

USE OF ECONOMETRIC MODEL FOR DEVELOPING AN OUTLOOK FOR LIVESTOCK SECTOR IN LATVIA

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Abstract. In 2015 in Latvia, livestock products accounted for 36.6 % of the total final value of agricultural production, including meat production – 15.5 % and egg production – 3.4 %. Beef and pork production stabilised in the last decade, mutton and goat meat production has tended to increase since 2010, while poultry and egg production has shown an increasing trend since 1999 in Latvia in the period 1995-2015. There are all preconditions for the development of these industries in Latvia, which allow expecting growth in the industries. It is determined by globalisation processes: the increasing world population and growing demand for food, rising incomes and change in eating habits. Livestock output is determined, to a great extent, by the number of agricultural animals kept. For this reason, it is important to project the population of agricultural animals for the period until 2050 in order to assess the development of the livestock industries. This paper reflects the projections elaborated by an econometric, recursive, dynamic, multi-period scenario model developed by the authors of this paper in 2016. The model has been developed according to the specifics of every agricultural industry and takes into account the trends in the industries. The present research on the livestock sector exploited only a part of the model functions – calculations were performed for cattle, pigs, sheep, goats and poultry. The results allowed to conclude that the processes in livestock industries were determined by diverse drivers, e.g. increase in productivity, expansion of large livestock farms, export opportunities and the market situation.

Keywords: agricultural animals, projections, modelling.

Introduction

In 2015 in Latvia, livestock production accounted for 36.6 % in the distribution of agricultural final products, including milk – 17.7 %, meat – 15.5 % and eggs – 3.4 %. In meat production, the most significant sectors were pork – 5.1 %, beef and poultry meat – 3.5 % each, other sectors – 3.4 % [1]. The meat sector was also important in the EU: 10 % of the total value of the EU agricultural production and 13 % of the world beef and veal production [2]. The OECD/FAO projects that the demand for food is going to increase in the world. This is determined by a number of factors: 1) the world population is projected to rise from 7.4 bln. in 2016 to 8.1 bln. in 2025; 2) income growth per capita, which adds to the consumption of each person; 2) consumer habits are changing. But higher incomes translate first into a demand for more calories, and then into a demand for more protein (typically from animal sources). The demand for meat, fish and dairy products will grow relatively strongly [3]. Meat consumption increased importantly over the last decade in China, South Korea, Taiwan and Japan [4]. World meat consumption is expected to increase by 15 % between 2015 and 2025, less than in the previous decade, but still equivalent to a year's total meat production in the EU [5]. However, production is not the only purpose of keeping agricultural animals. Grazing cattle are very important to keep the natural grasslands open and full of biodiversity. The more grazing animals we keep, the more semi natural grasslands will continue to provide biodiversity and a beautiful landscape with strong recreational values [6].

In Latvia, there are all the necessary preconditions for livestock farming: an appropriate climate, vast and still unutilised areas useful for meat cattle farming, experience in farming and great opportunities to increase sales both in the domestic and in foreign markets [7]. This industry is an alternative for milk production and pig farming, which faced various problems in recent years [8]. That is why it is very important to analyse the agricultural industries in order to be able to predict their development in the future and make prudent decisions contributing to their development. It is usually easier to perform this task if designing various development scenarios. It is also agreed by other authors stressing that a model has to be used to simulate changes to systems (policy, market and production) and test new prototype systems [9]. The sectoral modelling of agriculture in the EU is closely intertwined in the literature [10].

Therefore, the overall aim of this research was to develop a model for projecting the number of agricultural animals. To achieve that, the following specific research tasks were defined: 1) to analyse the output of meat and eggs in Latvia; 2) to design a model for projecting the number of agricultural

animals that is appropriate for Latvia; 2) to produce an outlook of the number of agricultural animals for the period until 2050.

Materials and methods

This paper represents the projections generated for the agricultural sector developments in Latvia until 2050. The authors of the paper have developed the Latvian Agricultural Sector Analysis Model (LASAM) in 2016. LASAM is an econometric, recursive, dynamic, multi-period scenario model, which can also simulate GHG emissions. It covers all agricultural sectors. Most of the estimations within the model are done by performing linear regression, the regression models are evaluated by their statistical significance and the coefficient of determination. Sensitivity analysis is used to calculate possible deviations of the results from the projected base scenario. Verification of LASAM was done using several approaches. First, the historical data were compared with the back-looking modelling results. Second, examination of the model output results reasonability was done to understand weather projections are within logical limits. Third, experts in agriculture from the main Latvian stakeholder organisations were involved to verify the main logical constructions of the model and the results.

Using the LASAM parameters, exogenous data and lagged endogenous data, it is possible to generate projections for the model endogenous variables over a set of alternative policy scenarios and over a given projection period. However, due to the research limitations, the present research deals with only a part of the LASAM model, presenting a simulation of the number of agricultural animals, except for the dairy sector, and a projection produced for it for the period until 2050 [11]. The key information sources used by the present research were as follows: the Central Statistical Bureau (CSB) of Latvia and the Agricultural Data Centre (ADC), FADN data on pig and poultry farms and the Rural Support Service (RSS) database on meat production and consumption balance.

Results and discussion

1. Changes in the meat and poultry industries in Latvia

Cattle farming. In Latvia, beef production transforms from an auxiliary economic activity in dairy farming into a specialised industry that exploits meat breeds and their crosses. The development of the industry was also promoted by the process of restructuring of dairy farms.

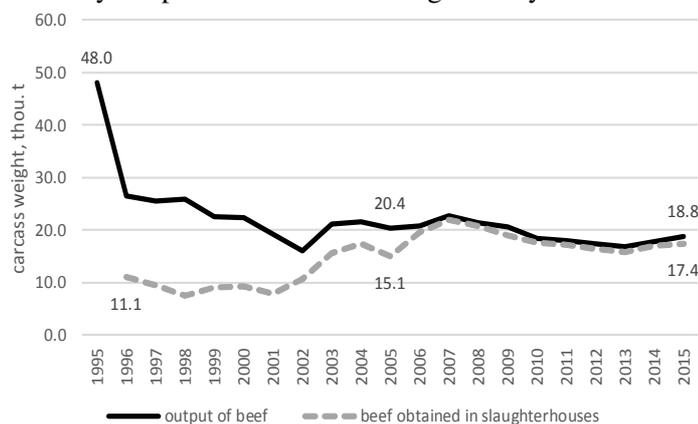


Fig. 1. Output of beef and the quantity of beef obtained in slaughterhouses in Latvia in 1995-2015, thou. t [11-14]

In 2015, compared with 2005, the output of beef slightly decreased – from 20.4 to 18.8 thou. t (-8 %). However, compared with 1995, a decrease in the output of beef was considerable – 2.6 times (Fig. 1). Compared with 2005, the quantity of beef obtained in slaughterhouses (all the cattle slaughtered at slaughterhouses, which involves the services provided by the slaughterhouses) increased by 15 %. Since 2006, the output of meat and the quantity of meat obtained in slaughterhouses have almost stabilised, which was promoted by farm structural changes. The number of farms keeping cattle considerably decreased – their number in 2015 was 2.5 times smaller than in 2005. The sharpest decrease was observed for the number of farms with 1-2 and 3-5 cattle.

Consequently, the average number of cattle per farm increased from 6 cattle in 2005 to 16.5 in 2015 (almost 2.8 times) [15].

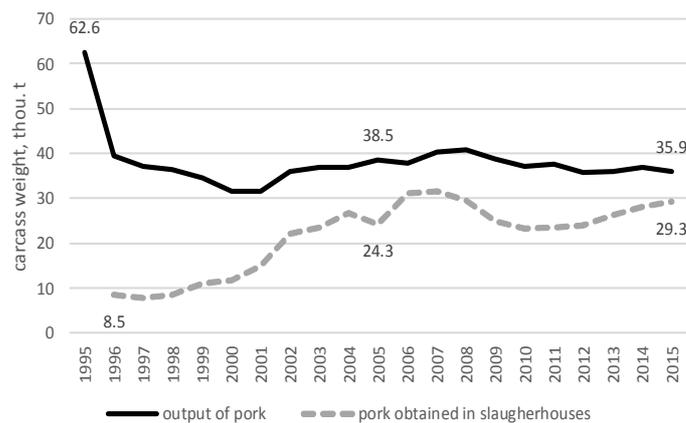


Fig. 2. Output of pork and the quantity of pork obtained in slaughterhouses in Latvia in 1995-2015, thou. t [11-14]

The industry considerably increased exports, which accounted for 73 % of the total output of beef in 2015 (i.e. exports of beef and live cattle). Since 2006 the export of live cattle has significantly increased in Latvia, reaching almost 5 thou. t and comprising almost 30 % of the total export of this industry [16].

The beef price is very low in Latvia – more than twice as low as the average price in the EU. Such a situation is determined by both the difference in the meat quality (the proportion of dairy cow meat, which is actually a by-product of dairy farming, is very high in the beef market in Latvia) and by the market development level [17].

Pig farming. In the period from 2005 to 2015 in Latvia, the output of pork gradually decreased by 2.6 thou. t (-7 %). However, the quantity of pork obtained in slaughterhouses slightly increased in this period owing to structural changes taking place in the industry (Fig. 2). The number of farms with 1-9 pigs decreased 6.6 times – from 36.6 thou. in 2005 to 5.5 thou. in 2015. The intensification process is observed in the industry – farms having more than 5000 pigs accounted for 72 % of the total number of pigs in Latvia in 2015 [18].

Exports of the pig industry rose 3.3 times in 2015 compared with 2005, which was determined by an increase in the exports of live pigs. In 2015, 39 % of the total quantity of pork produced was exported (compared with 14 % in 2005) [16].

In recent years, the industry was negatively affected by an outbreak of African swine fever (ASF), and the price of grain sharply rose in 2010 and 2011 owing to a poor grain harvest, increasing the cost of feed, while the purchase price of pork remained almost unchanged. The purchase price of pigs in Latvia in 2015 decreased to the level of 2005 [17], although the prices on key production inputs considerably rose. A similar trend in prices was observed also in the other Baltic States and in the EU.

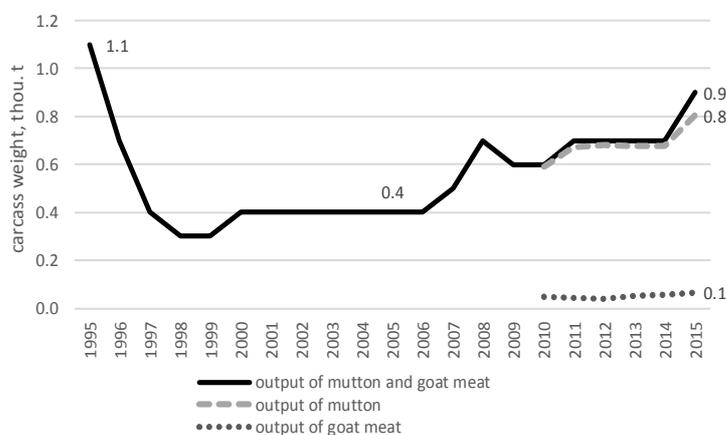


Fig. 3. Output of mutton and goat meat in Latvia in 1995-2015, thou. T [11;13;14]

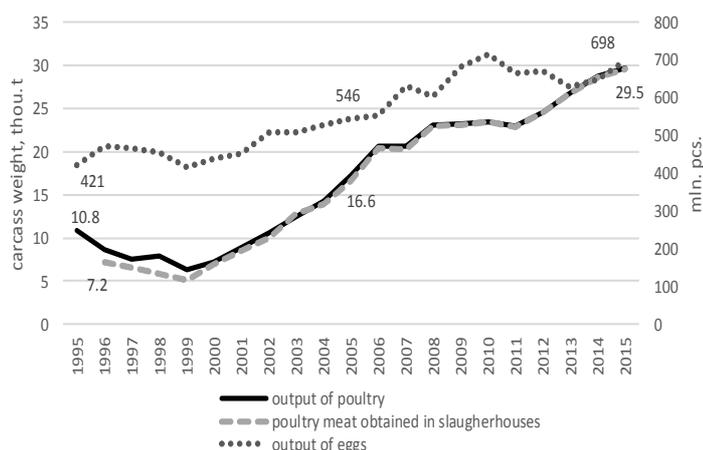


Fig. 4. Output of poultry and the quantity of poultry meat obtained in slaughterhouses, thou. t and the output of eggs, mln. pcs. in Latvia in 1995-2015 [11-14]

Sheep farming. Positive trends in the sheep industry were determined by the growing demand for mutton as well as the development of organic farming in Latvia. In 2015 in Latvia, the output of mutton and goat meat reached 872 t, which was twice as much as in 2005. However, compared with 1995, the production of mutton and goat meat has declined. The proportion of mutton in the total output was high (805 t in 2015), while the production of goat meat was relatively insignificant – only 67 t in 2015. In recent years, exports of mutton and goat meat in terms of quantity significantly increased, and the exports as a percentage of the total output increased fourfold, reaching 12 % in 2015.

There were 4033 sheep farms in Latvia in 2015. Compared with 2010, the number of sheep farms declined by 5 %, while the average number of sheep per farm increased from 18 sheep in 2010 to 25 in 2015 [19].

An analysis of changes in the prices of mutton and goat meat in Latvia shows that overall the prices have considerably risen – more than twofold – in 2015 compared with 2005 [17].

Poultry farming. In the period since 1995, the poultry industry has developed in Latvia. The output of poultry meat increased 2.8 times, reaching 29.7 thou. t in 2015, while the production of eggs rose by 66 %. Most of the poultry meat was obtained in slaughterhouses, as the output of poultry meat and the quantity of poultry meat obtained in slaughterhouses were similar in the entire period of analysis. The output of eggs slightly decreased after 2010 (Fig. 4). One of the reasons of it was a directive adopted in the European Union that set new compulsory standards for the protection of laying hens and higher welfare requirements for the laying hens.

The poultry industry considerably increased its export, as the export of poultry meat in terms of quantity rose 7.5 times in 2015 compared with 2005. The exports as a percentage of the total production increased from 13 % in 2006 to 53 % in 2015. A similar situation was observed in egg production, as the exports of eggs significantly increased – 7.2 times in 2015 compared with 2005 –, and the export as a percentage of the total output also rose, reaching 55 % in 2015. Unlike the production of poultry meat for own-consumption, the production of eggs for the market exceeded the domestic market demand for the eggs in the entire period of analysis [16].

According to a survey of agricultural holdings, the number of poultry farms has considerably declined. In 2013 in Latvia, there were 21.9 thou. farms that kept poultry, which was 64 % less than in 2015, as the number of small farms decreased. Poultry farming is a very concentrated industry, as the group of large poultry farms consisted of only four farms [20].

Overall, in the period of analysis, the purchase prices of poultry meat have risen both in the EU (+23 %) and, even much more, in the world (2.7 times in 2015 compared with 2005). It has to be mentioned that the world price of poultry was considerably below the poultry prices in the EU and Latvia in the whole period of analysis. A slight price decrease was observed in the EU as a whole and also in the Baltic States in the last three years [17].

2. Development of the model for projecting the livestock population

In the livestock sector, the number of livestock is a crucial factor in the production of meat or eggs; therefore, in developing the model, the key focus was placed on this indicator. The LASAM model simulates the number of livestock for the following livestock groups: all kinds of cattle, pigs, sheep, goats and poultry. A projection of the number of livestock can be produced for each livestock group.

Although the methodology for projecting the number of animals in each livestock group differs between groups, it is based on the historic development of each livestock group in terms of the number of livestock, production and productivity. For some livestock groups (pigs and dairy cows via production of milk) such factors as costs and revenues (including support payments for produced milk) are also considered. The projections for costs and prices of agriculture goods are calculated based on the projections of the European Commission [5]. This approach differs from the methodology used for projecting the agricultural sectoral developments and GHG emissions for Latvia by a group of researchers in 2015, that used the projections of the macro indicators developed by the Ministry of Economics (GDP, the number of inhabitants, agriculture exports, consumption of agriculture products, etc.) to develop the projections of agriculture sectors for 2050 [25]. The approach used in LASAM is similar to the approach used in the EU level model AGMEMOD that is an econometric, dynamic, multi-product partial equilibrium model [26]. AGMEMOD uses a large dataset of the historic time series for each EU member state and equations that capture the development trend of an indicator driven by the historical development of the particular indicator and other driving forces as key markets, price, amount of support, costs etc. Both of the methodologies described above are efficient and used in other dynamic models, yet the developers of LASAM considered the approach used in AGMEMOD to be more precise keeping in mind that Latvia is a small and open economy highly affected by the price, support, cost and demand trends within and outside the EU but not so much limited by the changes of the trends within the country.

Number of cattle. The number of cattle (*beef_no*) is calculated by adding the number of dairy cows (*d_c_no*) and the number of suckling cows (*s_c_no*) together, and each of the numbers is multiplied by coefficients *a* and *b*:

$$beef_no = (d_c_no * a + s_c_no * b) \quad (1)$$

However, the number of cows is projected based on an estimate of the number of cows for the previous year (*d_c_no*) [11; 19; 21] and an estimate of the output of milk for the previous year (*milk_tt_pr*) as well as a projection of the milk yields (*milk_yield*) [11; 22]:

$$d_c_no = (milk_tt_pr) / milk_yield \quad (2)$$

A projection of the number of suckling cows (*s_c_no*) is made based on the historical trend in the number of suckling cows (*s_s_c_tr*), which tended to decrease in the past [19; 22]:

$$s_c_no = s_c_no(-1) * (1 + s_c_tr) \quad (3)$$

$$s_c_tr = f(s_c_tr(-1), t) \quad (4)$$

Number of pigs. An analysis of changes in the pig industry in the last decade shows that the number of pigs decreased quite significantly; just like in the other agricultural industries, the decrease was specific to small farms. The industry increased its level of intensification and industrialisation, and a small number of large pig farms mostly operate in this industry. The number of pigs (*pig_no*) is expressed as a function of pork price per tonne (*p_t_pork*) [11; 17], which is divided by the sum of the previous year wheat price per tonne (*p_t_wheat(-1)*) [11; 23] and unit labour costs (*lb_unit_cost*) [11; 24]:

$$pig_no = p_t_pork / (p_t_wheat(-1) + lb_unit_cost) \quad (5)$$

Such a way of calculation is employed because high proportions of the feed cost (mainly wheat) and labour cost in the total cost are typical of the pig industry, and profits could be maximised in this industry on condition that the price of pork increases, while the price of wheat decreases. Accordingly, this ratio of revenue to cost is taken into account when producing an outlook for the pig industry. A projection of the number of pigs is based on DG AGRI projections of pork and wheat prices [5], as well as a projection of unit labour costs produced by the LASAM model [24].

Number of sheep. A projection of the number of sheep is based on the historical trend in the number of sheep since 2002. A forecasted annual increase in the number of sheep (*sheep_no*) is calculated as the average increase in the period 2005-2015 [11; 19], and a projection of the number of sheep is made by adding an estimated number of sheep in the previous year and (*sheep_no(-1)*) the projected annual increase (*sheep_tr*) together:

$$sheep_no = sheep_no(-1) * (1 + sheep_tr) \quad (6)$$

$$sheep_tr = f(sheep_tr(-1), const) \quad (7)$$

Number of goats. A projection of the number of goats (*goats_no*) is based on a fixed constant value – the number of goats in the most recent year for which data are available (*last*)–, because in the last years the number of goats both increased (in the period 2005-2010) and decreased (in the period 2011-2014) [11; 19]. Since 2015, an insignificant increase in the number of goats has been observed, yet overall one can assume that in a long-term the number of goats is going to remain relatively unchanged and no significant increase in it is expected:

$$goats_no = goats_no(last) \quad (8)$$

Number of poultry and laying hens. A projection of the number of poultry is based on the fact that a small number of producers operate in this industry and the development of the industry to a great extent depends on their decisions made on their business expansion. A projection of the number of poultry (*poultry_no*) represents a constant value, assuming that this value will remain at the average level of the period 2006-2015 (average) [11; 21], as the enterprises operating in the industry have developed their infrastructures and one can expect that the enterprises will focus on the optimal exploitation of their infrastructures in order to maximise their incomes from their economic activity over the next years:

$$poultry_no = poultry_no(average) \quad (9)$$

One can expect that the number of laying hens could slightly increase in the projection period, reaching 2.5 million by 2050. The number of layers (*hens_no*) was calculated based on the historical trend in their number (*hens_tr*):

$$hens_no = hens_no(-1) * (1 + hens_tr)$$

$$hens_tr = f(hens_tr(-1), log(t)) \quad (10)$$

3. Key results of the simulation of the livestock sector

Cattle farming. The total number of cattle includes dairy cows, suckling cows and calves and young cattle of both mentioned groups. Since the proportion of dairy cows in the total number of cattle is high, it is projected that the number of cattle is going to increase until 2025, reaching 506 thou. units (+21 % compared with 2015), whereas over the next period their number is going to decrease to 494 thou. in 2030 and 414 thou. by 2050(-1 %, compared with the situation in 2015) (Fig. 5).

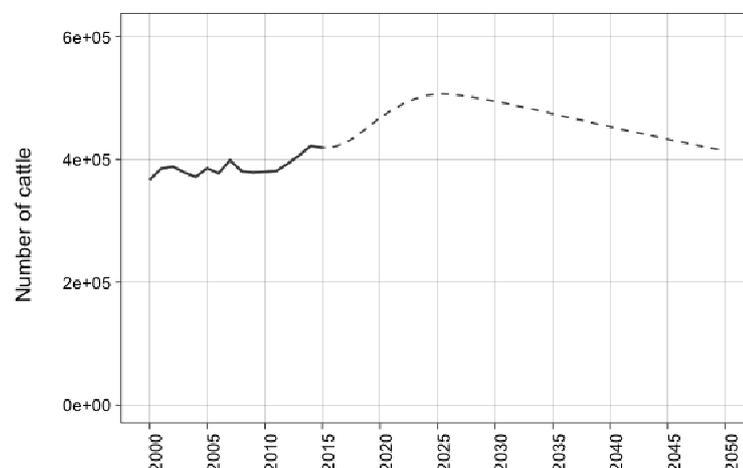


Fig. 5. Number of cattle in Latvia in 2000-2015 and a projection for 2016-2050 [11; 19; 21; 22]

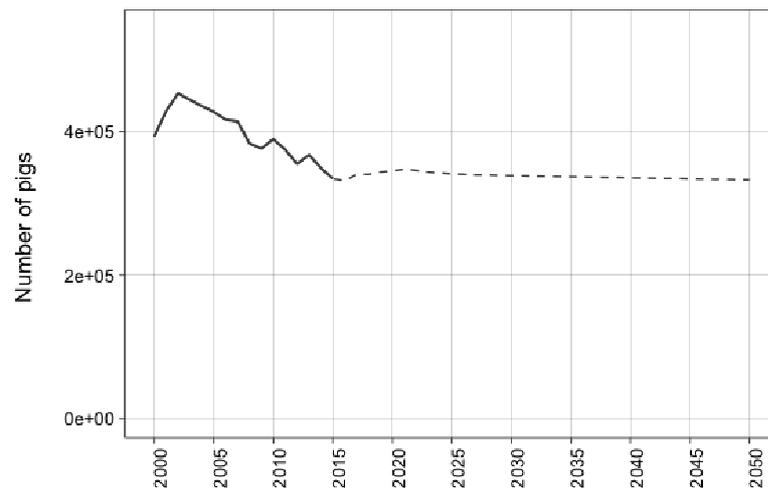


Fig. 6. Number of pigs in Latvia in 2000-2015 and a projection for 2016-2050 [5; 11; 17; 23; 24]

Pig farming. In the last decade, the difference between the price of feed and the price of pork sharply decreased, which significantly affected the profitability of pig farming, and the number of pigs decreased. This process was due to the decrease in the number of pigs on small farms, as the pig industry reached a higher level of intensification (Fig.6).

Sheep farming. It is projected that the sheep farming will continue developing, yet this prediction is optimistic and the development pace might be slower because, regardless of the relatively high growth rate, the industry has not found an export niche and is mainly oriented towards the domestic market. Its orientation towards the domestic market is a significant constraint. With the incomes of the population growing in Latvia, the consumption of cheap meat (poultry meat, pork) will be partly replaced by mutton; however, there are no traditions of consumption of mutton, and no considerable change may be expected in the percentage distribution of meat consumption. At the same time, the projected increase in the number of sheep from 102 thou. in 2015 to 190 thou. in 2030 and 304 thou. in 2050 is realistic (Fig. 7), and mutton will comprise a relative proportion in the total amount of meat consumed.

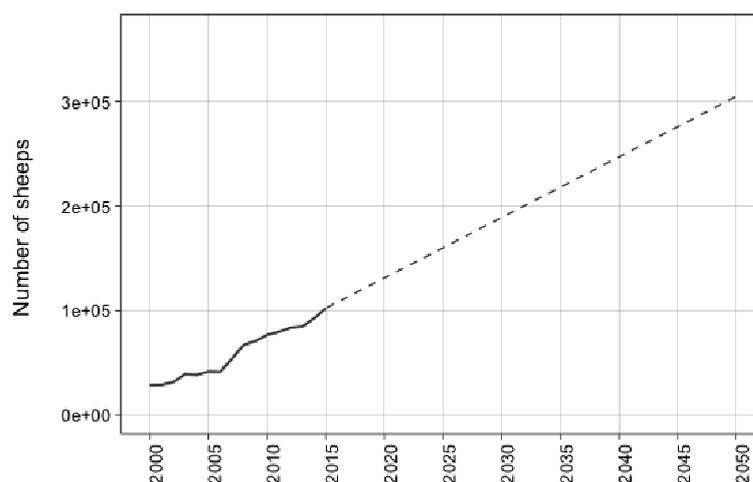


Fig. 7. Number of sheep in Latvia in 2000-2015 and a projection for 2016-2050 [11; 19]

The sheep industry, just like the meat cattle industry, could be fostered by government policies with regard to efficient use of grassland, as well as emissions from sheep are lower than from cattle. New export markets have to be found to develop sheep farming. If it is not done in the nearest future, the projection has to be critically reassessed.

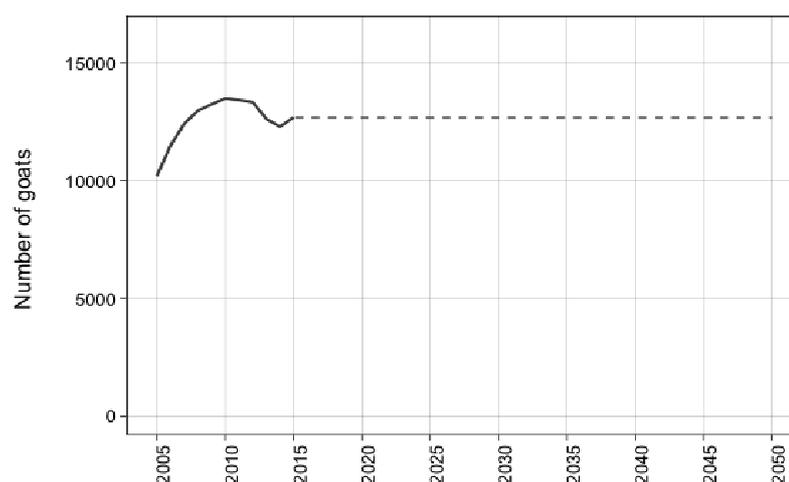


Fig. 8. Number of goats in Latvia in 2000-2015 and a projection for 2016-2050 [11; 19]

Goat farming. This industry output represents own-consumption and niche products, and the traditions of consumption of such products in Latvia are not as strong as in other countries. This factor constraints opportunities in the domestic market, which, in its turn, does not contribute to an increase in the capacity of farms to a level and a quantity that are needed to successfully export such products to foreign markets. The number of goats is projected to be almost constant for the entire period, remaining at the level of 12 thousand (Fig. 8). An analysis of the historical data on this industry does not suggest a stable trend, and one cannot foresee a considerable increase or decrease in the consumption of goat products if assuming that this industry remains oriented towards the domestic market.

Poultry farming. The development of the industry is determined by a few large poultry enterprises; therefore, it is difficult to project the trend that, to a great extent, depends on the enterprises' business strategies and decisions. For this reason, a projection of the development of poultry farming is based on the average level of the last years, assuming that the number of poultry is going to be rather constant in the projected period (4.7 million) [11; 21]. The enterprises engaged in this industry have made investments to develop their production infrastructures and will continue to optimally exploiting their infrastructures in order to maximise their incomes from their business. Since no expansion of the domestic market and no entry into new markets by the enterprises are expected, one cannot predict a fast expansion of this industry.

Conclusions

1. In Latvia, livestock products accounted for a significant share in the total final value of agricultural production. Beef and pork production stabilised in Latvia in the last decade. Besides, 93 % of beef and 82 % of pork were obtained in slaughterhouses. The output of mutton and goat meat has tended to increase since 2010, while the production of domestic poultry meat and eggs – since 1999. The reason of it was the structural changes taking place in the industries in respect to the expansion of large livestock farms. The exports of almost all industries increased in the period of analysis, which contributed to their development, as the domestic market was limited.
2. In projecting the numbers of agricultural animals in Latvia, individual indicators were selected for every animal group: cattle, pigs, sheep, goats, poultry and horses, which were based on the trends in these industries in the period 2000-2015.
3. By employing the model designed for projecting the number of agricultural animals in Latvia, which is the key factor determining the output of livestock products, one can foresee: a) an increase in the number of cattle over the period until 2025; afterwards, a slight decrease is predicted, which will be mainly caused by a decrease in the total number of cows due to increase in milk yields; b) the number of pigs is projected to be stable, as it is determined by the number of pigs on large farms that have stabilised their production; c) the number of sheep is projected to increase the most (1.6 times) over the period until 2050; however, it is necessary to find export

markets for mutton; d) the numbers of goats and poultry are forecasted to be almost unchanged. This is determined by the specifics of the industries – the goat industry is small and oriented towards the domestic market, while the poultry industry is prevailed by large enterprises with stable output.

Acknowledgements

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