Agent-Based Model Results

Poland

Sensitivity analysis

The region of Poland was simulated in the model following the setup values for the Farm network mechanism represented by the Polish region in Table 1. These parameters must be adjusted in NetLogo platform to each region before starting the simulations.

Table 1. Parameter values to define 3 regions in the agent-based model.

Mechanism	Case study	Main-product	Prop-org-inn	Prop-org-main	Farm-size-org	Farm-size-conv	Biodiversity-index	Mean-qol-lci	Farm-links-prob	Group-cons
Circularity	Italy	Eggs	0.005	0.08	24	8	1.101	2.3	0	0
Farm network	Poland	Beef	0.005	0.005	33	11	1.463	4.3	0.4	0
CSA	Flanders	Zucchini	0.005	0.005	8	26	1.407	4.2	0.05	50

We explored the sensitivity of certain parameters to the main output of the model of the **percentage of innovative organic farms**. The parameters selected for this sensitivity analysis of the Polish case study are presented in Table 2.

Table 2. Parameters tested for sensitivity analysis in Polish case study.

Parameter	Name	Units	Values tested	Description
Opportunity window threshold	*change-threshold*	index	0.1, 0.2, 0.3, 0.4, 0.5	Defines when the threshold to outscale starts.
Downscale of farms	*Downscale?*	boolean	False, true	Allows farms to scale down to mainstream if a set of conditions are met.
Economic orientation	*Economic-orientation*	ratio	0.75, 0.85, 0.95	Maximum ratio of revenues that the farmers would accept from which they would consider it an economically bad year.
Innovative consumption trend	*inn-consumer-trend*	index	0.1, 0.2, 0.3, 0.4, 0.5	Defines the trend that is pushing toward organic and innovative food consumption through e.g. social media, demand,…
Subsidies	*subsidies*	€	0, 1000, 10000	Subsidies for innovative organic farms.
Subsidies application time	*subsidies-time*	year	2023	Year in which the subsidies are being applied.

For the sensitivity analysis, we tested sets of three parameters included in Table 2 in a simulation with 50 runs.

Set 1 of parameters: *inn-consumer-trend, change-threshold, economic-orientation*

In Figure 1, we observed that *inn-consumer-trend* needs to overcome *change-threshold* in order to increase the percentage of innovative organic farms out of the total population of farms. Also, having a lower *economic-threshold* (values = 0.75, 0.85) promotes a higher percentage of innovative organic farms.

In Figure 2, we observe the same results expressed in percentage out of organic farms. The simulation starts with only 1 innovative organic farm and another organic mainstream farm, and until the year 2015 there is only one innovative farm. That is why we observe that the simulation starts at 50% (1 innovative and 1 mainstream organic farms), slowly descends because the organic farms are increasing and then, more innovative farms starts to scale out.

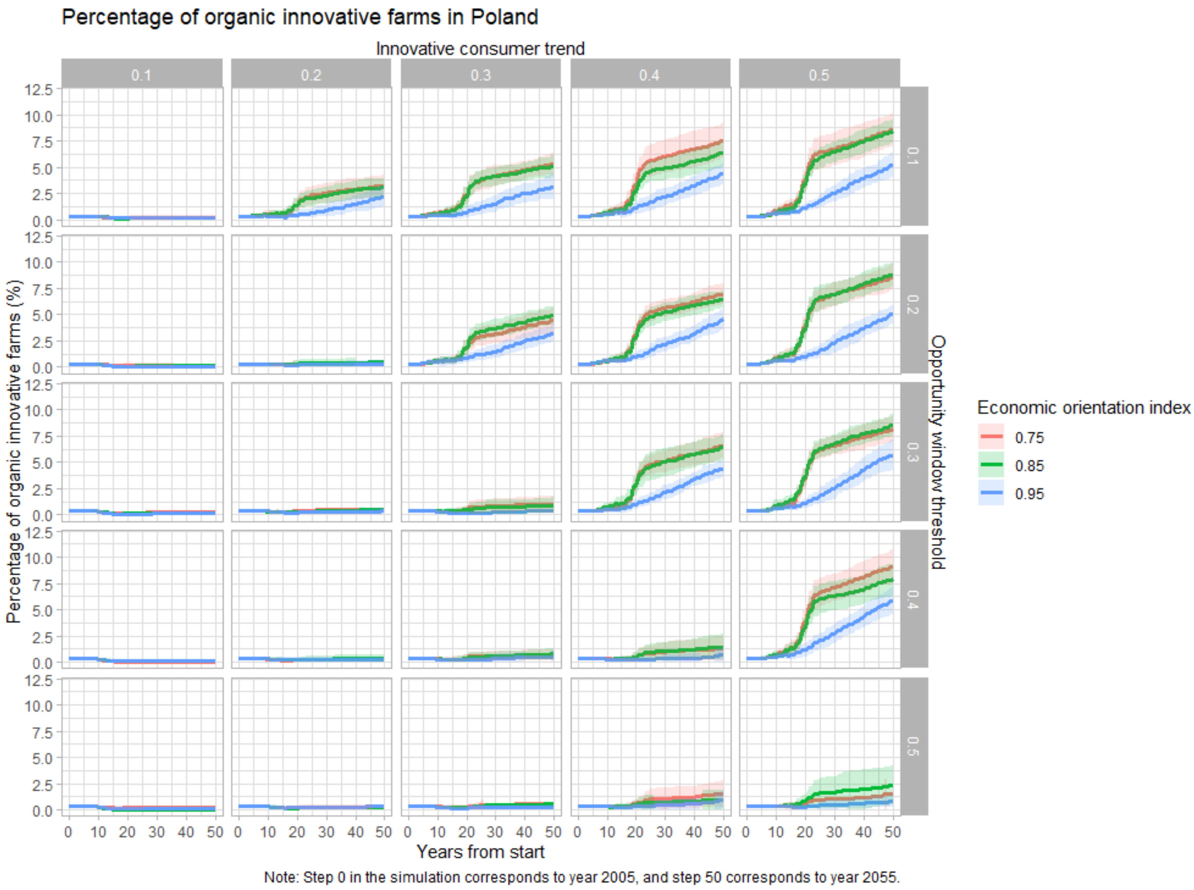

Figure 1. Influence of the parameters inn-consumer-trend, change-threshold, and economic-orientation on percentage of organic innovative farms.

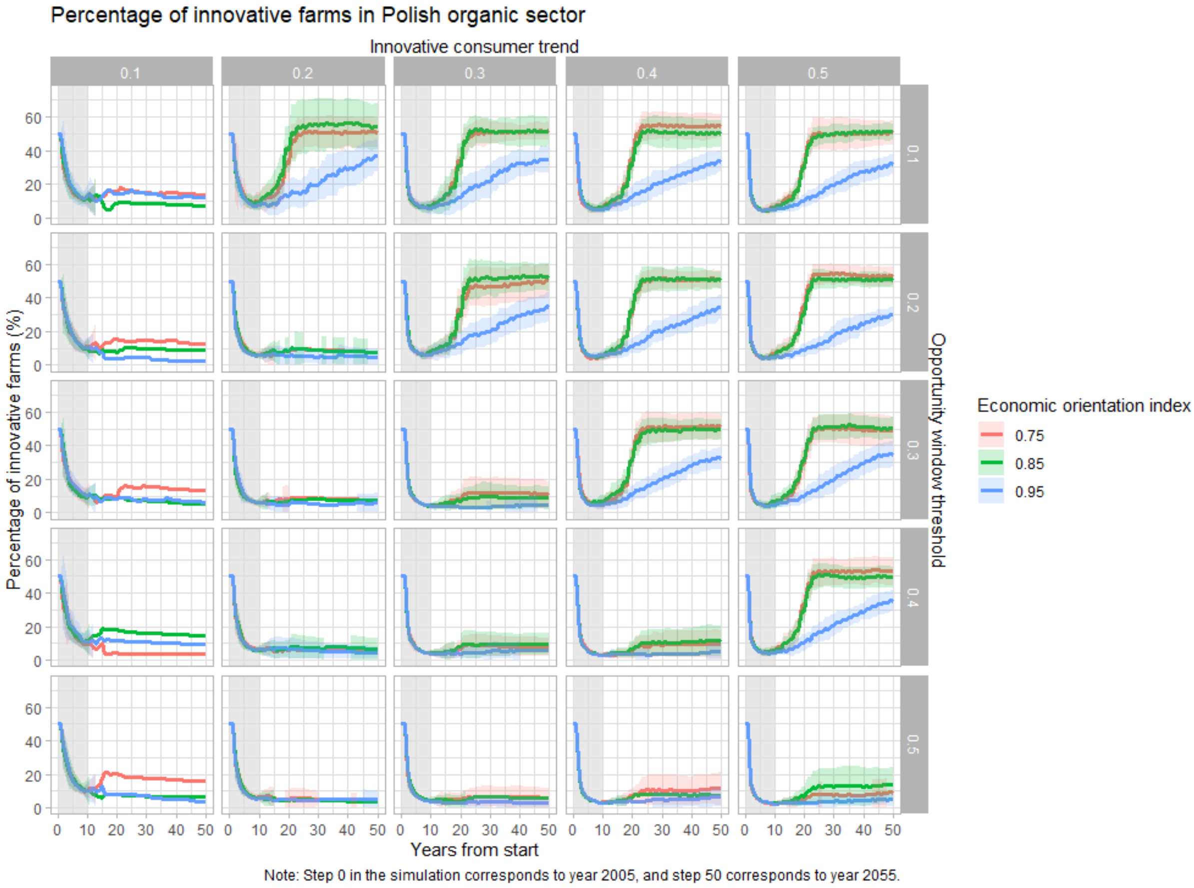

Figure 2. Influence of the parameters inn-consumer-trend, change-threshold, and economic-orientation on percentage of innovative farms in the organic sector. The grey area represents the time of the simulation where there is only one innovative farm but increasing organic ones and therefore, we see a decrease in the percentage.

Set 2 of parameters: *inn-consumer-trend, change-threshold, subsidies*

In Figure 3, we observed that subsidies have an effect when *inn-consumer-trend* is not higher than *change-threshold*, so the *subsidies* give a boost to overcome the barrier to scale out. After this, there is no effect of subsidies. There is not much difference between earning 1000€ or 10000€ as a subsidy in this set of parameters. In Figure 4, we observe similar results expressed in percentage out of organic farms, however, it has to be taken into account that the standard deviation when *inn-consumer-trend* = 0.1 are too high. This is due to the fact that the simulations starts with 2 organic farms, so when we close up the results to the organic sector only, changes in the percentage of a population of 2 can be enormous.

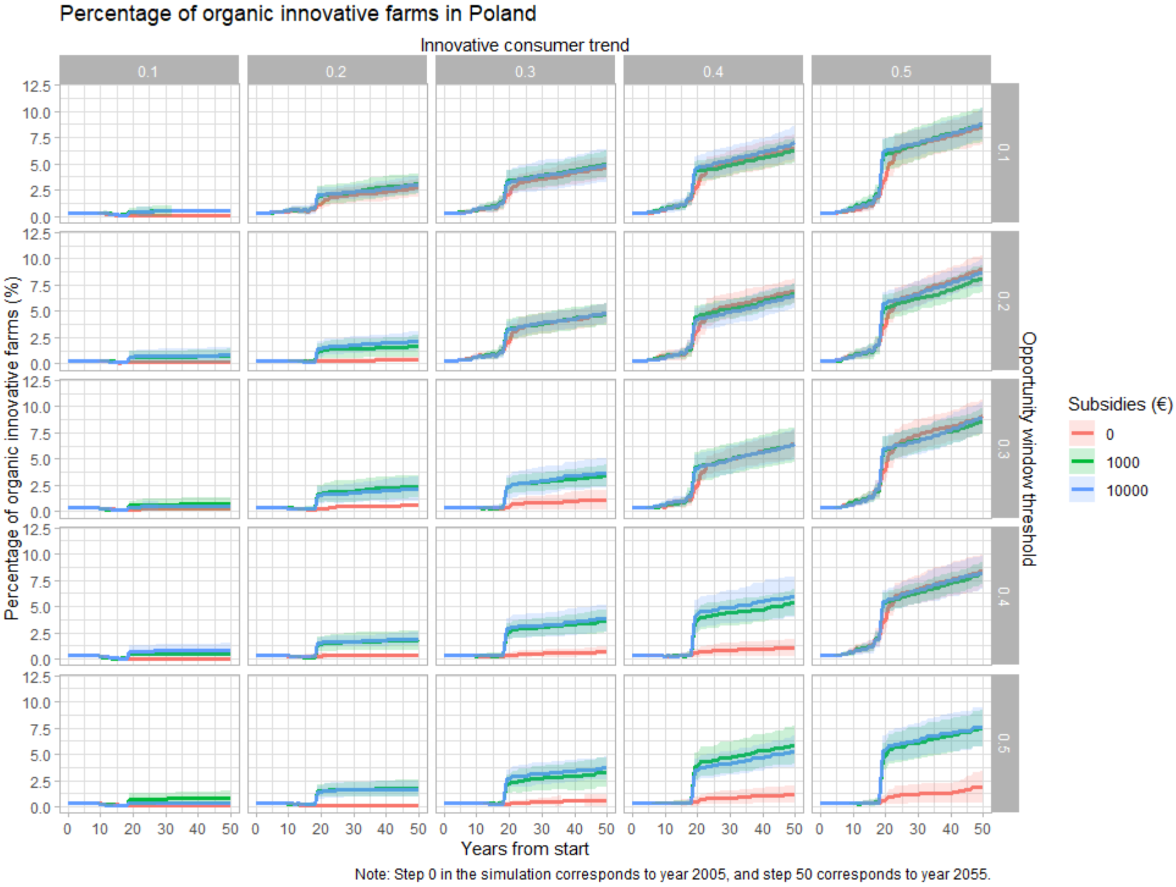

Figure 3. Influence of the parameters inn-consumer-trend, change-threshold, and subsidies on percentage of organic innovative farms.

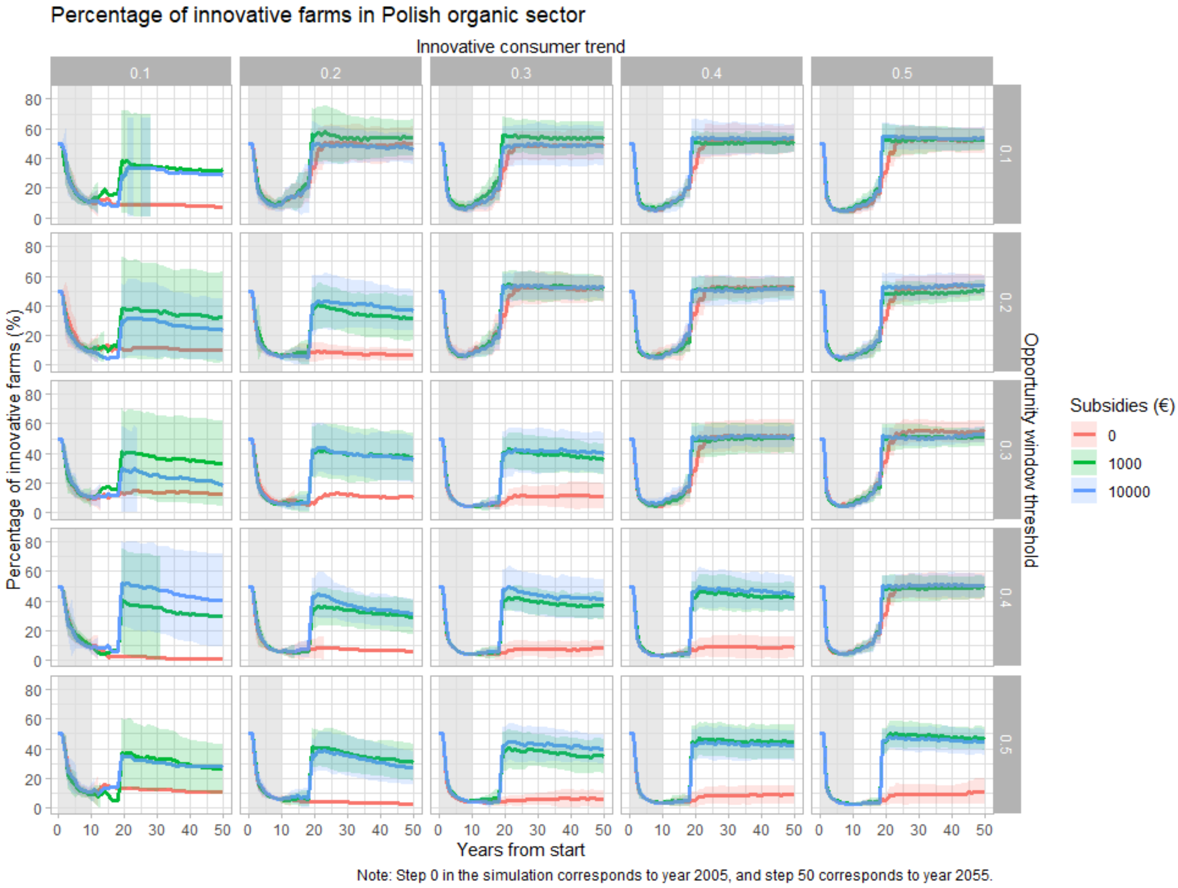

Figure 4. Influence of the parameters inn-consumer-trend, change-threshold, and subsidies on percentage of innovative farms in the organic sector.

Set 3 of parameters: *inn-consumer-trend, subsidies, subsidies-time*

Having earlier *subsidies-time* makes them jump to innovative, however, they end up having the same or even slightly less percentage of innovative organic farms on the long run (Figure 5). Having later *subsidies-time* makes it impossible to outscale when *inn-consumer-trend* < *change-threshold*, which is set to 0.2 in this simulations. Similar results for the percentage of innovative farms in the organic sector (see Figure 6) However, the percentage of innovative farms seems to decrease when *inn-consumer-trend* < *change-threshold*. Note that the standard deviation is too high in this region.

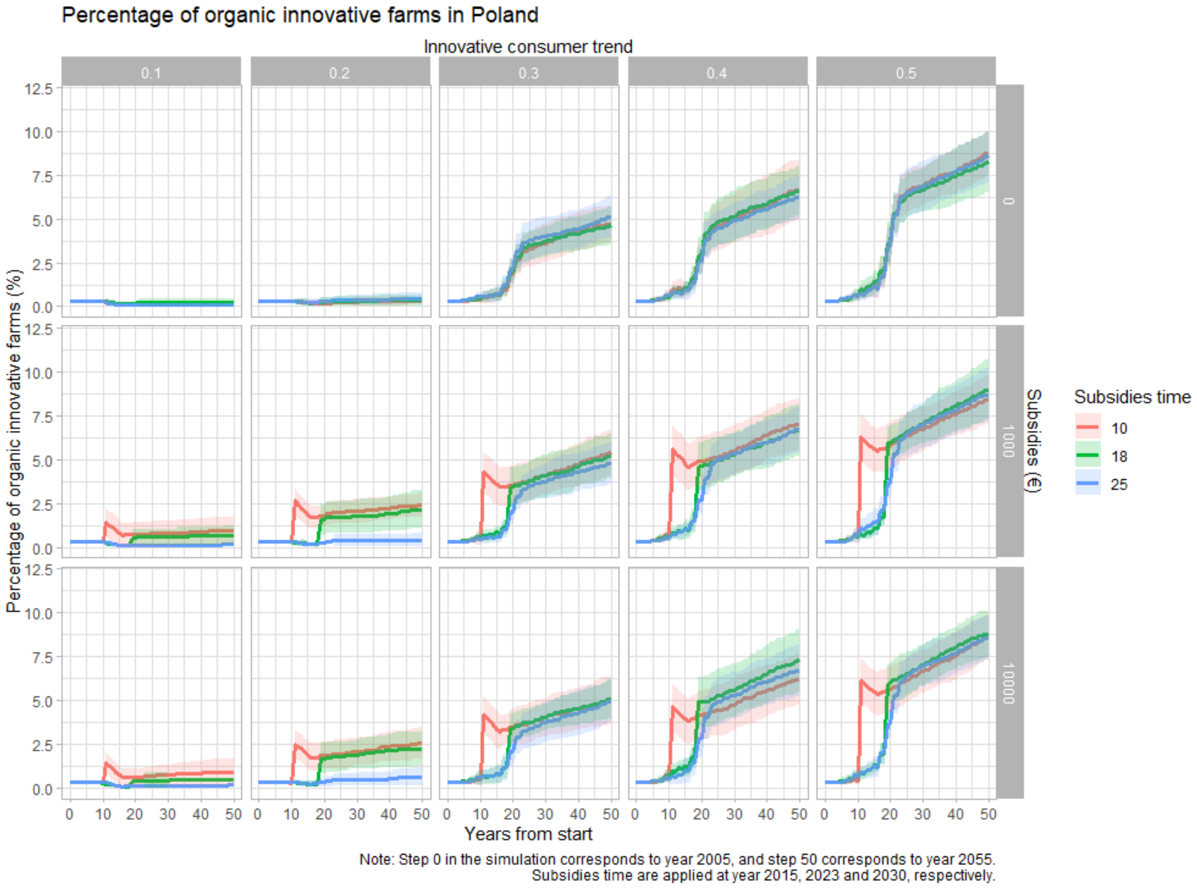

Figure 5. Influence of the parameters inn-consumer-trend, subsidies, and subsidies-time on percentage of organic innovative farms.

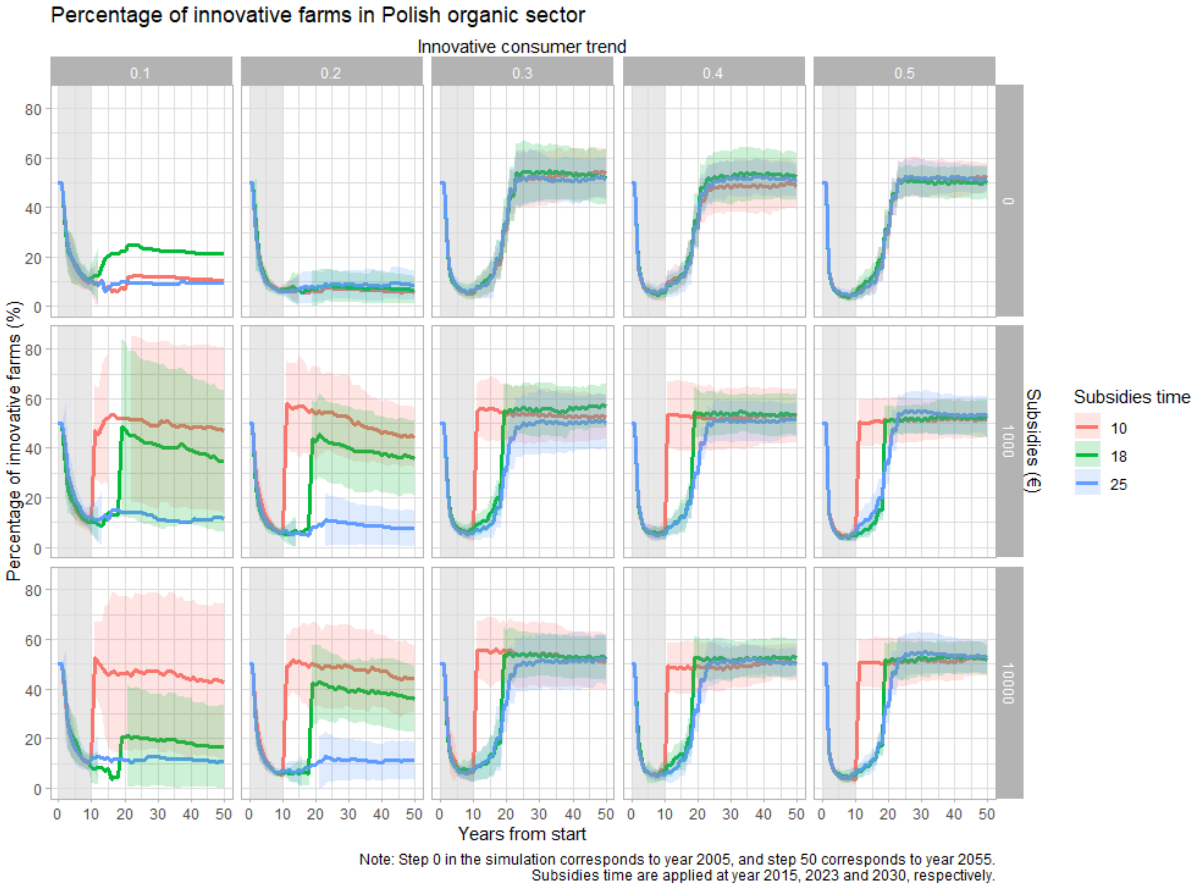

Figure 6. Influence of the parameters inn-consumer-trend, subsidies, and subsidies-time on percentage of innovative farms in the organic sector.

Set 4 of parameters: *inn-consumer-trend, subsidies, downscale*

Having at least some subsidies helps when *inn-consumer-trend* is lower than the *change-threshold* (which is fixed at 0.2 in this simulation; Figure 7). Also, when *downscale* is present, we observe more peaks in the percentage of innovative organic farms and less percentage. The results are similar when observing the percentage of innovative farms in the organic sector (Figure 8).

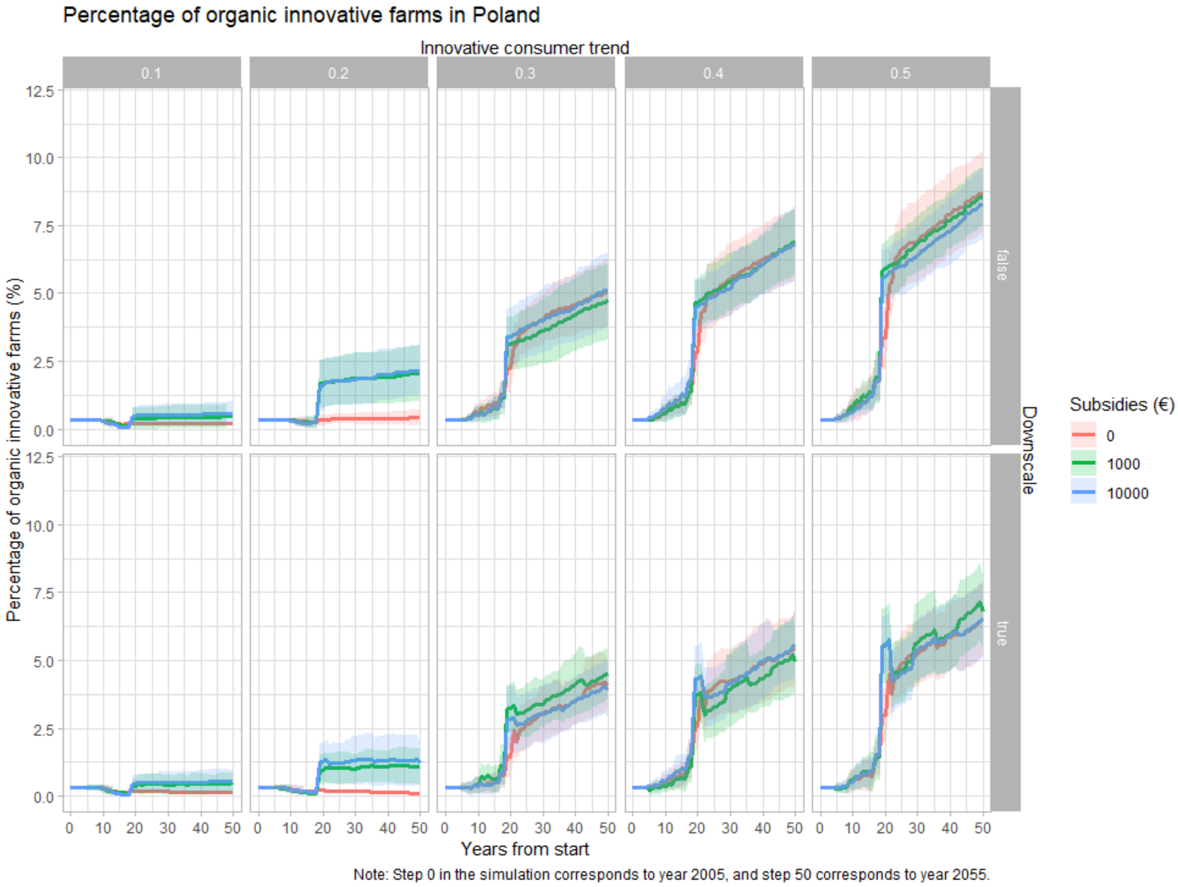

Figure 7. Influence of the parameters inn-consumer-trend, subsidies, and downscale on percentage of organic innovative farms.

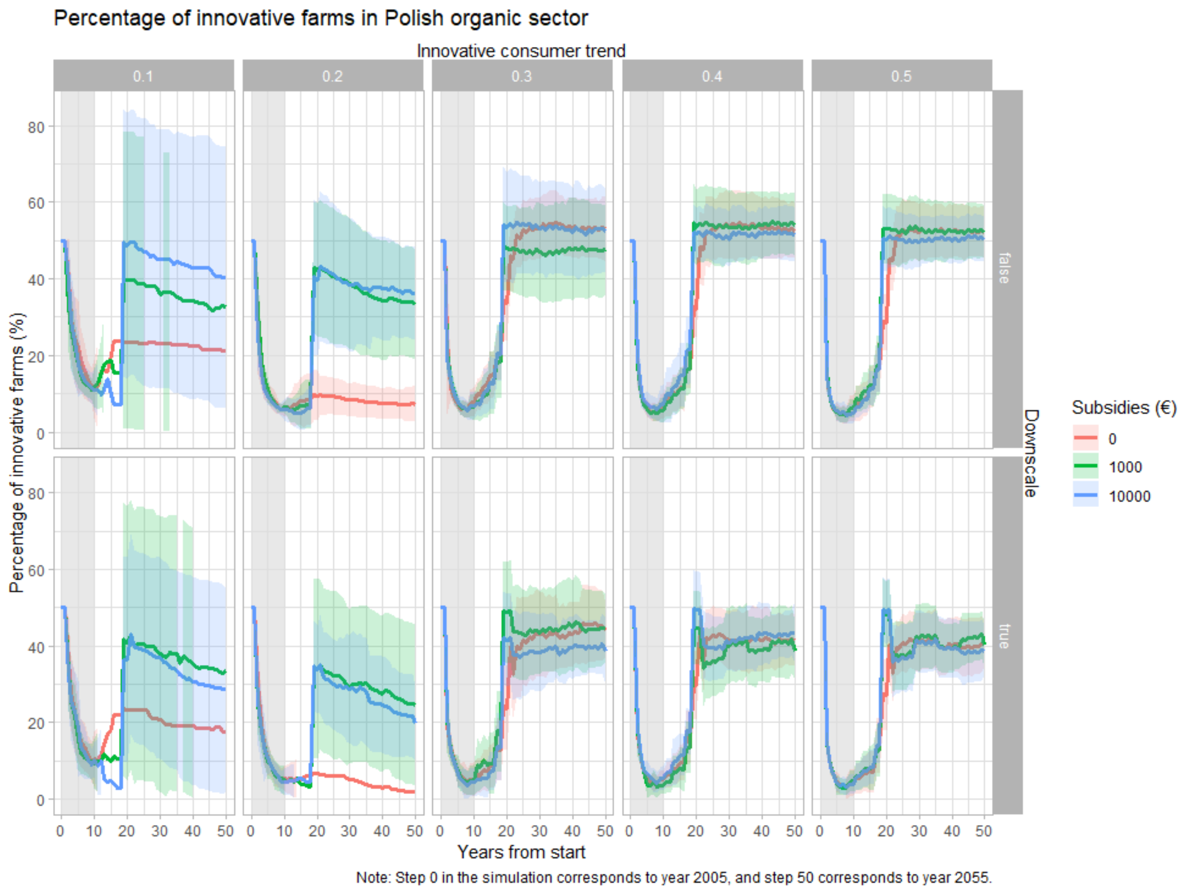

Figure 8. Influence of the parameters inn-consumer-trend, subsidies, and downscale on percentage of innovative farms in the organic sector.

Set 5 of parameters: *inn-consumer-trend, economic-orientation, downscale*

We tested the parameters *inn-consumer-trend*, *economic-orientation*, and *downscale* in a simulation with 50 runs. Being less economically-oriented, that means, for values = 0.75 and 0.85, there is higher percentage of innovative organic farms (Figure 9). When *downscale* is activated, there are more peaks in the curve and a lower percentage of innovative organic farms is observed. For the close up observation of the organic sector, there is a decrease in percentage of innovative farms when values of *inn-consumer-trend* are too low to overcome the *change-threshold* barrier (fixed at 0.2; Figure 10). Even for higher values of this parameter, the general trend for innovative farms is decreasing, showing a market saturation, with even less percentage of innovative farms when downscale is activated.

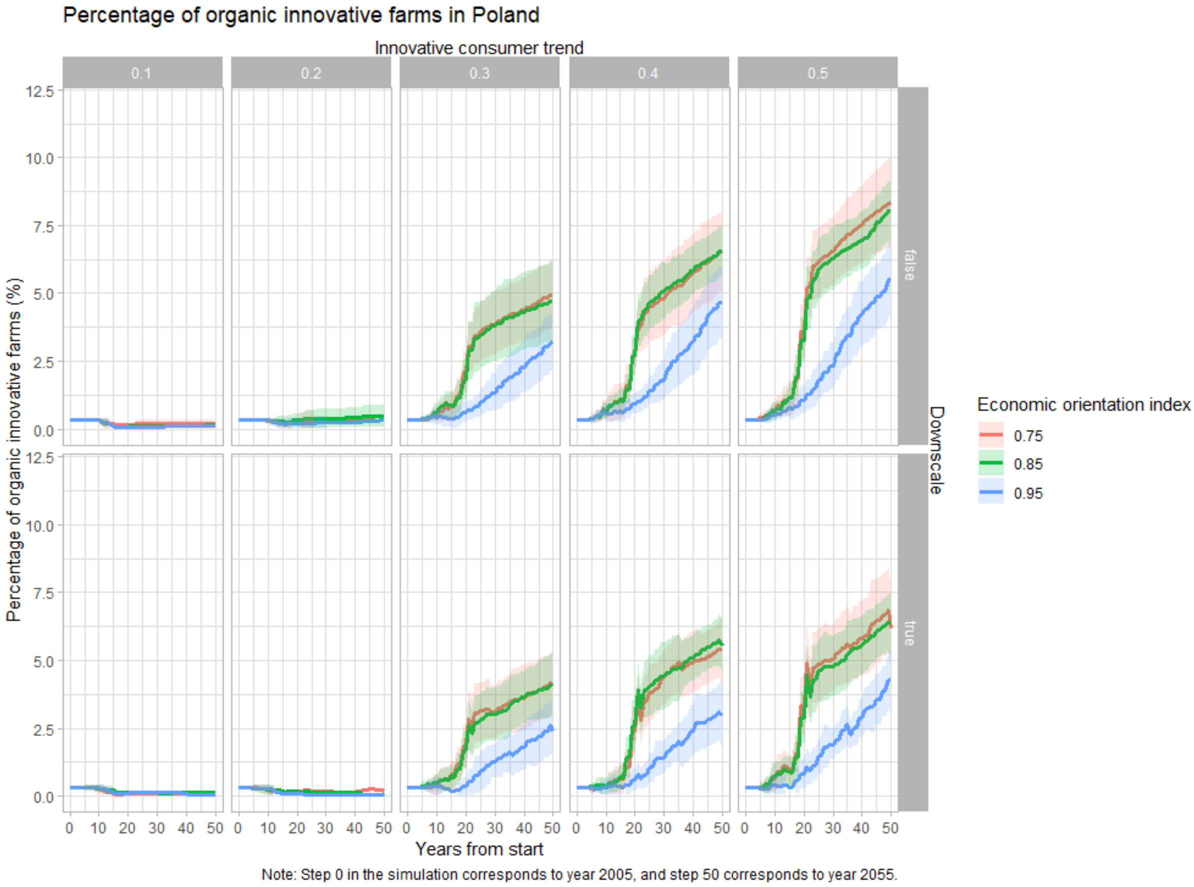

Figure 9. Influence of the parameters inn-consumer-trend, economic-orientation, and downscale on percentage of organic innovative farms.

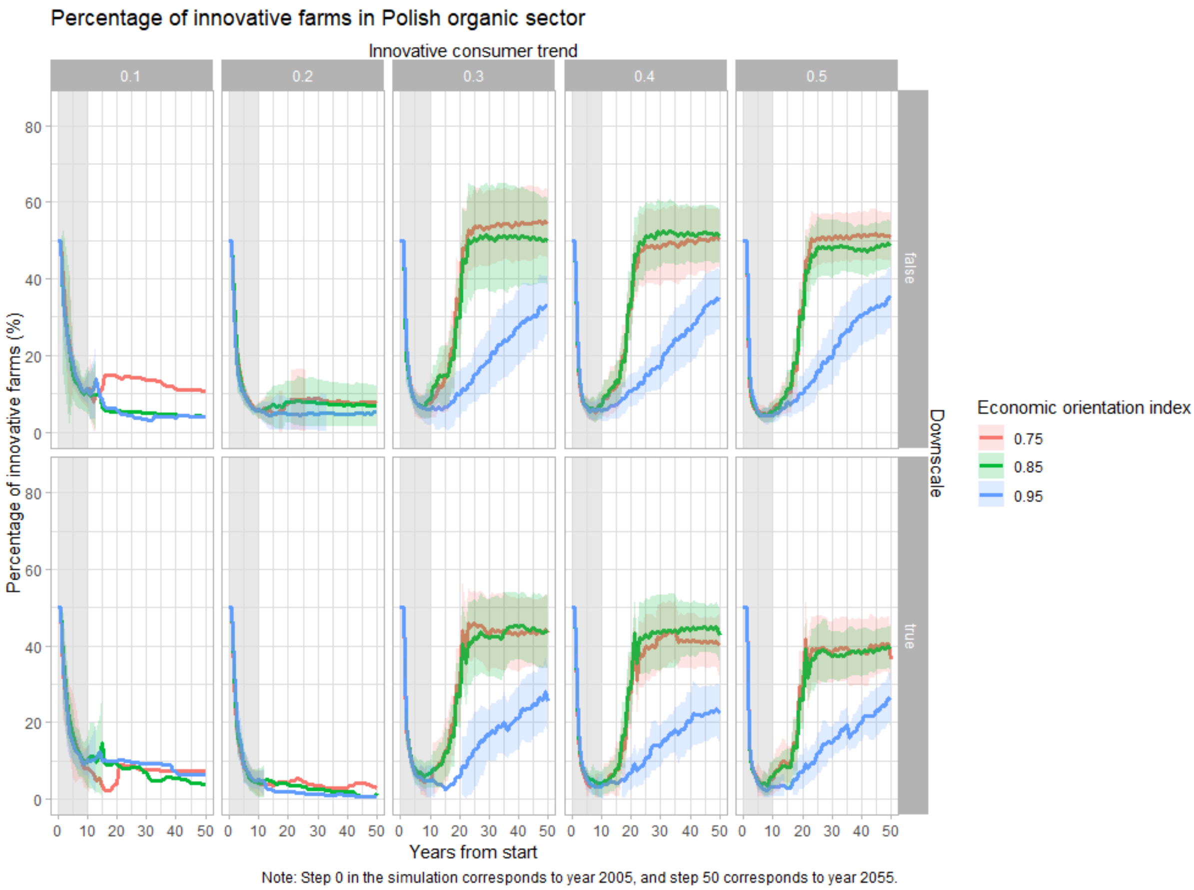

Figure 10. Influence of the parameters inn-consumer-trend, economic-orientation, and downscale on percentage of innovative farms in the organic sector.

Scenario exploration

Results scenarios

We explore the baseline scenario (A) and two potential scenarios in Poland (B and C). The baseline **scenario A** is representing the current situation, with no strong trend for organic and innovative products, no subsidies for these innovative initiatives, and no scale down to mainstream production. On the other hand, scenarios B and C represent potential future situations. In **scenario B**, the trend for innovative and organic production systems increases, and there is the possibility for innovative farmers to downscale to mainstream production. Besides, a subsidy for biodiversity can be claimed by farmers in this scenario. **Scenario C** studies the possibility to increase the outscaling of innovative farms through subsidies for scaling out while maintaining the downscale possibility for farmers.

The parameters that characterize the scenarios are shown in Table 3. Scenario simulations are run in BehaviourSpace platform in NetLogo with 100 repetitions.

Table 3. Parameter values used in simulation to define the scenarios.

Scenario	Name	Parameter	Value
A	Downscale	*Downscale?*	false
	Innovative consumption trend	*Inn-consumer-trend*	0.1
	Subsidies (€)	*Subsidies*	0
	Subsidies for biodiversity (€)	*Bio-subsidies*	0
B	Downscale	*Downscale?*	true
	Innovative consumption trend	*Inn-consumer-trend*	0.3
	Subsidies (€)	*Subsidies*	0
	Subsidies for biodiversity (€)	*Bio-subsidies*	1500
C	Downscale	*Downscale?*	true
	Innovative consumption trend	*Inn-consumer-trend*	0.2
	Subsidies (€)	*Subsidies*	10000
	Subsidies for biodiversity (€)	*Bio-subsidies*	0

The percentage of innovative organic farms is the lowest in the baseline scenario (A), and the highest in the scenario B with more than 3% in the total population (Figure 11 left). Although the scenario C reaches higher percentages of organic innovative farms than the baseline, it is still around 1% out of the total population. Nonetheless, both scenarios B and C reach a higher proportion of innovative farms in the organic sector than scenario A (Figure 11 right).

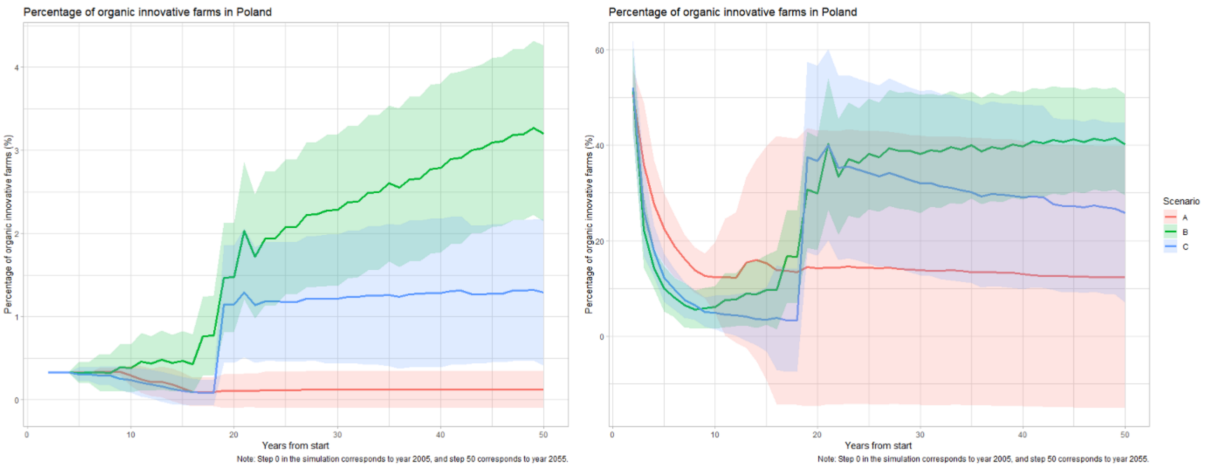

Figure 11. On the left side, percentage of organic innovative farms in Poland in three scenarios. On the right side, percentage of innovative farms in the organic sector in three scenarios.

The area under innovative organic agriculture is slightly higher in the scenario C compared to the baseline scenario, with more than 1% in the total Polish agricultural area (Figure 12). Moreover, the innovative organic agricultural area reaches 2.5% in scenario B. The substantial increase in the area under innovative organic production is correlated with the increase in innovative organic farmers previously observed in this scenario.

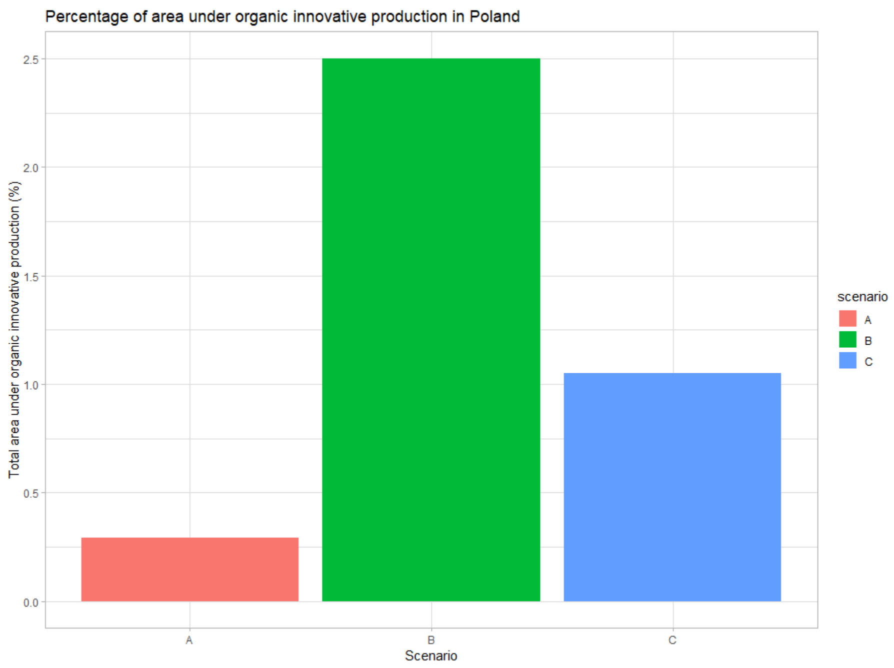

Figure 12. Area under innovative organic agriculture in Poland in three scenarios.

On the other hand, the total innovative organic food production, based on the Polish mean product beef, varies throughout the scenarios (Figure 13). Scenario B presents the highest food production with 38.2 ton/year on average, and the highest variability. The lowest food production is shown in scenario A, with 9.7 ton/year, and the scenario C resulted in a food production of 22.7 ton/year.

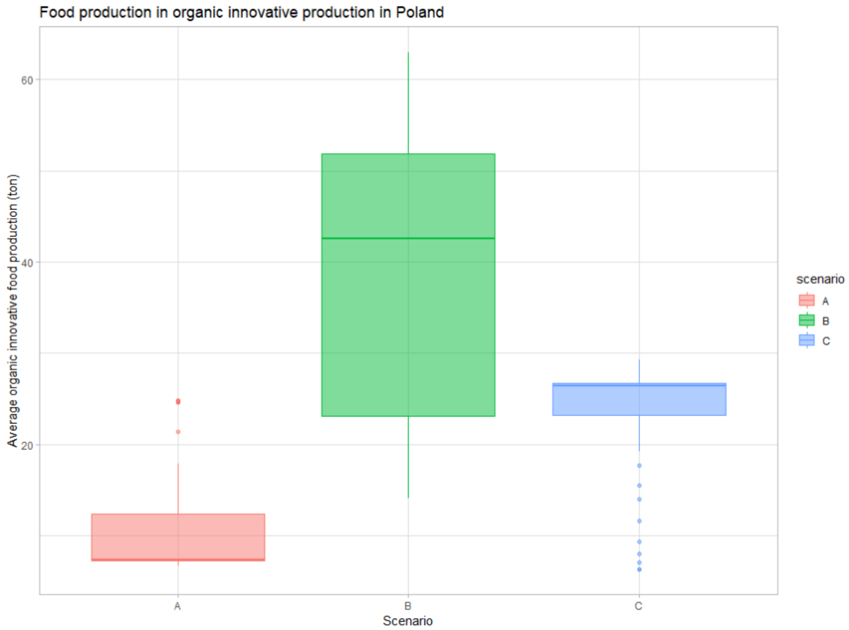

Figure 13. Total innovative organic food production for three scenarios in Poland.

The average total revenues of innovative organic farms in the last year of the simulation is similar in the three scenarios, with an average of 34.582€/year, 34.931€/year, and 34.165€/year for scenarios A, B, and C, respectively (Figure 14 left). Although the three scenarios present considerable variation in their average total revenues, they end up with similar values by the end of the simulation (Figure 14 right). Observing the average of revenues throughout the years of the simulation, the peak around the year 2023 reflecting the subsidies in the scenario C can be noticed. This represents the increase in revenues due to the received subsidies for that year in the scenario C. The high deviation observed in scenario A is due to the small number of innovative organic farms in this scenario.

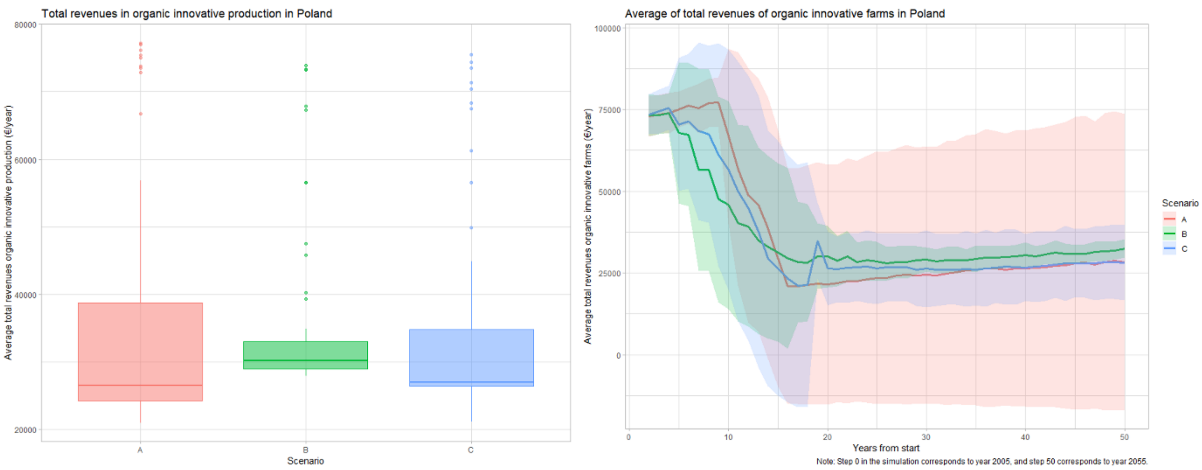

Figure 14. On the left side, boxplot of average total revenues for innovative organic farms. On the right side, this is represented throughout the years of the simulation.

Differences for biodiversity have been observed in the three potential scenarios (Figure 15). As expected, the scenario B where subsidies for biodiversity are applied presents the highest number of species, with a value of 25.12 on average. Also, scenario C shows slightly higher values compared to the baseline scenario.

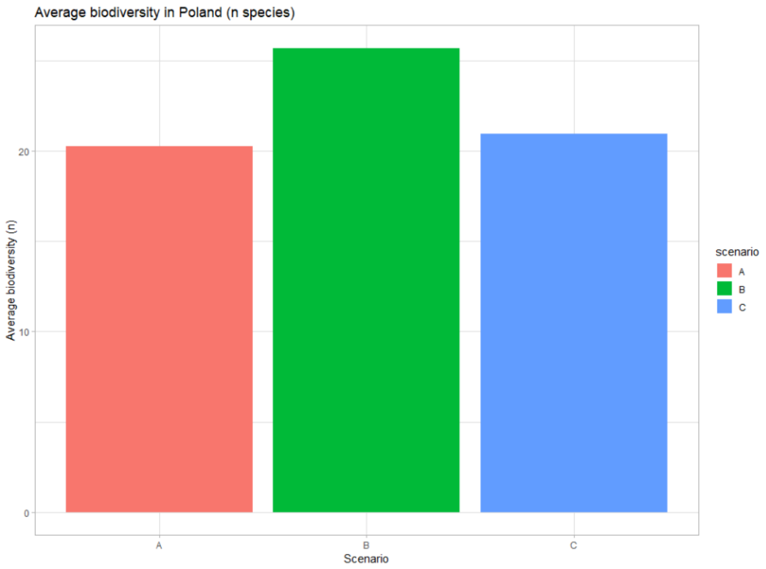

Figure 15. Average biodiversity measured in number of species (species richness) for innovative organic farms in three potential scenarios.

Limitations of the analysis

- The regional context of Poland is very specific and complex, therefore the generic ABM might have overlooked essential parameters for this region. The development of organic farming in Poland depends to a greater extent on dynamics of administrative issues and the low capacity of the organic processing sector rather than demand and prices.

Conclusions

- Higher values of (i) the trend for innovative and organic production coming from society (*inn-consumer-trend*), as well as (ii) lower values of the economic orientation of the farm (*economic-orientation*) have a great potential to increase the percentage of innovative organic farms.
- *Subsidies* help when the trend for innovative organic production is too low. However, administrative barriers for innovative organic farming must be taken into account.
- Giving early subsidies (before 2023) makes the farms quickly outscale to innovative, however, on the longer run results of percentage of innovative organic farms are very similar compared to later subsidies time.
- Promoting more innovative and organic production, as well as giving subsidies for biodiversity (scenario B) results in higher percentage of innovative organic farms in the Polish farm population, which also leads to bigger areas under innovative organic production and higher biodiversity.
- Giving subsidies in 2023 for farms that would like to scale out (scenario C) leads to greater percentages of innovative farms in the Polish organic sector, although this percentage tends to decline over time.
- Revenues of innovative organic farms remains similar between the three scenarios[1].

[1] Prices and consumer preferences dynamics should be further studied.