

Forecasting the size of the dairy market in anylogic environment

Vera Konkina, and Alexey Martynushkin*

Federal State Budgetary Educational Institution of Higher Education "Ryazan State Agrotechnological University Named after P.A. Kostychev", Ryazan, Russia

Abstract. The current situation at the market for food and agricultural raw materials is difficult, and critical for some industries. The processes of import substitution, that is, shaking-out imported products from the markets and the growth of domestic production, have significant differences for segments of the food market. There was a significant differentiation of food markets in the following main indicators: the growth rate of domestic production, the share of imports in resources, the share of exports in production, and the amount of state support. However, 2020 showed that the course taken by the Government and the Ministry of Agriculture of the Russian Federation for import substitution was not fully implemented, and a large share of products is imported from third countries that were not included in the sanctions list. Economic and mathematical modeling can partially solve this problem. Analysis of scientific literature on modeling the equilibrium at agri-food markets showed the absence of any actual domestic development. The most famous foreign conceptual models dated back to 1990-2000. The Organization for Economic Cooperation and Development (OECD) and the World Bank have developed such general and private equilibrium models as RUNS (Rural-Urban North South), MRT (Regional Trade MRT, Harrison), AGLINK COSIMO, etc. These recursive-dynamic models make it possible to determine the equilibrium parameters for the main types of products for almost all countries of the world, including the Russian Federation and all agricultural markets. However, the introduction of sanctions has stopped work in this direction.

1 Introduction

The milk market is a complex component of the food market. The market situation in this sector of the economy is determined by the following factors:

- the amount of state support determines the rate of development of the dairy industry, including domestic production;
- the price index for dairy products correlates with the level of market availability of these products;
- export and import are instruments for achieving the equilibrium at the dairy market [1-6].

* Corresponding author: martinyshkin@mail.ru

The AnyLogic system dynamics format based on simulation experiments can contribute to assessing the impact of various system factors and allows to develop effective solutions up to elements of strategic management.

At the same time, the dairy industry in the Russian Federation is distinguished by specific features of state regulation aimed at ensuring food security and enhancing import substitution processes. Therefore, the market of milk and dairy products will be described in the context of each commodity heading using Walras-Evans-Samuelson model (WES) [7, 8]:

In the process of building a model, it should be borne in mind that the variable price (P), demand (D) and supply (S) are continuous functions of time (t). Graphs D and S are described by the following functions:

$$D(P) = \alpha - a \cdot P \quad (1)$$

where α and a are constant coefficients.

$$S(P) = -\beta + b \cdot P \quad (2)$$

where β and b are constant coefficients.

The rate of price increase is proportional to the excess demand for a particular product with a constant proportionality coefficient (λ).

This indicator testifies to the elasticity of consumers' reaction to shortages. As a result of the increase in excess demand, the rate of price also increases. In this case, the model appears as a linear differential equation:

$$\frac{dP}{dt} = \lambda \cdot (D - S) \quad (3)$$

where $\frac{dP}{dt}$ is the rate of price change,

$(D - S)$ makes up a shortage of goods,

λ is the coefficient of the reaction rate of buyers to a shortage of goods.

The linear WEC model of the market for one product with a piecewise-linear supply price lag has the following form:

$$P'(t) = \lambda E(P(t), P([t/T]T)) + \eta(t), \quad t \geq 0,$$

where $E = D - S$ is the excess demand function (export);

$D(t) = \alpha - aP(t)$ is the demand function;

$S(t) = -\beta + bP([t/T]T)$ is the offer function;

$P(t)$ is the unit price at time t ;

T is the lag of buy price;

λ is the sensitivity factor, speed of reaction or price adjustment.

$\lambda, T, a, b, \alpha, \beta$ are positive parameters,

$\eta(t)$ – is uncontrollable indignation.

Let's move on to digitalization of the model.

$$P'(t) = \lambda E(P(t), P([t/T]T)) + \eta(t), \quad t \geq 0,$$

Let $t = k \cdot T$, $k = 0, 1, 2, \dots, \Delta t = T$

After transformations, one gets:

$$P((k+1)T) + P(kT)(-1 + T\lambda(a+b)) = T\lambda(\alpha + \beta)$$

Let us take $T=1$ and compose the characteristic equation:

$$\eta + (-1 + \lambda a + \lambda b) = 0$$

$$\eta = 1 - \lambda a - \lambda b \quad [9]$$

2 Materials and Methods

The purpose of this study was to determine the equilibrium values of the balance of milk resources in the Russian Federation. AnyLogic 8.1.0.4 information environment acted as a modelling tool. The information base for building a simulation model included data from Rosstat and Federal Customs Statistics (milk balance and resource use, consumer prices, household income, etc.). Research time horizon was 2001-2019 and localization concerned Russian milk and dairy products market [10-12].

The direct implementation of the model describing the state of the dairy market is carried out in the AnyLogic software package. The simulation model includes several modules: a module for working with data and a calculation module. In turn, each of the above modules consists of built-in blocks having definite functionality.

The formalization of the behaviour of the dairy industry will be based on the Harvard Concept. Therefore, the following determinants are the main blocks of the conceptual model of the dairy market: supply and demand volumes; the type of the market structure, policy of firms and the state; efficiency [13].

Considering the identified determinants, the dynamic equilibrium model in the single-product market will consist of the following modules:

- Module 1 contains information on the known values of supply and demand for milk and dairy products. Price dynamics for these types of products is due to the influence of the laws of supply and demand, the mathematical formalization of which is described by Evans model;

- Module 2 describes the balance of resources and use of milk and dairy products: production volumes, stocks, etc.;

- Module 3 contains information on scientifically based norms of consumption of dairy products established by the Ministry of Health of Russia;

- Module 4 provides information on government support instruments [14-18].

When modeling the state of the dairy market, the interface block includes 61 variables, which have been subjected to system-dynamic simulation in the head module of the AnyLogic program. Source data was imported from MS Excel.

The systemic dynamics of supply and demand determines the equilibrium prices for milk and dairy products and equilibrium volumes. The equilibrium at the dairy market is the traditional intersection of supply and demand curves and is interpreted as the volume of consumption of a given type of product at the desired price. [19-22]

In general, the equilibrium at the dairy market is a state in which an extreme social benefit is reached for all economic agents.

The demand function is decreasing and nonlinear $Q_{spros} = \frac{\beta}{price}$. Since the market

conditions are volatile, the demand curve is constantly changing.

The support function, on the other hand, is ascending and exponential $Q_{predl} = 1 + \gamma \cdot pow(delay(price.tau), 0.8)$. Since there is a time lag in the response of manufacturers to changes in demand, therefore the price is determined as follows:

$$\frac{d_{price}}{dt} = k \cdot (Q_{spros} - Q_{predl})$$

The offer is formed as the sum of domestic production and imports. Surplus products are sent to warehouses, and if their quantity exceeds the critical mark, then it is sent for export:

$$\frac{d(stock)}{dt} = production_flow - Stock_flow_exp - Q_p$$

$$\frac{d(ex_all)}{dt} = Stock_flow_exp + Export$$

$$Stock_flow_exp = production_flow - Q_p \quad [9]$$

It is logical that demand is determined by the consumption of milk and dairy products for the period. In turn, the upper level of consumption is limited by the rational consumption rate and the population size. Accordingly, this parameter can be adjusted. If the actual consumption is lower than own production, then the surplus is sent to the warehouse, otherwise, the "voids" are filled with imports. The mathematical interpretation is as follows:

$$\frac{d(lm_all)}{dt} = Im\ port - flow_Im\ port$$

$$flow_Im\ port = norm_potr - Q_s$$

$$\frac{d(Potr)}{dt} = flow_Im\ port + Q_s$$

To regulate the equilibrium at the market, exports and imports act as a trigger. By influencing their volumes, the so-called "exit from the market" or, conversely, "expansion of presence" is ensured [9].

$$\frac{d(Market)}{dt} = Im\ port + Q_p - Export - Q_s$$

$$Q_p = Q_predl$$

$$Q_s = Q_spros$$

$$Export = key_Export \cdot Exp_flow$$

$$Im\ port = key_Im\ port \cdot Exp_flow$$

$$Market \leq Stock_Export$$

$$key_Im\ port = 0$$

$$key_Export = 0$$

A feature of this model is that the increase in own production and, accordingly, the increase in the export component occurs with the help of additional government support. This is due to the fact that no other agricultural industry has such a range of grants and subsidies from the state as the dairy farming industry [23, 24].

$$\frac{production}{Subs} = production_s$$

$$production_s_flow = Subs_flow \cdot production_s$$

$$production_all = productoin + production_s_flow$$

3 Results and Discussion

Thus, the experiment carried out on the implementation of a simulation model to determine the equilibrium at the dairy market states its success. In addition to the fact that when modelling there were satisfactory values of price dynamics and constancy of stocks both on average at the market and in the context of individual commodity items, the stability of supply and demand flows. All this allows to make an unambiguous conclusion about the adequacy of the model and the correctness of the forecast indicators for milk and dairy products market of the Russian Federation. However, it can be applied to analyze the markets of other commodity groups and other countries. These conclusions are due to global integration and the influence of system-wide determinants of the balance at world food markets [25, 26].

The end points of the modeling are:

- price indicators for milk and dairy products;
- indicators of the balance of resources and the use of milk and dairy products;
- milk consumption per capita;
- the level of household income, etc.

Thus, this array of information for the future allows to make reasonable management decisions [27].

Further the analysis of the results obtained will be dwelled in more detail.

The milk market has been dynamically developing in recent years with substantial government support. Milk production volumes are only increasing. However, the market is not saturated with products of domestic manufacturers. Imports of milk for 1999-2019 increased from 12.35 % to 16.92 %. Consequently, state support measures should be aimed exclusively at increasing the scale of the industry [28].

The data obtained during the implementation of the model indicate that the most significant annual value of the milk market at the current level of consumption should be at the level of 33.5 million tons. If the model is "closed" to rational consumption rates, then the equilibrium volume should be 44.5 million tons. In this case, it's not about any export. And only import will be used as a trigger, which for each of the equilibrium options should respectively amount to 2.14 million tons and 13.14 million tons. In fact, in 2019, import amounted to 6.73 million tons. It is quite possible to import and export at the same time, because the milk and dairy products market is a wide commodity group that includes both raw materials and finished products. So one imports raw milk, cheeses and cottage cheese from Belarus, and exports butter to China. However, due to customs preferences, Belarus and Kazakhstan appear as both importers and exporters of products according to the TSVT 04 nomenclature "Dairy products; eggs; natural honey; food products of animal origin, not elsewhere specified or included" [29].

As shown by the results of simulation calculations, the volume of the market and, accordingly, the achievement of the equilibrium, depend mainly on two determinants: a given volume of consumption of dairy products and the structure of consumption within a commodity group. Personal income changes the structure of consumption. There is a transition from cheap dairy products with the addition of vegetable fats to products of a higher price segment and, accordingly, of higher quality.

Thus, the equilibrium at the dairy market is achieved by increasing imports.

4 Conclusion

The course of import substitution and export orientation of domestic agriculture proclaimed by the Ministry of Agriculture of the Russian Federation has not justified expectations at many industrial markets. The market for milk and dairy products demonstrates a low degree

of saturation; therefore, imports are growing with a simultaneous increase in government support. It is believed that the presented model of system dynamics is adequate. However, it requires further development due to additional detailing and scenario "playing" of state support instruments from traditional to world models.

References

1. G. Bakulina, V. Fedoskin, M. Pikushina, V. Kukhar, E. Kot, *International Journal of Circuits, Systems and Signal Processing* **14**, 232-240 (2020)
2. A.B. Martynushkin, Yu.B. Kostrova, Yu.O. Lyashchuk, *The Bulletin of KrasGAU*, **6 (162)**, 157-164 (2020)
3. T.N. Belova, *Economy of the region*, **15(1)**, 285-297 (2019)
4. V.S. Konkina, A.B. Martynushkin, *International Transaction Journal of Engineering, Management and Applied Sciences and Technologies* **11 (10)** 11A10L. (2020)
5. P.C. Beukes, P. Gregorini, A.J. Romera, G. Levy, G.C. Waghorn, *Agriculture, Ecosystems and Environment* **136(3-4)**, 358-365 (2010)
6. A.B. Martynushkin, V.S. Konkina, J.B. Kostrova, I.V. Fedoskina, N.V. Barsukova, M.V. Polyakov, *Modern Trends in Agricultural Production in the World Economy*, 77-84 (2020)
7. N.V. Byshov, S.N. Borychev, I.A. Uspenskiy, A.V. Shemyakin, I.A. Yukhin, D.A. Fedyashov, I.A. Piskachev, *Intern. J. of Engin. And Tech.* **7(4.36)**, 914-919 (2018)
8. N. Anikin, V. Terentyev, K. Andreev, A. Shemyakin, A. Martynushkin, *Qualitative assessment of passenger service*, *Journal of Physics: Conference Series*, 012094, (2020)
9. P.M. Simonov, *Proceedings of Bratsk State University. Series: Natural and Engineering Sciences*, **2**, 55-58 (2006)
10. E.N. Krylatykh, *Economics of the region* **4(28)**, 21-35 (2011)
11. E.N. Krylatykh, V.P. Fedorov, *Modern Europe*, **2(54)**, 138-142 (2013)
12. A.S. Zavgorodnyaya, I.G. Shashkova, V.S. Konkina, L.V. Romanova, E.I. Mashkova, M.Yu. Pikushina, *Journal of Advanced Research in Dynamical and Control Systems*, **7**, 2022-2031, (2018)
13. S. Kuhl, L. Flach, M. Gauly, *Italian Journal of Animal Science* **19(1)**, 41-50 (2020)
14. A.B. Martynushkin, V.S. Konkina, *Quality improvement of public service of automobile transport: economic evaluation method*, *Advances in Economics, Business and Management Research. Proceedings of the Russian Conference on Digital Economy and Knowledge Management (RuDEcK 2020)*, 449-455 (2020)
15. V. Konkina, *BIO Web of Conferences*, **17**, 00086 (2019)
16. A.S. Emelyanova, L.G. Kashirina, E.E. Stepura, S.D. Emelyanov, Yu.P. Borycheva, *BIO Web of Conferences*, **17**, 00095 (2020)
17. L.G. Kashirina, K.A. Ivanishchev, K.I. Romanov, *BIO Web of Conferences*, **17**, 00096 (2020)
18. I.Yu. Bystrova, O.A. Fedosova, G.V. Ulivanova, G.N. Glotova, E.N. Pravdina, E.A. Rydanova, *Intern. J. of Adv. Biotech. and Research* **10(2)**, 392-405 (2019)
19. G.M. Tunikov, I.Yu. Bystrova, N.G. Byshova, Zh.S. Mayorova, E.N. Pravdina, K.K. Kulibekov, *Intern. J. of Adv. Biotech. and Research* **10(2)**, 465-473 (2019)

20. A.S. Emelyanova, E.E. Stepura, M.A. Gerasimov, S.D. Emelyanov, *IOP Conference Series: Earth and Environmental Science, Russian Conference on Technological Solutions and Instrumentation for Agribusiness (TSIA-2019)*, Stavropol, Russia, **488** (2019)
21. A.S. Emelyanova, L.G. Kashirina, S.D. Emelyanov, M.T. Trfandyan, J.E. Dorokhina, *IOP Conference Series: Earth and Environmental Science*, **422 (1)**, 012068 (2020)
22. V. Khripin, V. Ulyanov, A. Kiryanov, E. Kurochkina, L. Cherkashina, *E3S Web of Conferences*, **175**, 03005 (2020)
23. L. Kashirina, K. Ivanishev, K. Romanov, *E3S Web of Conferences*, **176**, 02001 (2020)
24. I. Kondakova, E. Vologzhanina, J. Lomova, N. Kryuchkova, *E3S Web of Conferences: International Scientific and Practical Conference*, **222**, 02013 (2020)
25. E. Saitkhanov, D. Besedin, V. Semenov, V. Kulakov, K. Gertseva, *E3S Web of Conferences*, **222**, 02017 (2020)
26. N.B. Guber, N.I. Morozova, M.V. Eliseenkova, T.I. Sereda, S.A. Tamaev, *IOP Conference Series: Earth and Environmental Science*, **613(1)**, 012044 (2020)
27. I.A. Stepanova, A.A. Nazarova, M.V. Arisov, *World Vet. J.*, **10(4)**, 492-498 (2020)
28. M.N. Britan, K.A. Gerceva, E.V. Kiseleva, V.V. Kulakov, E.O. Saytkhanov, R.S. Soshkin, *Intern. J. of Pharm. Research*, **11 (1)**, 1040-1048 (2019)
29. E. Metelkova, G. Demishkevich, A. Gusev, *IOP Conference Series: Earth and Environmental Science*, **274(1)**, 012036 (2019)