Do investors ruin Germany’s peasant agriculture?

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Abstract:

This paper deals with the activity of non-agricultural investors in the German agricultural biogas production with an agent based approach. A literature review and two expert interviews are carried out for their characterization. An investor is hypothetically implemented in an east German case study region. The goal of the simulations with the agricultural structural model AgriPoliS is to determine its effects on other farms in the region and the region itself. The results show that the non-agricultural investor can run its business economically viable. The presence of this investor increases the rental prices in the region. This applies to both arable land and grassland. The results, however, suggest that an investor does not accelerate the structural change, because in this scenario more farms persist until the end of the simulation and especially smaller ones are economically better off. The investor has changed the cultivation patterns of the whole region: In general, an intensification of land use is observed as more energy crops are produced for the production of biogas substrates. On the other hand, the production of less intensive crops and cereals decreases. Regarding the use of grassland, the production of grass silage is increased at the expense of grazing.

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The results show that the non-agricultural investor can run its business economically viable. The presence of this investor increases the rental prices in the region. This applies to both arable land and grassland. The results, however, suggest that an investor does not accelerate the structural change, because in this scenario more farms persist until the end of the simulation and especially smaller ones are economically better off. The investor has changed the cultivation patterns of the whole region: In general, an intensification of land use is observed as more energy crops are produced for the production of biogas substrates. On the other hand, the production of less intensive crops and cereals decreases. Regarding the use of grassland, the production of grass silage is increased at the expense of grazing.

1 Introduction and background

Rental prices as well as purchases of agricultural land have experienced a strong increase in Germany since 2007. Meanwhile, an annual increase of up to 25% has been recorded (TIETZ and FORSTNER 2014). Especially the federal states in the north-east showed high dynamics within Germany. For example, prices for agricultural land in eastern Germany increased by around 240% between 2007 and 2015 (TOPAGRAR 2017). Despite regional differences in land prices and price dynamics, farmers increasingly fear for the viability of their farms. Therefore, the topic is lively, sometimes also emotionally discussed (AGRARHEUTE 2015). For the increases in land prices, different explanatory approaches exist. As one major factor biogas production is frequently cited in the literature as price-increasing on the land markets (BRAUN et al. 2009; KILIAN et al. 2008; HABERMANN and BREUSTEDT 2011; HÜTTEL et al. 2012). This effect is primarily caused by the demand for fermentation substrate, which consists mainly of silage, either from maize or grass. To produce the necessary biomass, a corresponding amount of land is needed. The land can either

belong to the farm itself or to farms that supply the biogas producers. In addition to the effects on the land markets, biogas production also affects the composition of local production (APPEL et al., 2016). The production of plant-based foods and feed production for livestock farming are increasingly suppressed by the cultivation of energy crops (AGRARHEUTE 2013; KLU 2013).
With the introduction of the Renewable Energy Act (REA, German: EEG) in 2000, the biogas production became more and more relevant on the market. The REA gave strong incentives for farms to invest in biogas plants because of increased and above all long-term guaranteed feed-in tariffs (APPEL et al. 2016). Due to the amendment of the REA 2014 and the associated drastic reduction of the feed-in tariffs, meanwhile the construction of plants has almost completely come to a standstill (TLL 2017).

1.1 Non-agricultural investors

Price increases on the land market are also regularly associated with non-agricultural investors in the public debate (AGRA-EUROPE 2012, AGRARHEUTE 2015b, RBB 2017). Especially through the guaranteed feed-in tariffs of the REA, investments in biogas plants became interesting for these types of investors (FORSTNER et al. 2011). That possibly resulted in an increased competition on the land market even further.
First, it should be mentioned that non-agricultural investors are not a homogenous group. The investors can become active in agriculture in different ways. So, there are land and farm purchases with subsequent leasing or self-management of the land. But silent participations also play a role in providing the necessary equity capital (EMMANN et al. 2015). There are also very different motivations for engaging in agriculture. FORSTNER et. al 2011 mention the following ones according to REIM 2010:

- fear of inflation (85% of investors),
- search for a material value (75%),
- use of the boom in agricultural commodities (40%),
- portfolio diversification (40%).

Three of the four main motives are aimed at securing assets; only the motive "use of the boom in agricultural commodities" serves to achieve high returns. According to TIETZ (2017) the dynamics of the engagement of non-agricultural investors have hardly changed in recent years. In absolute terms, of course, the proportion of agricultural land managed by investors increases anyway, but is rather driven by the continuous succession problem of the farms. From the point of view of the agricultural holdings there are two main reasons for the takeover by Investors: On the one hand, there may be a need for capital as a result of economic weakness, for the realization of necessary investments, for the securing of the landbank or for the compensation of leaving shareholders. On the other hand, this often happens in the course of the generational change on farms: "*If there is no qualified junior staff, an in-family succession is excluded and no one of the remaining shareholders can pay the required compensation, selling to an external investor is often the only feasible option*." (FORSTNER and TIETZ 2013).
The investors importance increased enormously, especially during the last financial crisis. Before 2008/09, for example, between 1 and 1.5 million hectares of land were annually purchased by

non-agricultural investors, in contrast to more than 47 million hectares in 2008/09 (EMMANN et al 2015). As a result, some federal states discuss to toughen legal regulations (FORSTNER and TIETZ 2013). The European Commission has also addressed the topic by providing guidelines for dealing with price speculation and property concentration in agriculture (EUROPEAN COMISSION 2017). However, with the exception of Baden-Württemberg in 2010 (ASVG 2010), no tougher regulations have been established to in any federal state in Germany (FORSTNER and TIETZ 2013).
The long-term guaranteed feed-in tariffs of the REA also made biogas production favorable for investors (TIETZ 2017). In a study by the Fachverband Biogas Brandenburg (Biogas Association), 51% of the 502 biogas plants were operated by investors. An estimated 80% of power generation comes from these plants (BIOGAS JOURNAL 2016). According to estimates by LUDLEY (2017), around 20-33% of the biogas flow in Germany is generated in investor plants. The non-agricultural investors are also very heterogeneous in biogas production and not easy to classify. According to TIETZ (2017), however, their behavior is rather characterized by economic rationality. The goal of maximizing profits may even be more pronounced here than on farms run by farmers. However, it is quite conceivable that investors can produce more efficiently, or at lower costs, and have higher willingness to pay on the land market due to higher economic land rents (TIETZ 2017).

This paper aims to examine the role of non-agricultural investors in the biogas sector and the resulting implications for regional land markets, structural change and land use.

1.2 Hypotheses

The economic land rent is an indicator of the average remuneration of the production factor land. It indicates the amount that is available for the factor land after deduction of all other costs (GÖMANN et al., 2013). It is therefore the part of the income which tenants pay to the landowners; thus, represents the price for the use of the land. When an investor becomes active in a region, there will be farms that produce energy crops and sell them to the investor. Since the farms act profit-maximizing, they will only sell to the investor, if the price is higher than the regular market price and also the in-farm use is less lucrative. As a result, they make higher profits when selling to an investor, which also increases their economic land rent. It can be assumed that rising economic land rents lead to rising rental prices in the long term (GÖMANN et al., 2013). This leads to Hypothesis 1:

- If a non-agricultural investor becomes active in a region, the rental prices rise.

Since the industrial revolution, agriculture has been undergoing structural change, characterized by high productivity gains, changes in the factor endowment and the migration of workers to other sectors (BALMANN and SCHAFT 2008, KIRSCHKE et al. 2007). With the rising land prices expected in Hypothesis 1, it can be assumed that especially smaller and less competitive farms will reach their financial limits due to investor activity, especially regarding the acquisition of new rental plots. Ultimately, this could lead to increased bankruptcy among smaller farms (ABL E.V. 2017). This leads directly to Hypothesis 2:

- Non-agricultural investors are leading to an increased exit of smaller farms and thus accelerate structural change.

Biogas production is often associated with a change in land use, e.g. an increase in maize cultivation (LINHART and DHUNGEL 2011). Also APPEL et al. (2016) found evidence of a change in cultivation patterns in connection with a general intensification of land use. As the modeled investor becomes active in the biogas production, Hypothesis 3 reads as follows:

- The activity of a non-agricultural investor in biogas production in the region leads to an increased cultivation of energy crops and to an intensification of land use.

2 Methodological approach and case study region

To analyze the impact of non-agricultural investors, we used the agent-based model AgriPoliS (Agricultural Policy Simulator, e.g. HAPPE et al. 2006). In this chapter, we describe the model's features and the study region. Moreover, a description of the model extensions is provided.

2.1 The agent-based model AgriPoliS

AgriPoliS is a spatially explicit and dynamic agent-based model that is able to simulate the evolution of agricultural structures over time. It is mainly used to study the influence of agricultural policies on agricultural structural change. It is based on the work of BALMANN (1997), who studied path dependencies in agriculture using an agent-based approach. Balmann's model was initially based on hypothetical data; However, AgriPoliS in its current version can be calibrated to empirically collected data and thus provide results on structural change in real existing regions (SAHRBACHER et al. 2012). The first more detailed model description of AgriPoliS was published in HAPPE (2004). SAHRBACHER et al. (2012) provides a detailed documentation of AgriPoliS following the ODD standard protocol (Overview, Design concepts and Details).

2.2 Case study region

The case study region for our simulations is the Altmark, which is situated in the north-east of Germany, in the federal state Saxony-Anhalt. It comprises the two districts Stendal and Altmarkkreis Salzwedel. The region has a total area of 4,716 km^2, while 274,000 ha of this land is used by agriculture (STALA 2016). The Altmark is characterized by a large-scale agricultural structure which is typical for east Germany. Many of the farms are specialized arable farms and large mixed farms with livestock production. There is a total of 1,070 farms operating in that region, which use an average of 256 ha of land (STALA 2016). Compared to other regions in north-east Germany, the share of grassland (25%) is high in that region (STALA 2016). Because there are plant and animal substrates available in the Altmark, the region is suitable for biogas production (APPEL et al. 2016). OSTERMEYER (2015) provides a detailed description on how the Altmark region is implemented in AgriPoliS.

2.3 model extensions

The following passage contains explanations for the model extensions, i.e. the modeling of non-agricultural investors in AgriPoliS and the implementation of a substrate market.

Since statistical data of non-agricultural investors are very difficult to access, this study attempts to generate a corresponding data basis for the modeling through a literature search and two interviews. Statistical data are not available on the quantitative occurrence of investors in the Altmark, which is why the model implements a hypothetical investor who has the characteristics derived from literature research and interviews. The heterogeneity of investors was therefore left out of consideration here. The focus of modeling is not on the realistic depiction of investor activity in the region. Rather, the interactions of the investor with other farms on the substrate market and the identification of general tendencies are the subject of this work.

As a result of the expert interviews, the case described below was assessed as relevant and was therefore selected for modeling.

It is assumed that a gender-neutral investor is building a biogas plant in the region. It will get an 800 kW biogas plant as initial equipment. In the simulation process, it is possible for the non-agricultural investor to invest in further and, if necessary, smaller plants. Apart from a biogas plant, the investor has no other assets, not even land. Equity capital was set to 1,300,000 €. This amount corresponds to half of the investment costs for an 800 kW biogas plant and is available to the company to cover the capital service. According to LUDLEY (2017), the leverage ratio for investments was set at 70%.

Because the non-agricultural investor does not have its own land and cannot rent land, it is necessary for the investor to buy fermentation substrates to operate the biogas plant. The substrates are produced by the other farms of the region and sold to the non-agricultural investor. The smallest sales unit is one tonne (t). A price function regulates the price change in the market. The average distance of a land plot to the biogas plant was assumed to be 15 km. According to LFL (2007), this results in transport costs of around 5 € per t. If the fermentation substrate is not available regionally, it is also possible for the investor to buy substrate outside the region. To capture the higher transport costs in this case, the price per t is 1.5 times the regional price.

3 Scenarios

The present work will analyze two scenarios. In a reference scenario (REF scenario), the region is modeled based on data from OSTERMEYER (2015) and APPEL et al. (2016). In a second scenario, henceforth called "NAI scenario", an investor is put into the region. The scenarios differ only by the additional agent "non-agricultural investor". It is equipped with the characteristics described in chapters 1.1. and 2.3. Each of the simulations start in 2006 and will calculate 24 iterations until the year 2030. The political framework conditions (Common Agricultural Policy (CAP) and REA) have been assigned to the respective iterations. For the analysis, the years since the REA amendment 2014 are of particular interest.

4 Results

In order to estimate the effects of non-agricultural investors in biogas production, the analysis focuses on the following aspects: First, results describing the agent "Non-agricultural investor" are shown. Afterwards, the results of agricultural structural effects, the effects on the land market, individual economic effects as well as effects on the land use are presented.

4.1 The agent “Non-agricultural investor”

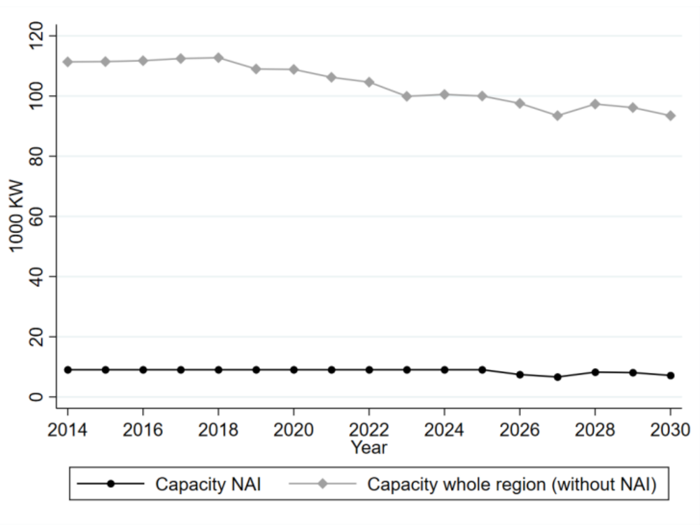

Fig. 1: Installed biogas capacity

Figure 1 shows the installed biogas capacity in kW of the non-agricultural investor and the installed capacity of the other farms in the region. The curves allow conclusions about the investment behavior. The initial equipment of the investor is an 800 kW biogas plant. Due to the political incentives, the investor quickly invests in further biogas plants. Already in the first year of the simulation, it is investing in another 800 kW plant. By 2013, there will be investments in additional 800 kW plants, as well as 150 kW and 450 kW plants. From 2014, the year of the comprehensive REA amendment, new investments will come to a standstill. The installed capacity is constantly 9,050 kW until 2025. From 2025, the first plants build from 2006 onwards will be amortized and decommissioned. As a result, the installed capacity drops. However, the conditions of the REA 2014 do not exclude new investments. In 2028, for example, the investor is investing in new plants again. The other farms of the region show a very similar behavior. Biogas capacity will be greatly expanded by 2014, after which it will stagnate and begin to decline as of 2019. However, occasional reinvestments also take place here. For the full duration of the simulation the investor, on average, has almost 10% of the total installed biogas capacity of the entire region.

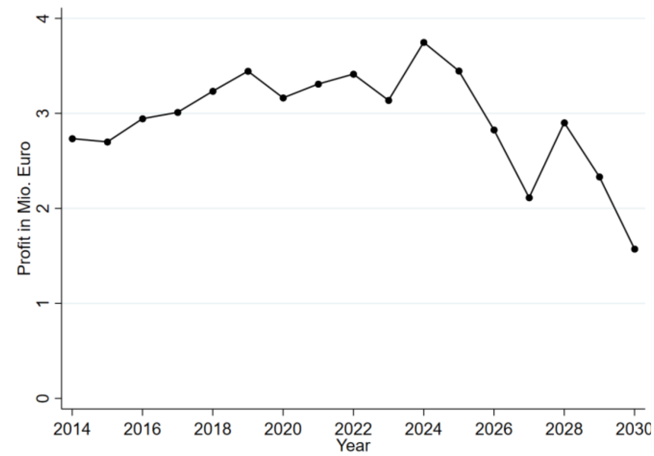

Fig. 2: Profit NAI

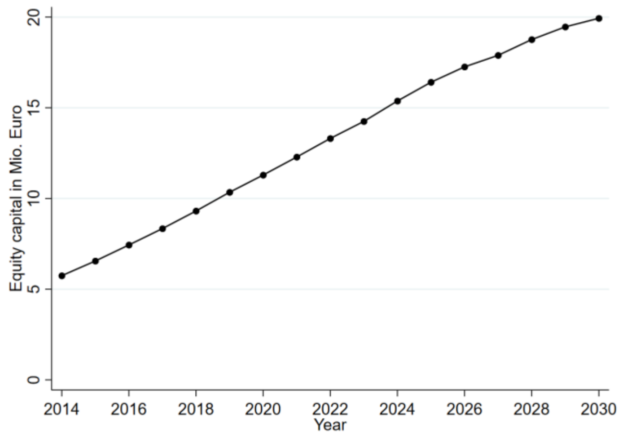

Fig. 3: Equity NAI

Figure 2 shows the evolution of the profit of the non-agricultural investor over time. From 2014 onwards, it can gain stable profits. The profit reaches a maximum of around 3.75 million € in the year 2024. Subsequently, the profit decreases until 2030. This decrease is also justified by the decommissioning of the first biogas plants, which have been in operation by the investor since 2006 and have reached their maximum useful life. The development of equity is characterized by a continuous increase. The effect of the decommissioning of the first plants can also be seen here, since the increase runs somewhat flatter from 2026.

4.2 Substrate price trends

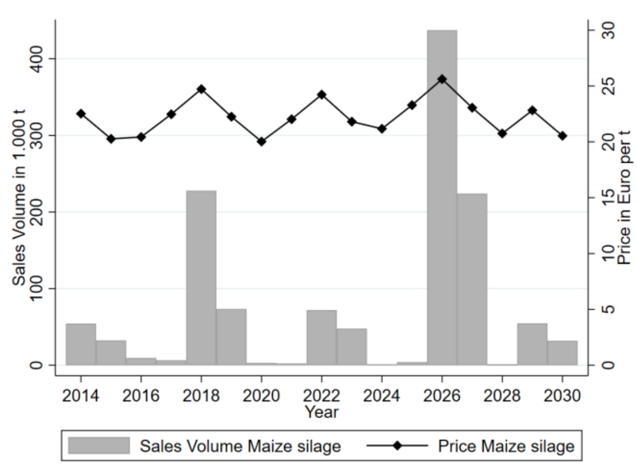

Fig. 4: Development of price and sales volume of maize silage

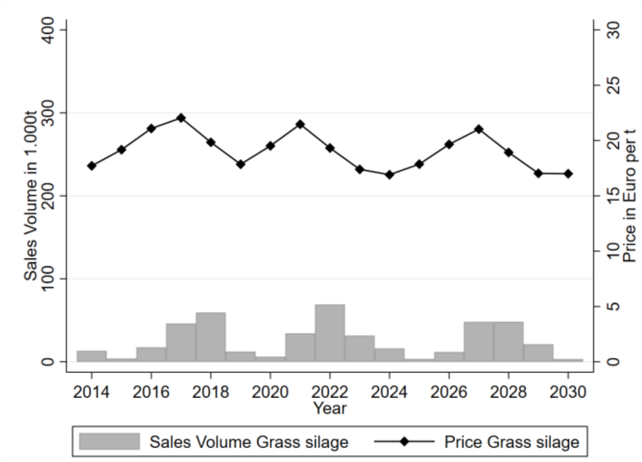

Fig. 5: Development of price and sales volume of grass silage

The substrate price development can only be determined for the NAI scenario, since there is no trading in the reference scenario; consequently, no market and no prices arise. Due to the model assumptions (profit maximization, linear optimization, no supply contracts, etc.), both the quantities and the prices are subject to greater fluctuations and to a certain extent form a pork cycle. When looking at the substrate prices in the NAI scenario over time, it is noticeable that they fluctuate but do not show a strong trend overall. The price for corn silage fluctuates over the course of the simulation by 22 €/t. Grass silage starts at a price of 17.7 €/t and is at 17.0 €/t in the last year, so has a slightly decreasing price trend. The sales volume of maize silage tends to increase, while for grass silage the opposite is the case. This is due to the fact that maize silage at around 108 MJ ME/kg contains significantly more energy than grass silage at around 70 MJ ME/kg. The variable costs of production, on the other hand, do not differ to this extend at 529 €/t for intensive grass silage and 745 €/t for maize silage.

4.3 Land market

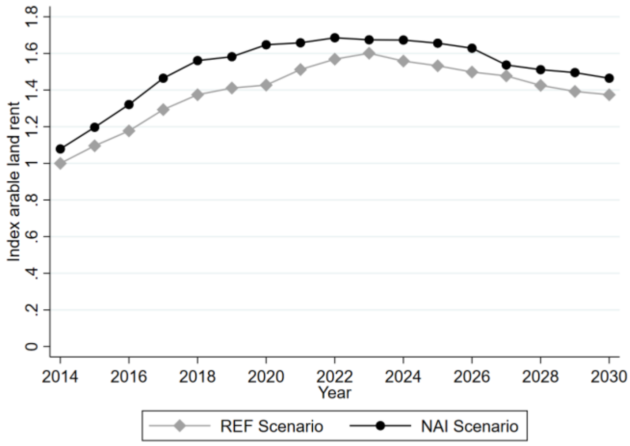

Fig. 6: price index arable land

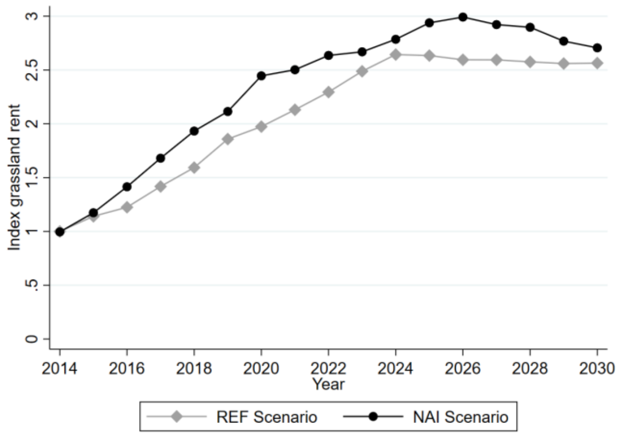

Fig. 7: price index grassland

In both figures above, the rental price of the base scenario in 2014 was taken as a reference and equated to the value 1. The rent payments for arable land are increasing in both scenarios (Figure 6). This increase will last until 2023 in the REF scenario, reaching 1.6. In the NAI scenario, the rental prices increase until 2022 and reach a value of 1.67. In the following years, until the end of the simulation, rents will decrease in both scenarios. For arable land, the simulations on average show 8.9% higher rents in the NAI scenario than in the reference scenario.

Figure 7 shows the development of rental prices for grassland. It can be seen that the rental prices for grassland are also rising sharply, even more than for arable land. In both scenarios, the rental price in 2014 is on an identical level. The grassland rents in the reference scenario increase until 2024 and reach a value of 2.64. Scenario NAI shows a rise to 2.99 by 2026. On average for all iterations, the rental prices for grassland in the NAI scenario are 12.1% higher than in the REF scenario.

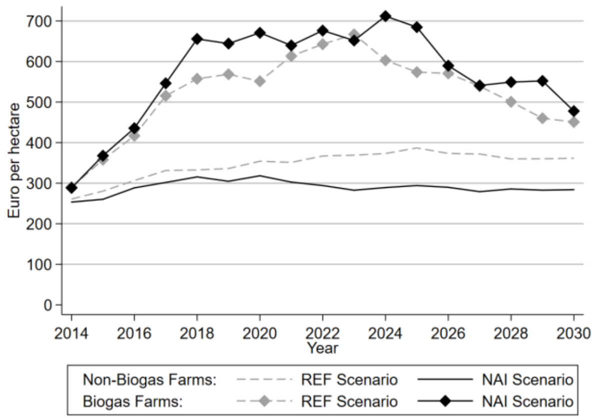

Fig. 8: Arable land rent for Biogas- and Non-Biogas Farms

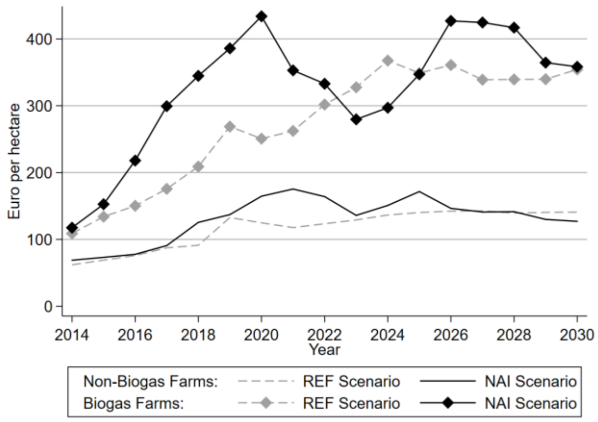

Fig. 9: Grassland rent for Biogas- and Non-Biogas Farms

In Figure 8 and Figure 9, we made a distinction between Biogas Farms and Non-Biogas Farms. Biogas Farms are those farms that produce biogas in the reference scenario, regardless of their behavior in the NAI scenario. Accordingly, the Non-Biogas farms are the ones that do not produce biogas in the reference scenario. This subdivision can be used to analyze how certain farms would have developed if an investor had occurred in the region. For arable land (Figure 8) a greater increase in rents for biogas farms can be seen in both scenarios. From 2025, however, the level of rental prices of biogas farms will decline again more. The reason for this is also to be seen again in the adaptation of the REA, since farms are included, which do not reinvest in a biogas plant. Biogas farms pay higher rents on average in the NAI scenario, than in the REF scenario. In the NAI scenario, non-biogas farms on average pay lower rental prices than in the REF scenario. Overall, the difference in the rental price level between biogas and non-biogas farms increases by the non-agricultural investor.

The rental prices for grassland also show increases for biogas and non-biogas farms in both scenarios (Figure 9). Again, the differences between biogas and non-biogas farms are considerable. The rental prices for biogas farms are rising faster than for non-biogas farms. For biogas farms, the rental prices in the NAI scenario are also higher on average than in the REF scenario. Unlike rents for arable land, rents in grassland are also higher for non-biogas farms in the NAI scenario than in the reference scenario. Reason for this may be the additional utilization possibility of the grassland, as the farms in this scenario can produce grass silage and sell it to the investor.

Due to the differences in the level of rental prices, Hypothesis 1 must be confirmed. In the scenario with the non-agricultural investor, rental prices rise for arable land as well as for grassland.

4.4 Number of active farms

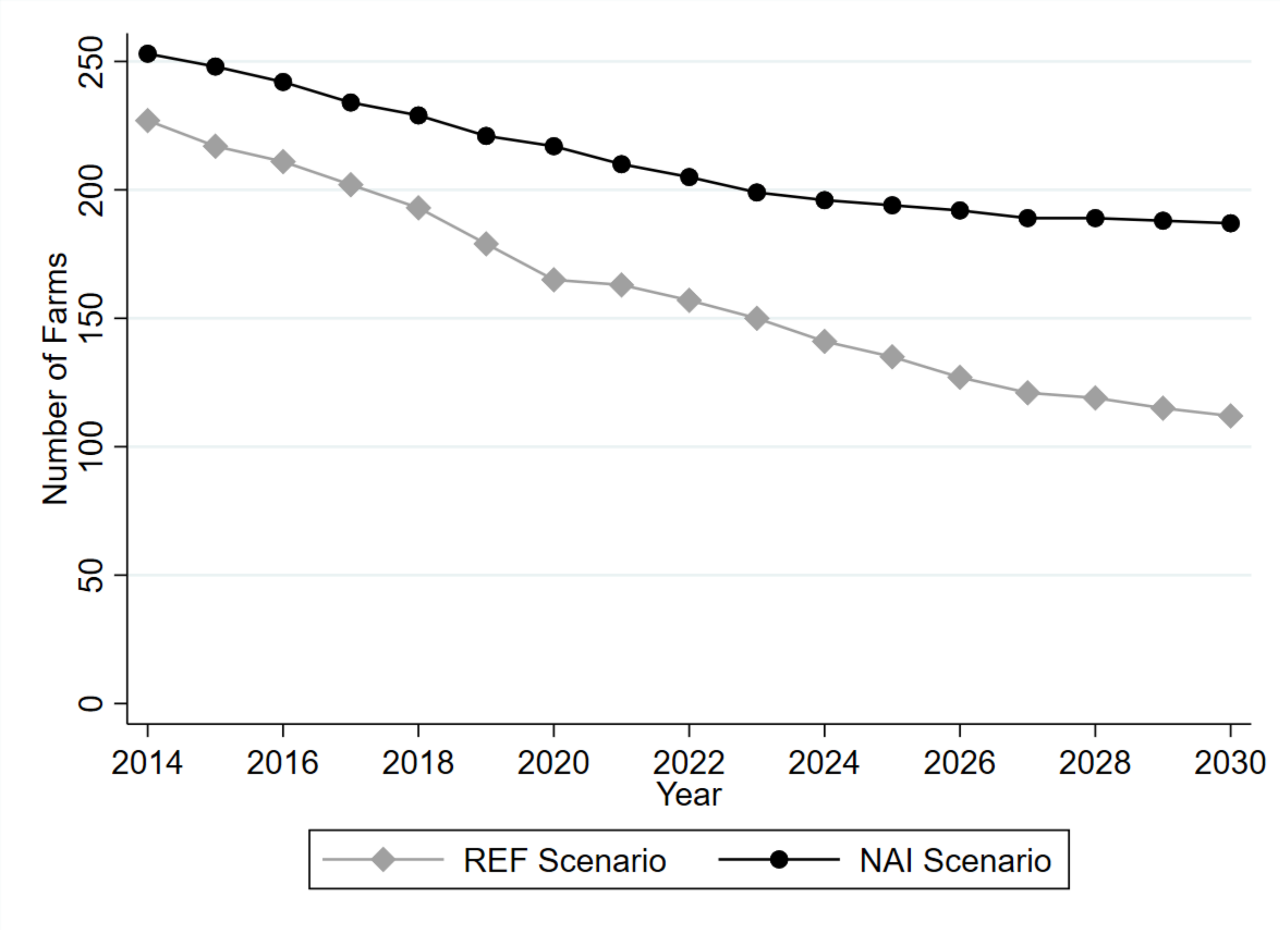

Fig. 10: Number of active farms in the model region

By analyzing the number of active farms in the region, we want to find out about the dynamics of structural change. The simulation starts in 2006 with 322 farms in the reference scenario. In the NAI scenario, there are 323 farms because of the additional agent. It turns out that in the reference scenario significantly more farms leave production than in the NAI scenario. In the reference scenario, there are 227 farms in 2014; in the NAI scenario there are 253 farms, including the non-agricultural investor. In 2030, in the last year of the simulations there are still 112 active farms in the REF scenario; in the NAI scenario there are 187. It seems that some farms in the region can benefit from the activity of an investor. For them, a new buyer of their products opens up with the investor. These farms could benefit indirectly from the subsidization of biogas production by the activity of an investor, even if they did not invest themselves in their own biogas plant. This assumption will be verified in the following analyzes.

4.5 Farmsize

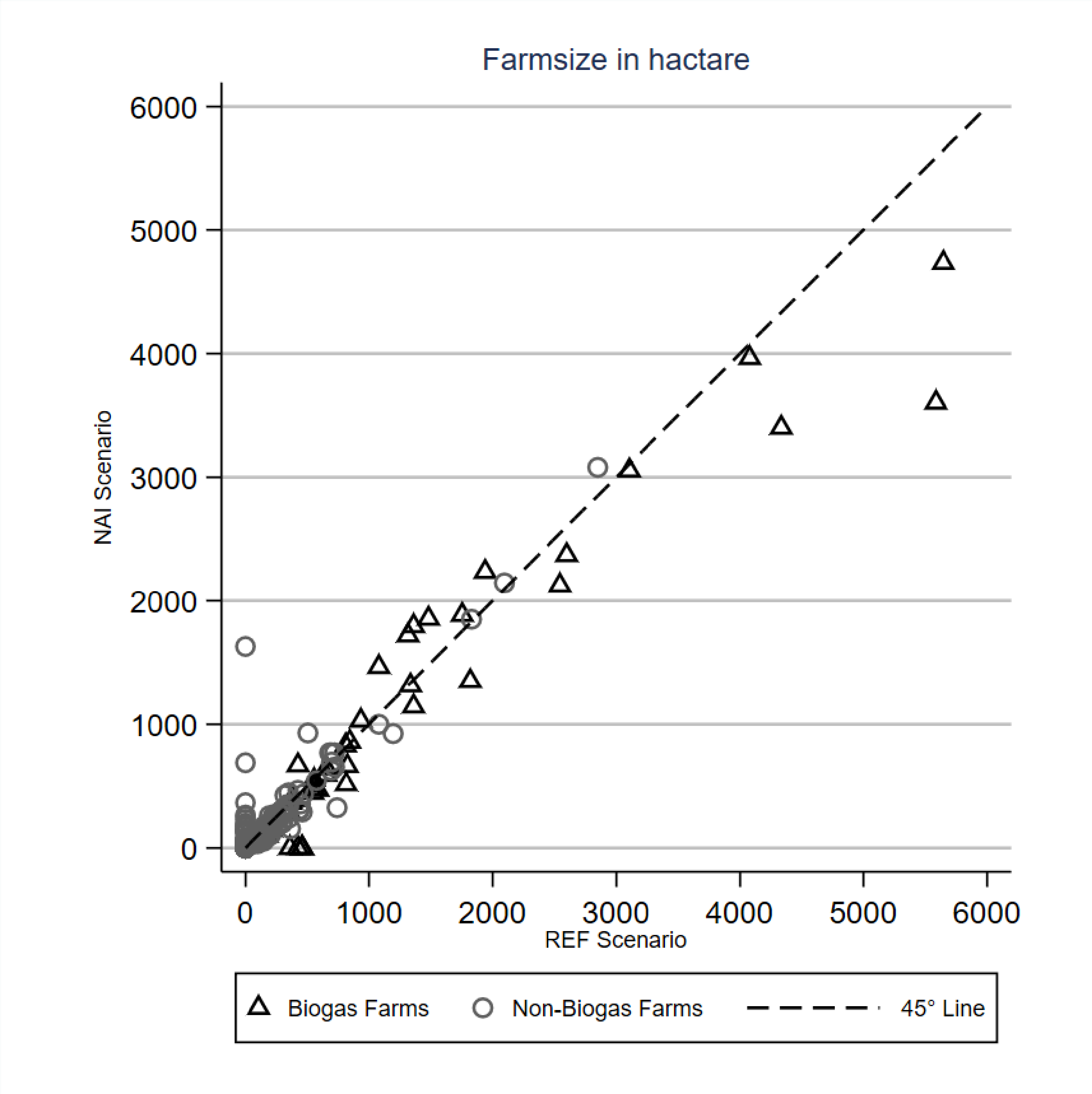

Fig. 11: Farmsize in hectare for Biogas- and Non-Biogas Farms. Note: Farm size in hectares of single farms in 2020

Figure 11 shows the farm size in hectares of biogas and non-biogas farms in both scenarios in the year 2020. Farms that are on the 45° line are equally sized in both scenarios. Farms underneath the 45° line are larger in the REF scenario, while farms above the 45° line farm more hectares in the NAI scenario. It can be seen that biogas farms deviate the most in the NAI scenario. They achieve smaller farm sizes there than in the REF scenario. This is especially true for biogas farms that are particularly small or very large in the REF scenario. However, for farms between 1,000 and 2,000 hectares, some may develop better in the NAI scenario. There tend to be more Non-Biogas farms that achieve a larger farm size in scenario NAI. A whole range of farms, which fall on zero hectares in the reference scenario, can still develop positively in the scenario NAI.

4.6 Profit

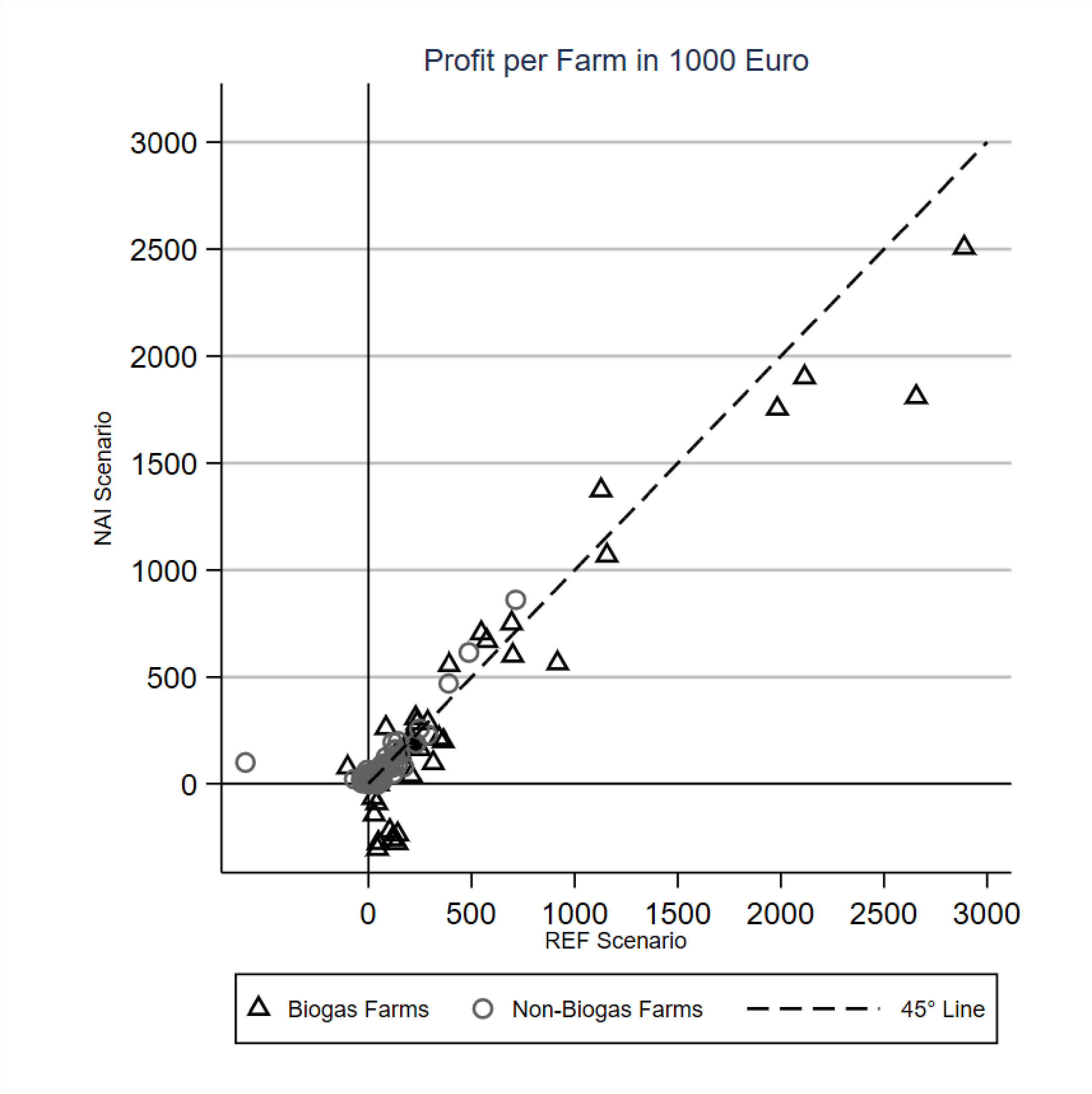

Fig. 12: Profit per farm in the year 2020

Figure 12 shows the profits per farm in 1,000 € for Biogas- and Non-Biogas farms in both scenarios in 2020. Farms below the 45° line have higher profits in the reference scenario; farms above the 45°line, in the NAI scenario. If the farms are directly on the 45° line, their profit does not differ in both scenarios. The profit per farm shows that biogas producing farms are more often below the 45° line; Thus, profits for these farms are lower in the NAI scenario, than in the REF scenario. Nine biogas farms even make losses in the this scenario.
In contrast, the non-biogas farms benefit in the NAI scenario more than in the REF scenario. On average, they generate higher profits here than in the REF scenario.

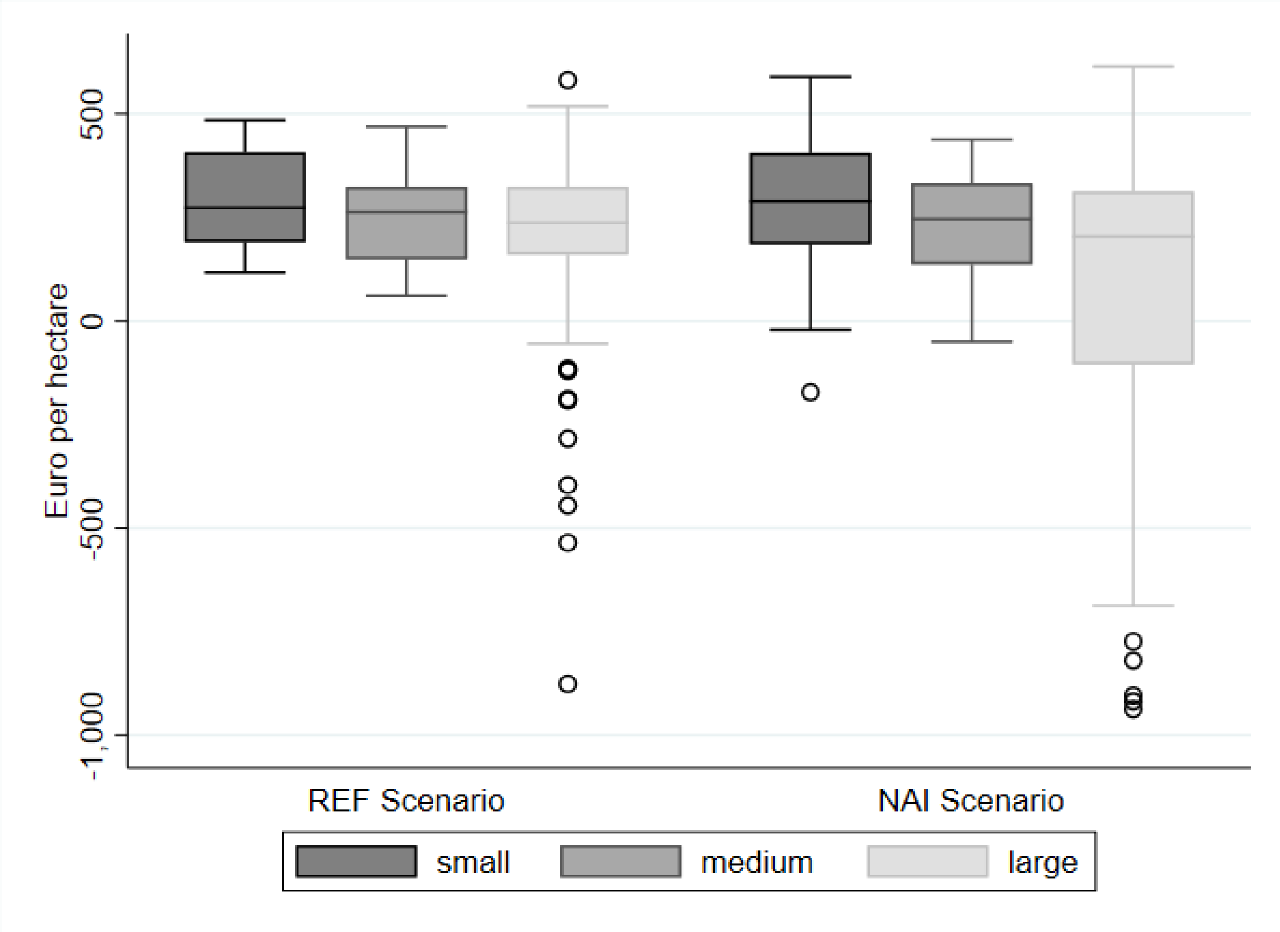

Fig. 13: Profit per hectare by farm size

Figure 13 shows profits per hectare in the year 2020 in a box plot. The farms have been subdivided according to farm size. "Small" in this chart stands for farms with less than 16 ESU (1 ESU corresponds to 1,200 € standard gross margin), „medium" for farms with 16 to <100 ESU and "large" for farms with more than 100 ESU. Small farms achieve slightly higher profits in the NAI scenario than in the REF scenario. Whereas medium-sized and large farms gain higher profits in the REF scenario. One can also see the larger number of large farms, which are significantly worse off in the NAI scenario. The illustration shows that the variance of profits is higher in all size classes in the scenario with the non-agricultural investor.

Due to the results, Hypothesis 2 must be rejected. Although land prices are rising, small farms are able to run their farms economically viable. Furthermore, the conditions for a positive development in terms of the landbank tend to improve.

4.7 Cultivation

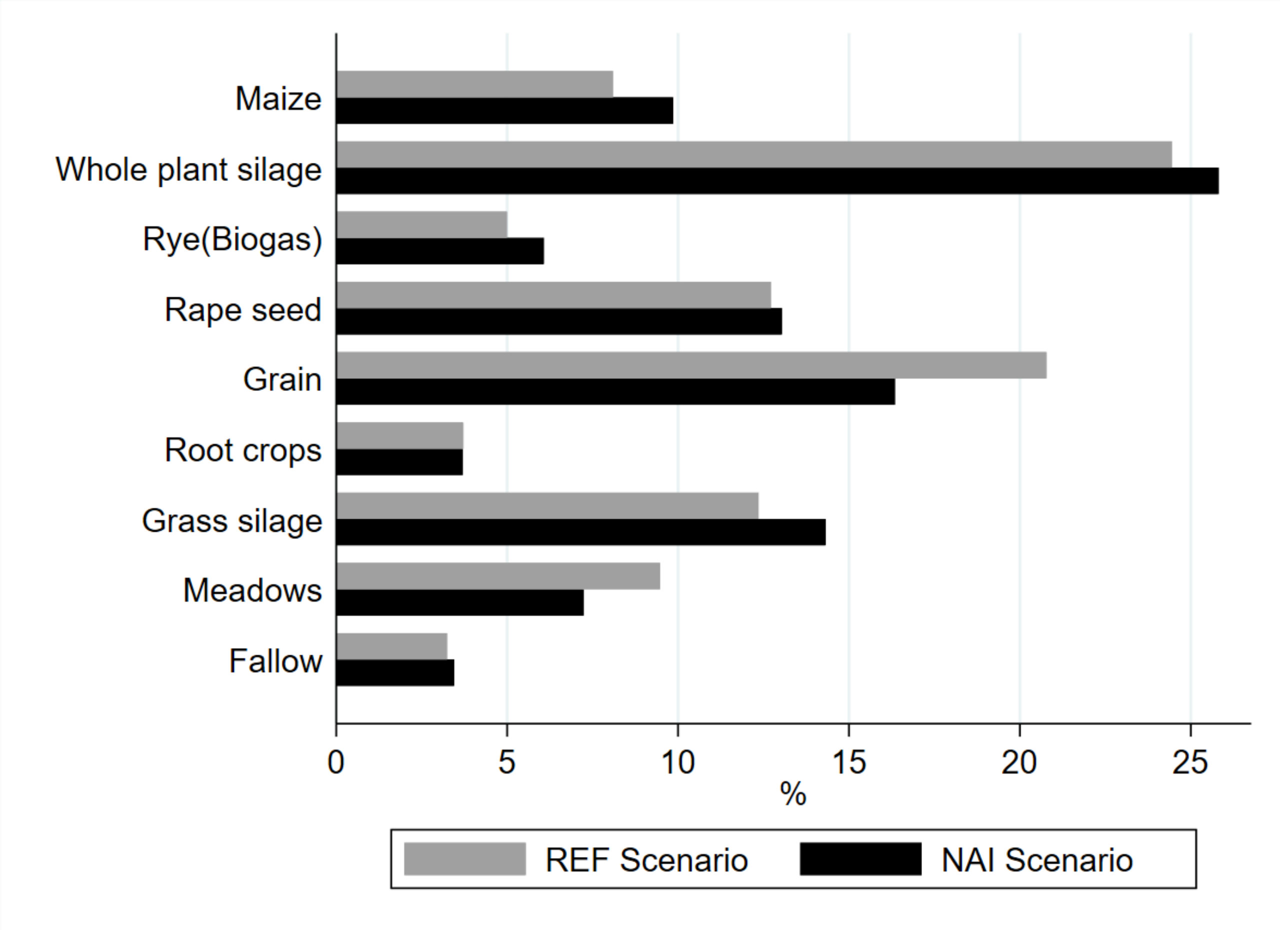

Fig. 14: Shares of different crop types in both scenarios from 2021 - 2030

The results of cultivation patterns show that there are also differences in land use between the two scenarios (Figure 14). As the quantities of the grown crops are very volatile between the years (see Figures 4 and 5, substrate market), we have chosen an average over the last ten years of the simulation for this depiction. The bars visualize the share of each crop in percent for both scenarios. It becomes clear that crops that are used for biogas production are increasingly produced in the NAI scenario. This is true for corn, whole plant silage and rye (for biogas). For rape seed and root crops (here sugar beets and potatoes), there are no significant deviations in the extent of cultivation. By contrast, the acreage for cereals decreases most. The use of grassland shows similar results. Grass silage, which is usable for biogas plants, is produced more frequently in the NAI scenario than in the reference scenario. This goes hand in hand with the reduction grassland used as meadows. In the NAI scenario, the proportion of fallow land is slightly higher. The analysis of land use change suggests that Hypothesis 3 needs to be confirmed. The non-agricultural investor leads to a land use change in favor of energy crops for biogas production.

5 Discussion and conclusions

The non-agricultural investor can run its business economically viable. It earns profits and increases its equity. Due to the one-sided orientation on biogas, however, the success parameters are highly dependent on the respective political framework conditions of the REA. In the simulations, the investor shows a similar investment behavior in biogas plants as the other farms do. This is not surprising, because the behavioral assumptions of profit maximization and rationality applies to the farm agents as well as to the investor agent. With an installed capacity of 9,050 kW, the investor can achieve an average share of about 10% of the entire installed biogas capacity in the region and thus gains a certain importance in the competition for fermentation substrates. This justifies the measurable effects of this agent on the agricultural region, respectively on the other farms.

On average, small farms and those that are not active in biogas production can benefit in the scenario with non-agricultural investor. They gain slightly higher profits in this scenario. Large farms with biogas production, on the other hand, have lower profits on average, some even losses. Overall, the variance in profits in the NAI scenario increases, which could be explained by the larger total number of active farms.

The rental prices are rising, which confirms Hypothesis 1 of this paper. Both, rental prices for arable land and grassland show a huge increase. Reasons for this may be rising economic land rents of those farms that produce substrates for the non-agricultural investor. Another reason may be the slowdown in structural change, which results in a larger number of farms in fiercer competition on the land market. The stronger increase of rental prices observed for biogas farms.

Large farms are slowed down in their development in terms of farm size in the NAI scenario. This is mainly attributable to the positive income development of smaller farms, which means that fewer companies are leaving production and consequently less land is available for growth. The results thus refute Hypothesis 2 in which an accelerated structural change was assumed by the investors activity.

In land use, we observed effects that suggest a general intensification. Energy crops for biogas production are grown more frequently. The acreage of cereals decreases. In the use of grassland, farms increasingly cultivate grass silage and restrict grazing. These results confirm Hypothesis 3.

The simulation results allow first conclusions on the effects of the activity of non-agricultural investors in biogas production. However, the modeling of an investor for our simulations was only hypothetical, since both the heterogeneity and the quantitative appearance of the investors were not taken into account. The results are thus able to show rough tendencies. However, they do not claim to measure or predict exactly quantifiable effects of investor activity in the Altmark region. For a supplementary development of the model, the implementation of additional types of investors could be relevant, for example, those who are themselves active in the land market. The substrate market also needs further adjustments in order to better reflect the reality. So far, for example, the annual fluctuation of the substrate quantities is possible, which is not a realistic assumption, as in the interest of farmers and the biogas plant operators, multi-year supply contracts are common. This would also affect price developments and the observed cyclical fluctuations might no longer occur. Moreover, in the model the spatial dimension is taken into account only in a rudimentary way (with average transport costs). The exact transport costs depending on the distance would be of interest. This could be followed by the analysis of spatial effects, e.g. Effects of investors on neighboring farms, effects on rented plots depending on the distance, etc.

To sum up, it can be stated that non-agricultural investors have measurable effects at the individual farm level and at the regional level. Overall, however, the results show a differentiated picture, as farms with different orientations and factor endowment are influenced in different ways by these effects. The results show that an investor does not necessarily have to be a disadvantage for the small-scale agriculture in Germany.

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