Intensive Dairy Farming in Northern Germany: Development and Impact of the New Fertilizer Act

Annotation: Germany, the largest milk producer in the European Union, increased milk production by 15.1% from 2007 to 2015. In 2015 intensive production regions with a milk production of more than 2,000 kg/ha contributed 59.8% to the German milk production whereby they represented 69.9% of the growth in German milk production from 2010 to 2015. The area of grassland and area of maize silage have a high positive and significant correlation with milk production. The regression model (R^2: 0.832) indicates the strong influence of these variables on milk production. Indeed data of twelve farms from an intensive production region show that fast grown farms get to limits due to the greening regulations on crop rotation and the nitrates limit of 170 kg/ha from manure of animal origin of the New Fertilizer Act. This will lead to increasing demand for land and the need of exporting nutrients to less intensive regions which will increase the costs of milk production.

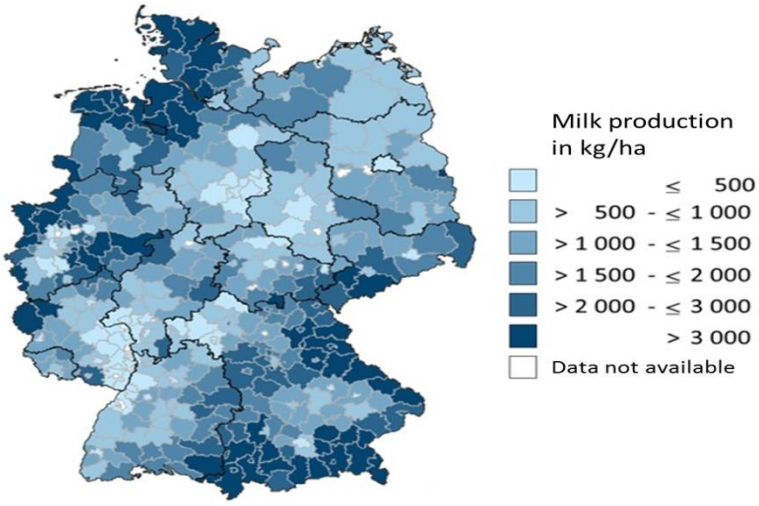
Key words: Milk Production, Dairy Farming, Fertilizer Act, Germany, Grassland, Limiting Factor, Maize Silage

JEL classification: Q12, Q18

1. Introduction

The European Union is the largest milk producer in the world. In 2015, European milk production amounted to 162.6 m tons, which is 24.4% of world milk production. Germany is the largest milk producer in the European Union with a production of 32.7 m tons in 2015, or 20.1% of European milk production (Zentrale Milchmarkt Berichterstattung ZMB 2016). German milk production decreased very slightly by 12.232 tons in 2016. That corresponds to a decrease of 0.04% (Bundesanstalt für Landwirtschaft und Ernährung BLE 2017a). This was the first time in more than 10 years that German milk production did not increase over the preceding year (ZMB 2011; ZMB 2016; BLE 2017). Overall, Germany's milk production grew by 15.1% between 2007 and 2015, which is above the EU-27 average of 9.5% (ZMB 2011, ZMB 2016). It should be noted, however, that milk production is not homogeneously distributed throughout Germany, as can be seen in figure 1.

Figure 1. Intensity of milk production per ha and year in Germany at county level in 2015



Source: Thünen-Institut 2016

Milk production is especially located where natural site conditions allow no or just a few types of land use beside grassland. This results in low opportunity costs for land, compared to

regions where more numerous and more profitable opportunities for arable farming exist (Gömann et al. 2006). Thus, the main milk production areas are located in regions with high shares of grassland. These can be found along the North Sea coast, in the upland regions in the middle of Germany, in the alpine uplands and along the Czech border. Further regions where intensive dairy farming takes place but where good conditions for arable farming also exist are the region bordering the Netherlands and the Lower Rhine region (Lassen et al. 2009). During the last decade, Germany's intensive dairy farming regions have attracted additional production volumes, whereas milk production has been shrinking in many less intensive areas (BLE 2011-2016).

Intensive dairy farming regions are characterized by large quantities of manure. Similar effects occur in regions with intensive pig and poultry production, were large amounts of manure are also produced (Chamber of Agriculture 2017). Due to the resulting nutrient surpluses, intensive livestock farming is held responsible for a substantial impact on nitrate contamination of groundwater (Taube et al. 2013). Next to nitrate, phosphate is also an important water and environmental pollutant because it has the highest eutrophication potential (Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz BMELV 2013).

The European Union's Nitrates Directive is one of its main efforts to reduce nitrate leaching from agriculture and sets forth a number of measures (Velthof et al. 2013). The Nitrates Directive helps to fulfil the goals of the European Union's Water Framework Directive, which was implemented in 2000 (BMU 2013). The Directive of Utilization of Fertilizers, Soil Excipients, Culture Substrates and Plant Aids—known as the Düngeverordnung (DüV), or Fertilizer Act—regulates the utilization of fertilizers, including technical aspects of utilization and amounts. The act is the main instrument for implementing the European Union's Nitrates Directive in Germany (BMELV 2013). The new regulations of the Fertilizer Act were passed by the German Federal Parliament on 31 March 2017 (BMEL 2017). The new regulation will come into force in the next planting season, starting after the 2017 harvest, and will affect dairy farms, among others. It regulates the balance of nitrates and phosphates as follows: nitrate use is limited to 60 kg/ha for a three year period, decreasing to 50 kg/ha in 2020, and phosphate use is limited to 20 kg/ha for a three year period, decreasing to 10 kg/ha in 2023. Furthermore, it introduces a lengthened blocking period for manure application, thus increasing the need for storage capacity to nine months for farms with more than three grazing livestock units per ha until 2020 and limiting the use of nitrogen from manure of animal origin to 170 kg/ha (BMEL 2015). In Lower Saxony, the N accumulation per ha will increase from 99.3 kg/ha to 123kg/ha of farmland due to the act's new regulations. This will lead to N accumulation close to the 170 kg N/ha limit or above in intensive livestock regions (Chamber of Agriculture 2017). In the Netherlands, one of the most intensively farmed countries in the world, the European requirements are estimated to cut the dairy herd by about 160,000 animals, or 6.6% of the Dutch dairy herd, in the short run. In the long run, it is estimated that a further expansion of dairy herd and milk production will occur due to improved efficiency within the sector (USDA 2017).

Against the background described above, the main objectives of this study are (1) to analyze the development of German milk production and its concentration in the time period 2010 to 2015, (2) to illustrate the coherence and strength of influence of the area of grassland and the area of silage maize production on milk production in Germany and (3) to examine the impact of the New Fertilizer Act on the production costs of dairy farms in an intensive region.

2. Materials and Methods

The study is based on official data from the Federal Office for Agriculture and Food on milk production at the county level from 2010 to 2015. Data for 2016 at the county level are not yet available. Additional data on the area of grassland and of silage maize production, disaggregated to county level, based on the agricultural structure survey of 2010 are provided by the KWS SAAT SE, a seed company based in Einbeck, Germany.

To analyse the concentration and development of milk production in Germany, descriptive statistics were used on county-level data. Concentration was measured as the share of milk production in intensive production regions relative to overall milk production in the respective state and in the country as a whole. Intensive production regions were divided into regions with moderate intensity, or milk production of 2,000 to 3,000 kg/ha, and with high intensity, or production of more than 3,000 kg/ha.

To do correlation and regression analysis, the data were analysed on a normal distribution using the Kolmogorov-Smirnov test. The coherence of variables without normal distributions—milk production (tons), area of grassland (ha) and area of silage maize production (ha)—was evaluated with a correlation analysis, using the Spearman correlation coefficient.

The influence of grassland and silage maize on milk production was analysed with an ordinary least squares model (OLS) using the software SPSS 23. Here, the area of grassland (A) and the area of silage maize (B) are the independent variables, influencing the dependent variable milk production in tons (Y). The correlation coefficients β1 and β2 estimate the influence of the independent variables. The residue item (U) shows the influence of other factors on the dependent variable.

$$Y = \beta_0 + \beta_1 * A + \beta_2 * B + Ui \quad \textbf{(1)}$$

To analyse the impact of the New Fertilizer Act on the production costs of dairy farms, data from 12 dairy farms in Northern Germany were collected with the help of a specialized consulting company in autumn 2016. The data refer to the financial year 2014/2015. This means that they show the economic situation from 1 July 2014 to 30 June 2015. Production costs were calculated with reference to the full cost accounting method. Therefore, opportunity costs were scheduled for production factors such as unpaid family workers and land. Depreciations were adjusted to the actual operating life expectancy.

3. Results and Discussion

In 2010 moderately intensive dairy farming regions accounted for 15.5% of German milk production, whereas highly intensive production regions were responsible for 43.3%. Thus, intensive production regions contributed 58.8% to German milk production in 2010. By 2015 the share of German milk production in intensive production regions had increased slightly to 59.8% including a slightly increased share in the highly intensive regions of 44.3% and a constant share in the moderately intensive regions of 15.5%. Although the share of the intensive regions in total milk production increased only by 1 percentage point, they play a very important role in the development of German milk production overall. In 2010 the intensive production regions were responsible for 76.2% of the surplus in milk production; the highly intensive regions alone contributed 62.4%. In 2015 the highly intensive regions were responsible for 67.8% of the increase in production, whereas the moderately intensive regions

contributed only 10.7%. From 2010 to 2015 intensive production regions represented 69.9% of the growth in Germany's milk production, of which 54.9% was observed in highly intensive and 14.9% in moderately intensive regions.

The German states of Bavaria (24.9%), Lower Saxony (21%), North Rhine-Westphalia (10.2%) and Schleswig-Holstein (9.1%) represented 65.1% of German milk production in 2015. Milk production of more than 2,000kg/ha also occurs in Hesse, Rhineland Palatinate, Baden Wuerttemberg, Saxony, Brandenburg and Thuringia.

Table 1. Contribution of intensive dairy regions to total milk production in different states (%)

State	2010	2011	2012	2013	2014	2015	Average
Schleswig-Holstein	92.4	92.7	92.2	92.3	92.5	92.3	92.4
Lower Saxony	77.0	77.9	77.8	77.8	77.9	78.3	77.8
North Rhine-Westphalia	67.1	67.5	67.5	67.8	68.2	68.0	67.7
Hesse	18.2	18.4	18.9	18.8	*	18.6	18.6
Rhineland Palatinate	51.5	51.5	51.2	51.7	51.7	51.4	51.5
Baden Wuerttemberg	41.4	41.3	41.0	41.0	41.1	41.3	41.2
Bavaria	75.3	75.5	75.9	75.7	76.3	76.6	75.9
Brandenburg	1.4	1.5	1.4	0.0	1.5	1.5	1.2
Saxony	58.0	58.0	58.1	57.9	58.2	59.0	58.2
Thuringia	23.7	23.9	24.2	24.5	24.9	25.3	24.4

*data missing

Source: Authors' calculations after BLE 2011- 2016

As can be seen in Table 1, there are great differences regarding the role of intensive production regions in the various German states. Milk production is most concentrated in Schleswig-Holstein, where 92.3% of milk production came from intensive production regions in 2015. Schleswig-Holstein is followed by Lower Saxony (78.3%), Bavaria (76.6%) and North Rhine-Westphalia (68%). The lowest concentration of milk production can be seen in Thuringia (24.4%), Hesse (18.6%) and Brandenburg (1.5%). In all German states, the highly intensive regions represent higher shares of total milk production than the moderately intensive regions. In Schleswig-Holstein the highly intensive regions contributed 70.3% to the state's total milk production in 2015. The highly intensive regions' share of total milk production was 67.6% in Lower Saxony, 55.5% in Bavaria and 51.8% in North Rhine-Westphalia. The growing concentration of milk production can also be seen when examining production growth in intensive regions. In Lower Saxony, for example, the intensive production regions were responsible for 91.1% of production growth in 2015, with 78% deriving from highly intensive regions. In some states, intensive regions contribute more than 100% to production growth. This is because production grew in these regions, while the states' overall milk production decreased. This is the case in Rhineland Palatinate (198.5%) and Saxony (136.4%).

Available grassland is an important factor for milk production. The weighted average share of grassland on total farming land in highly intensive regions is 49.2%. Moderately intensive regions have a weighted average share of 27.3%, and non-intensive regions 22%. The area of silage maize production is also higher in intensive dairy farming regions. In highly intensive regions, the weighted average share of arable land dedicated to silage maize is 37.6%, and the weighted average share in moderately intensive regions is 22.2%. In other regions silage maize accounts for a share of 15.2% of arable land. The share of arable land dedicated to

silage maize production is an important determinant of further growth in milk production because due to the greening regulations, the share arable land dedicated to the main crop is limited to 75% (Chamber of Agriculture 2016). In a few German counties, the share dedicated to silage maize is already up to 75%. Though at county level that share may average 37.6% in highly intensive regions, at the individual farm level it can be much higher, as is the case on the farms we analysed in the Northern German intensive region, where it is already nearly 75%. The close relationship between milk production (tons) and the areas of grassland (ha) and silage maize production (ha) can be seen when analysing the correlation. Both factors have a very strongly positive and highly significant correlation with milk production, as can be seen in Table 2.

Table 2. Correlation matrix with Spearman correlation coefficient

	Milk production	Area of grassland	Area of silage maize
Milk production	1.000	0.889**	0.887**
Area of grassland	0.889**	1,000	0.766**
Area of silage maize	0.887**	0.766**	1.000

**significance level 0,01

Source: Own calculations after BLE 2016, KWS 2017

The regression model analysed the influence of grassland area and the area of silage maize on German milk production. As can be seen in equation 2, both factors have a highly positive and significant influence.

$$Y = -9{,}448{,}894^{1} + \ 4{,}935^{1} * A + 5{,}647^{1} * B + Ui \qquad (\mathbf{2})$$

[1] significance level 0.01

The coefficient of determination, R^2, is 0.832; this means that 83.2% of the estimated residues can be explained by the independent variables "area of grassland" and "area of silage maize", both of which are essential for milk production. The result confirms the theory that milk production is allocated where natural resources allow no or just a few types of land use other than grassland. Furthermore, it indicates the strong influence of silage maize production on milk production in the prevailing production systems in Germany.

Another point that will influence the development of milk production is the new Fertilizer Act. The data from German dairy farms in intensive regions show that the farms which have grown strongly over the last years will not fulfil the tighter regulations of the new Fertilizer Act because their nitrate levels from animal manure are above the now more strictly defined 170 kg/ha limit. The share of total farm land dedicated to grassland on these farms is 45.9% Therefore, the farms will be impacted by the abolishment of the derogation option, which allowed them to put 230 kg/ha of nitrates from animal manure on grassland. The farms in our study have a surplus of 19.9 kg N/ha (Niemann 2016). As a result, they will be forced to rent additional land, export the nitrate surpluses to regions with lower livestock densities, reduce their herd size or reorganize their farms by, for instance, outsourcing of the rearing of calves. Export opportunities are restricted due to competition from pig and poultry farmers in intensive livestock production regions, who are also affected by the new legislation. These farms are further affected by the stricter phosphate limit because of the higher amounts of phosphates produced, especially in pig manure (Chamber of Agriculture 2017). This situation will lead to an increased demand for land even though land prices are already high in the intensive regions we studied. The opportunity costs for land are currently about €600/ha p.a.

for arable land (Niemann 2016). How land prices will develop is not completely clear. In general, prices increase when demand increases, as seen in the past. While rental prices for land are much higher even than €600/ha p.a. in other intensive livestock regions, they have stayed constant or even decreased in some intensive dairy regions because of farm failures due to the low milk prices in recent years. Nevertheless, recent increases in land prices have led to an increase in production costs of 0.7 ct./kg energy corrected milk (ECM). The costs for the export of manure within the blocking period will result in additional costs of 0.4 ct./kg ECM. Here cost of storage of €5/m³ were calculated and an average transport distance of 30 km is assumed (Niemann 2016). Indeed, these costs may increase in future due to the fact that the legally stipulated nitrate balance of 60 kg/ha will decrease to 50 kg/ha in 2020. Furthermore, export distances are also likely to increase due to competition with livestock farms and substrate from biogas plants because the new Fertilizer Act also limits the application of substrate to 170 kg N/ha (BMEL 2015). Last but not least, the low prices for mineral fertilizers could decrease the willingness of arable farmers to use manure.

4. Conclusion

From 2010 to 2015, German milk production grew more strongly than the European average, whereby the growth was mainly concentrated in intensive dairy farming regions. From 2010 to 2015, intensive production regions were responsible for 69.9% of production growth in Germany, whereby the highly intensive regions accounted for 54.9%. The result of this analysis confirms the theory that milk production is heavily based on grassland due to its low opportunity costs. Furthermore, the study confirms the strong influence of area of grassland and area of silage maize on milk production. Especially on farms which have strongly increased their herd sizes, EU greening regulations will further limit the growth of milk production. The new Fertilizer Act will increase the production costs of dairy farms, especially those of farms which grew quickly in the past. Affected dairy farms will have to develop strategies to solve this problem. Cost analyses show that strategies such as the outsourcing of the breeding of calves can decrease the surplus of nitrates to below the 170 kg/ha limit at the farm level (Niemann 2016).

Nevertheless, in most cases this will end up in increasing production costs on affected dairy farms, which will reduce their competitiveness against foreign competitors, especially those farms in less intensive areas with low opportunity costs. Indeed, there are competitors such as farms in the Netherlands which are more heavily impacted by the implementation of the European regulations. Policymakers should deal with the problem of nutrient surpluses by supporting the development of solutions, for example, economically more attractive export systems for nutrients into less intensive regions or more nutrient-efficient ratios for animals (Kröger 2016). These measures will help remedy the impact of the Fertilizer Act on dairy farming in Germany and preserve its competitiveness since, in the end, there are many good reasons besides site conditions, such as farmers' knowledge and presence of necessary infrastructure, why dairy farming is located in these areas and has been further concentrated there.

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