infrastructure, is the largest market for the dairy products and also has highest concentration of milk-processing facilities in Russia [2]. It is one of the most developed, innovative, and important milk-producing regions in Russia. The Moscow region experienced one of the largest surges in the development of peasant farms in last years [2].

For the analysis we use official reports. The official agro-industry accounting form №13 includes more than 200 indicators. In the analysis we will use these:

- Average annual cow livestock;
- Raw milk sold in tons;
- Proceeds from sales of raw milk, in thousands of rubles
- Cost of raw milk sold, in thousands of rubles

Based on these indicators we calculate the following:

- Profit from sales of milk in thousands of rubles = $proceeds - cost$.
- Profitability from sales of milk in thousands of rubles = $profit / cost * 100$
- Sales price = $proceeds / milk\ sold$
- Cost price = $cost / milk\ sold$

We include only farms that are focused on selling the raw milk and exclude beef cattle farms and full cycle farms that produce milk for processing inside the organization.

Dataset includes the following years: 2002, 2007, 2012, and 2017 (Table 1).

Table 1. Key indicators and data description.

Indicators	Year			
	2002	2007	2012	2017
Number of organizations	338	229	92	123
Average number of cows per organization	555.5	589.5	572.8	706.6
Total milk sold, tons	7175400	7141925	2834303	4705362
Percent of profitable organizations	59%	69%	74%	80%

Dataset includes 338 observations for 2002, 229 for 2007, and 92 and 123 for 2012 and 2017, respectfully. The trend indicates a significant decrease in the number of organizations from 2002 to 2012, with a significant growth in 2017.

3. Results

Traditionally, the raw milk production market is often modelled as a perfect market [4]. This means that all of the producers sell quite similar product for almost identical price and only way to be more profitable is to decrease production costs. We also assume that with an increase in the production scale (in our case, this is in the livestock), an organization would decrease production costs due to economies of scale [5]. In such a case, market growth should primarily be caused by the growth of the largest milk producers. Empirical data shows that this is not completely true. We will model the data with these assumptions and try to detect any contradictions that might explain the market trends.

To begin with, we model profitability as a dependent variable from cow livestock in the organization.

As the distribution of farm sizes is not normal, which is not optimal for linear modelling, and we also expect non-linear relationship (economies of scale effect should decrease with an increase in the organization size), we use the base-10 logarithm of this variable. The distribution of the new calculated variable much more resembles the normal distribution (Figure 1, Figure 2) and also should compensate for the decreasing rate of growth of the profitability.

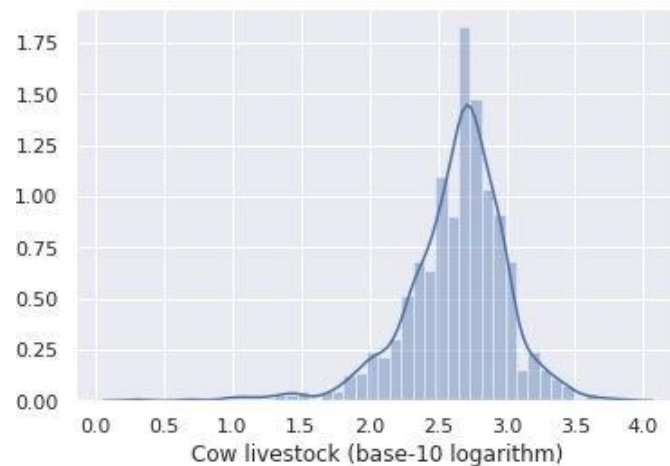


Figure 1. Probability distribution, the base-10 logarithm of cow livestock.

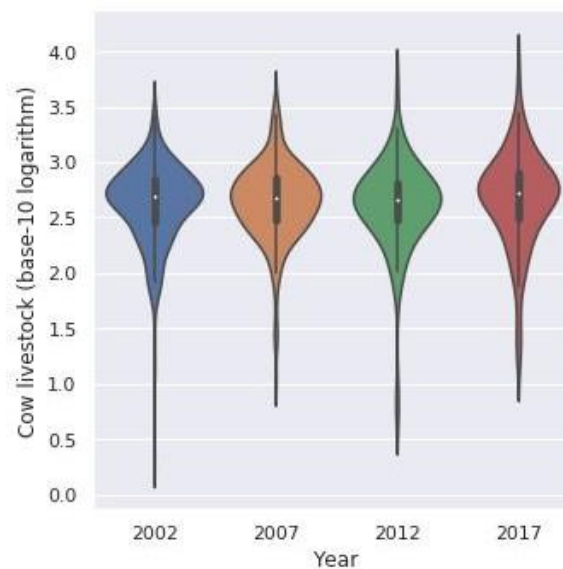


Figure 2. Distribution, the base-10 logarithm of cow livestock by year (violin plots).

The formula for the linear regression is $y = \beta_0 + x * \beta_1$, where y is profitability and x is cow livestock that a farm owns. β_0 and β_1 are the intercept and slope parameters that are optimized to fit the model. Separate models were fitted for each year.

Graph indicates noticeable changes of the market structure from 2002 to 2017 (Figure 3).

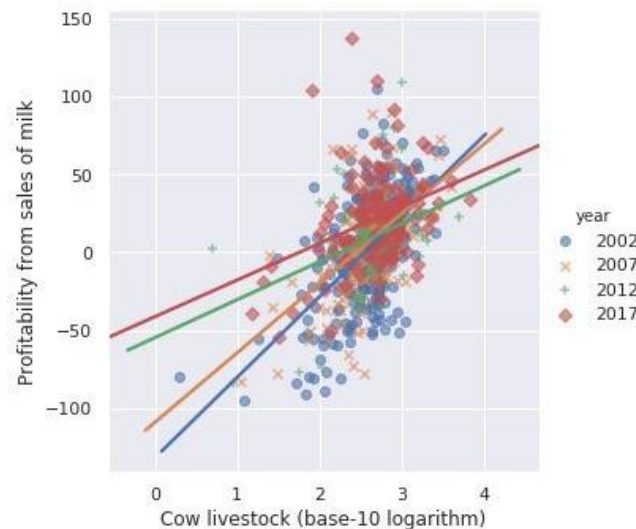


Figure 3. Relationship between profitability from sale of milk and base-10 logarithm of cow livestock by year.

First, the year of 2002 is characterized by a noticeable linear tendency, R^2 for 2002 ≈ 0.3 (Table 2). This means that larger farms were tend to be more profitable. The breakeven point of the linear tendency (356 cows) is quite close to the average farm size (556 cows). Almost half of the organizations are unprofitable, while most farms with cow livestock > 100 are profitable. Small farms were in the deep crisis.

Table 2. Model description and interpretation.

Indicators	2002	2007	2012	2017
R^2	0.33	0.30	0.12	0.11
Model intercept	-132.0	-109.2	-54.9	-41.4
Model slope	51.7	44.7	24.4	23.5
Breakeven point (log10)	2.6	2.4	2.3	1.8
Breakeven point (cows)	356	279	179	58

The year of 2017 shows a completely different picture. First of all, most of the organizations are profitable. Second, the linear trend became much less prominent with $R^2 \approx 0.1$. This means that the scale of production correlates with profitability in much lesser extent than in 2002. The breakeven point is approximately 58 cows, so all organizations with more than 58 cows on average tend to be profitable.

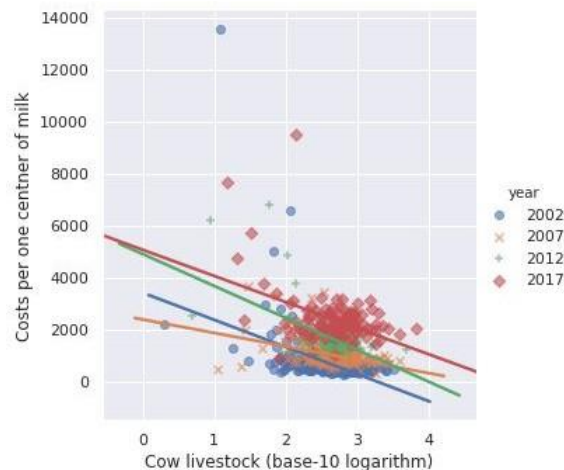
Other years, 2007 and 2012, show transitional stages between in the period of 2002-2017. On average, the number of cows per farm increased with a slight drop in 2012 (590 in 2007 and 573 in 2012), the breakeven point moved to the left (279 and 179 cows in 2007 and 2012 respectively), R^2 and slope decreased, This indicates less strong linear trend than in 2002.

What is the reason of such changes? Profitability of the milk production depends on production costs, price, and amount of the sold milk. Data shows very strong correlation between the number of cows and an amount of the sold milk for all years (Table 3), so probably the findings can be explained by changes in production costs and price per one center of milk and how these variables correlate with the scale of production.

Table 3. Pearson correlation between average annual cow livestock and amount of the raw milk sold in tons.

Year	Pearson R
2002	0.91
2007	0.95
2012	0.97
2017	0.92

As Figure 4 shows, there is a very strong correlation between the scale of production and costs per one centner of milk for every year. Regression lines has the similar scope; a vertical linear shift of the line can be explained by inflation. So larger farms are still able to produce milk more efficiently in 2017.

**Figure 4.** Relationship between costs per one centner of milk and the base-10 logarithm of cow livestock by year.

Now we model the regression between the scale of production and prices per one centner of milk (Fig. 5). And this graph is a lot more peculiar. First, we see a noticeable change of the slope between 2007 and 2012. Moreover, while the prices in 2002 and 2007 were almost identical, with a slight increase for the larger farms, the variation in prices in 2012 and especially 2017 increased dramatically, especially for small and medium farms. The correlation between the price and the number of cows reversed, and larger farms in 2012 and 2017 tend to sell their milk cheaper. Therefore, despite a stable correlation between the scale of production and costs of production per one centner of milk, we see much less prominent correlation between the size and profitability. Small farms produce more expensive milk, but they sell it more expensive. But why is this happening?

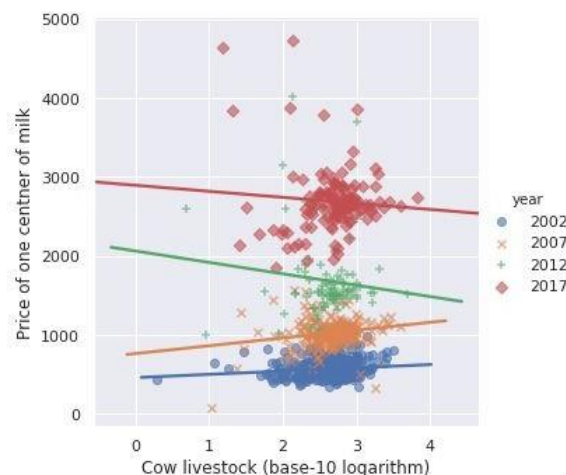


Figure 5. Relationship between the price of one centner of milk and base-10 logarithm of cow livestock by year.

4. Conclusions

How can we explain the shown trends in the data? The market of milk in the Moscow region in 2002 was quite close to the perfect market in the economic theory sense. So the milk market, as our analysis shows, was quite homogeneous: all the milk was quite the same and nobody really cared about hidden characteristics of the product. The larger organizations supplied more milk and were more convenient to work with for larger milk processing firms than smaller ones; therefore, the small ones increased their price [6, 11].

The market was in the state of crisis: old technologies, poor government support, and rough competition with milk producers from other Russian regions and foreign producers were the reasons why almost half of the producers were unprofitable, especially small ones. Most of them were the privatized old Soviet state farms that tried to operate in open market conditions. As data shows, most of them were closed in the 2017, and only some of the largest ones stayed active.

The milk was produced in the quite similar way; therefore, all of the farms were direct competitors. So there were no direct way to sell milk for the higher price and also no way to decrease costs without growth, which required substantial investments, which were not provided by government or business.

The situation was quite different in 2017. The most noticeable difference is the substantial variation on the sell prices when compared to 2002, especially among small and middle-sized farms. But how did they manage to sell milk more expensive? As it turns out, most of those who manage to sell milk more expensive were the suppliers to the dairy sector of deep processing, organic producers, and other buyers who were interested not just in milk, but in the particular kind of milk [7].

The quite large dairy sector of deep processing emerged after the counter-sanctions [8], when the government banned the cheeses and other agricultural products from the EU and the USA. Before these sanctions, most Russian producers stayed in the low and middle segment of the market with relatively cheap dairy products. After the imposition of sanctions, the situation changed considerably. In particular, a lot of new producers started producing high-quality expensive dairy products (deeply processed), including organic products. Obviously, they required better milk and, with government support [9] and protectionist measures, were ready to pay for it.

Therefore, the milk producers now are not direct competitors. The oldest segment of large farms sells larger quantities of milk to the mass market of milk processing firms. They tend to increase in size and be profitable because of the economies of scale. They, however, tend to decrease when organizations become larger.

Smaller new milk farms produce milk with specific characteristics for small number of producers, who make the expensive and high-quality dairy products. They tend to have higher costs because of

their tendency to use alternative, more expensive technologies that allow for more precise quality control and specific market qualities of the milk. They also tend to be less effective because of the size and limited possibilities to grow (because expensive and organic segments of the market are tend to be small, and these products are preferred only by a small number of consumers). Finally, they are not forced to be more efficient because of the emerged gap in the market and high demand for these specific types of milk.

All in all, the imposition of counter-sanctions caused radical changes and surged growth in the raw milk market of the Moscow region. The growth was associated with an increased livestock in agricultural organizations and a quite large extent with the establishment of new smaller peasant farms.

Before the sanctions were imposed, smaller forms of milk production had been unprofitable due to very high production costs. Therefore most of them closed in the 2000s. Newly established small peasant farms still have high production costs, but they can sell raw milk to the manufacturers of import-substituting products more expensively. With private investments and government protectionist policy, the dairy sector of deep processing stimulates the production of milk with specific characteristics for higher prices.

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