Agent-Based Model Results

Italy

Sensitivity analysis

The region of Poland was simulated in the model following the setup values for the Circularity mechanism represented by the Italian 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	Inn-cons-trend	Biodiversity-index	Mean-qol-lci	Farm-links-prob	Group-cons
Circularity	Italy	Eggs	0.005	0.08	24	8	0.15	1.101	2.3	0	0
Farm network	Poland	Beef	0.005	0.005	33	11	0.1	1.463	4.3	0.4	0
CSA	Flanders	Zucchini	0.005	0.005	8	26	0.1	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 Italian 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.
Distance to consumers	*distance-consumers*	NetLogo unit	4, 8, 12	How far does the farm provide food to their consumers.
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.
Weather shock	*weather-shock?*	boolean	False, true	Weather shocks (e.g. droughts) that affect yields.

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 when *inn-consumer-trend* overcomes or it's close to overcome *change-threshold*, the percentage of innovative organic farms increases 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, with almost no difference between those lower values.

In Figure 2, we observe the same results expressed in percentage out of organic farms. When *inn-consumer-trend* is still not high enough, we observe that the percentage of innovative farms in the organic sector starts to increase slowly. However, at higher values of *inn-consumer-trend* and low values of *change-threshold*, we observe that there is a peak in the first years of the simulation for the percentage of innovative farms in the organic sector. Nonetheless, this peak quickly decreases after 15 years of the simulation to start growing again. When *inn-consumer-trend* greatly surpasses *change-threshold*, the simulation estimates almost 100% of innovative, less economically-oriented farms. Having a high *economic-orientation* significantly slows down the scaling out of farms.

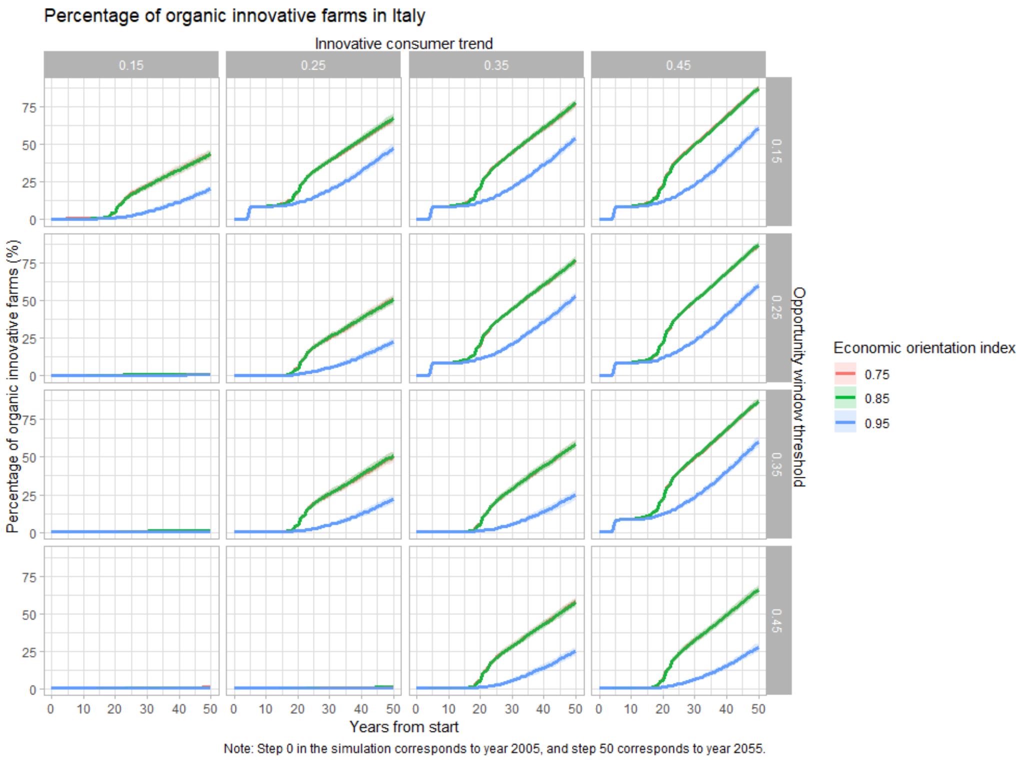

Figure 1. Influence of the parameters inn-consumer-trend, change-threshold, and economic-orientation on percentage of organic innovative farms.

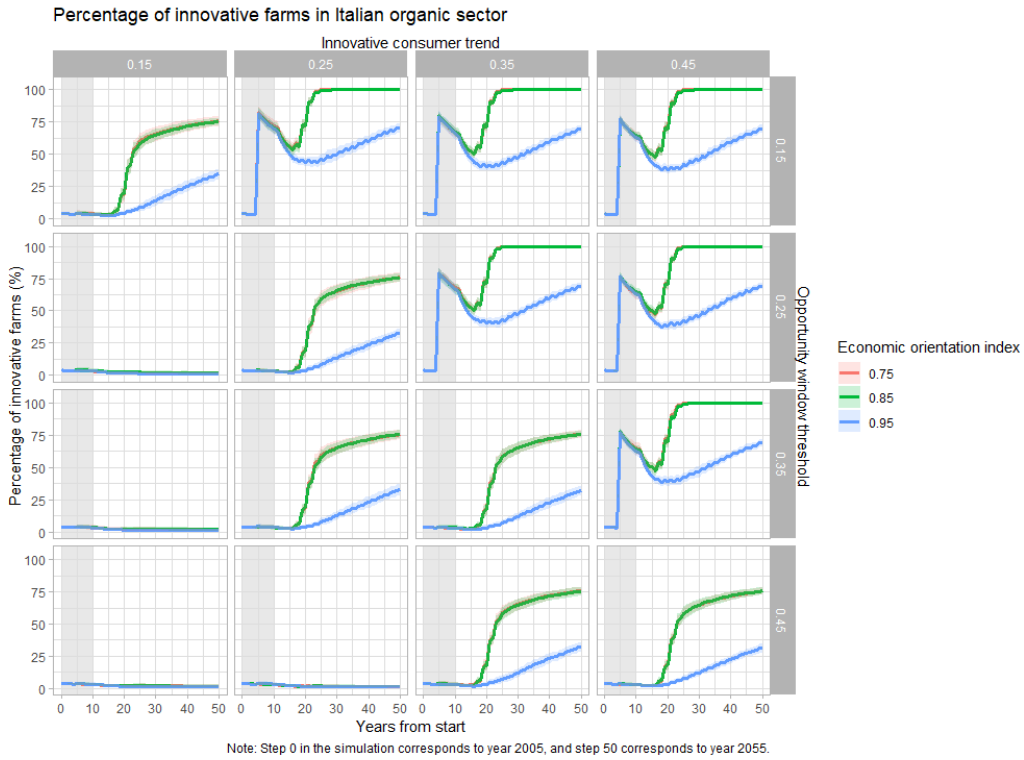

Figure 2. Influence of the parameters inn-consumer-trend, change-threshold, and economic-orientation on percentage of innovative farms in the organic sector.

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

In Figure 3, we observe that subsidies are promoting the scaling out of innovative organic farms when *change-threshold* is too high compared to *inn-consumer-trend*. That means, when there is a higher threshold to perceive this innovation while there is still not enough trend for innovative and organic food production. The effect is more conspicuous when the difference between the values of inn-consumer-trend and change-threshold are higher (see bottom right corner).

The percentage of innovative farms in the Italian organic sector is affected in a similar way (see Figure 4). Earning subsidies is significant when *inn-consumer-trend* values are low and *change-threshold* values are high. However, when there is enough *inn-consumer-trend* to overcome *change-threshold*, the effect of subsidies is minimal.

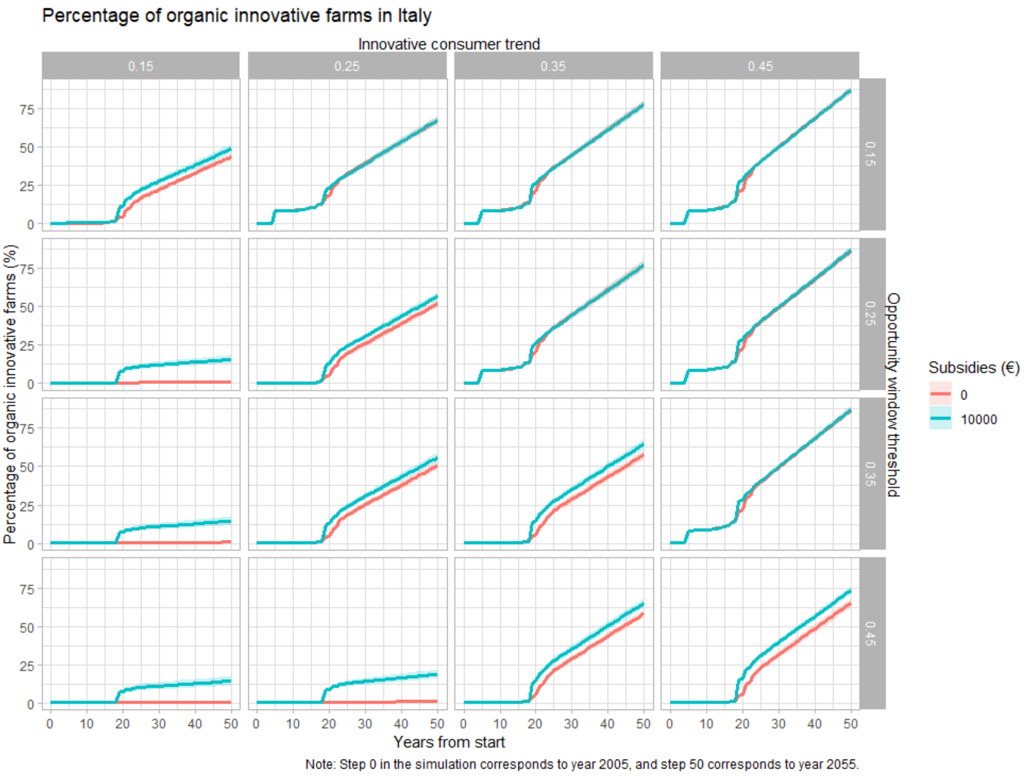

Figure 3. Influence of the parameters inn-consumer-trend, change-threshold, and subsidies on percentage of organic innovative farms.

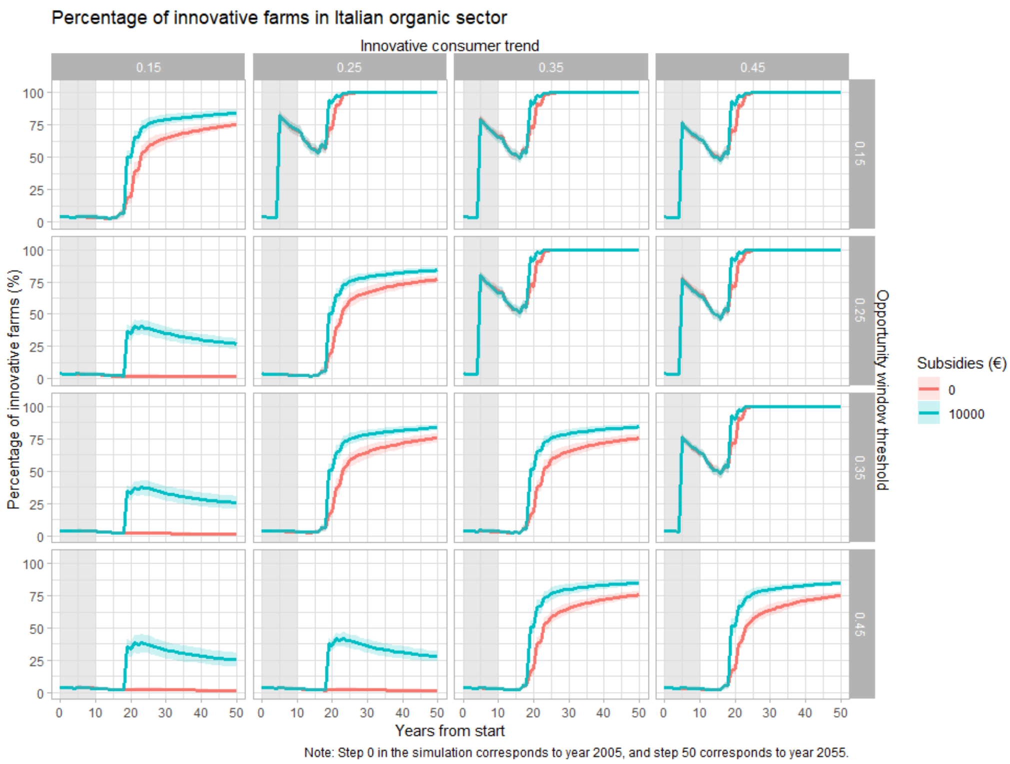

Figure 4. Influence of the parameters inn-consumer-trend, change-threshold, and subsidies on percentage of innovative farms in the organic sector.

Other combinations of parameters have been tested but no significant effects on the percentage of innovative organic farms have been reported.

Scenario exploration

Results scenarios

We explore the baseline scenario (A) and two potential scenarios in Italy (B and C). The baseline **scenario A** is representing the current situation. 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 farms get subsidies for both scaling out and improve biodiversity at the farm. **Scenario C** studies the effects of weather shocks when there is an increased interest for innovative and organic food production and farms get subsidies for biodiversity to increase resilience.

The parameters that characterize the scenarios are shown in Table 3.

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

Scenario	Name	Parameter	Value
A	Innovative consumption trend	*Inn-consumer-trend*	0.15
	Subsidies (€)	*Subsidies*	0
	Subsidies for biodiversity (€)	*Bio-subsidies*	0
	Weather shock	*Weather-shock?*	False
B	Innovative consumption trend	*Inn-consumer-trend*	0.4
	Subsidies (€)	*Subsidies*	10000
	Subsidies for biodiversity (€)	*Bio-subsidies*	1500
	Weather shock	*Weather-shock?*	False
C	Innovative consumption trend	*Inn-consumer-trend*	0.4
	Subsidies (€)	*Subsidies*	0
	Subsidies for biodiversity (€)	*Bio-subsidies*	1500
	Weather shock	*Weather-shock?*	true

The percentage of innovative organic farms is higher in scenarios B and C compared to the baseline scenario (see Figure 5). This increase in the percentage of organic innovative farms starts after 20 years of the simulation, reaching more than 40% of the farms in scenario A at the end of the simulation and more than 80% of the farms for scenarios B and C. Zooming in in the organic sector, we see a similar situation where scenario A ends up with 75% of organic farms being innovative while scenarios B and C achieves to get all organic farms being innovative. However, the transition starts by decreasing in scenarios B and C due to the fact that during the first 20 years of the simulation, organic farms are increasing but organic innovative not, so the percentage starts to drop. After this year, the percentage of innovative farms in the organic sector increases in a s-curve shape.

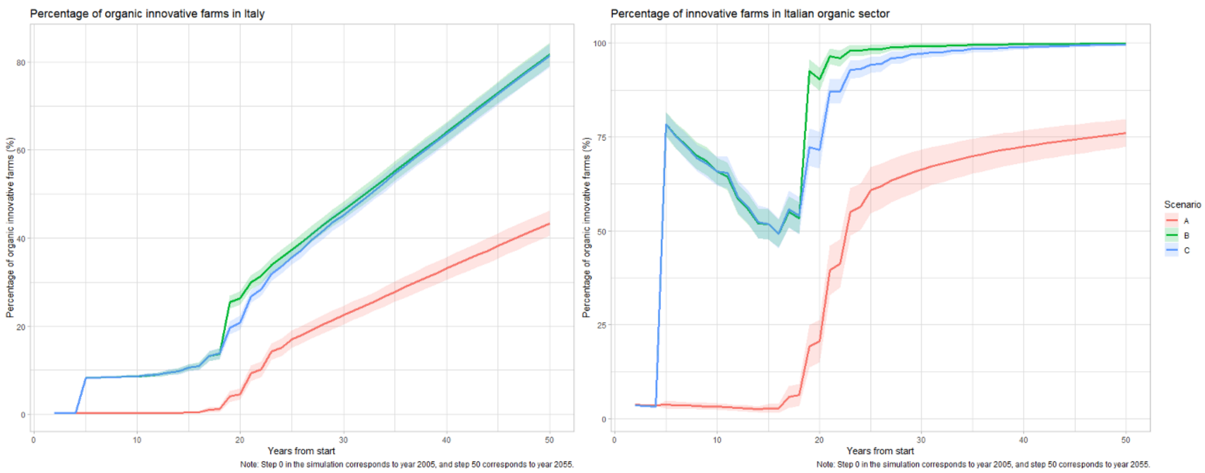

Figure 5. Percentage of organic innovative farms out of total farm population (left) and percentage of innovative farms in the organic sector (right) in three potential scenarios.

Following the observations for the percentage of innovative organic farms, we found that the percentage of agricultural area under innovative organic farming is higher in scenarios B and C (see Figure 6). For the baseline scenario, this maximum value of agricultural area under innovative organic production is 45.2%, while this value rises up to 84.3% and 84.1% for scenarios B and C, respectively.

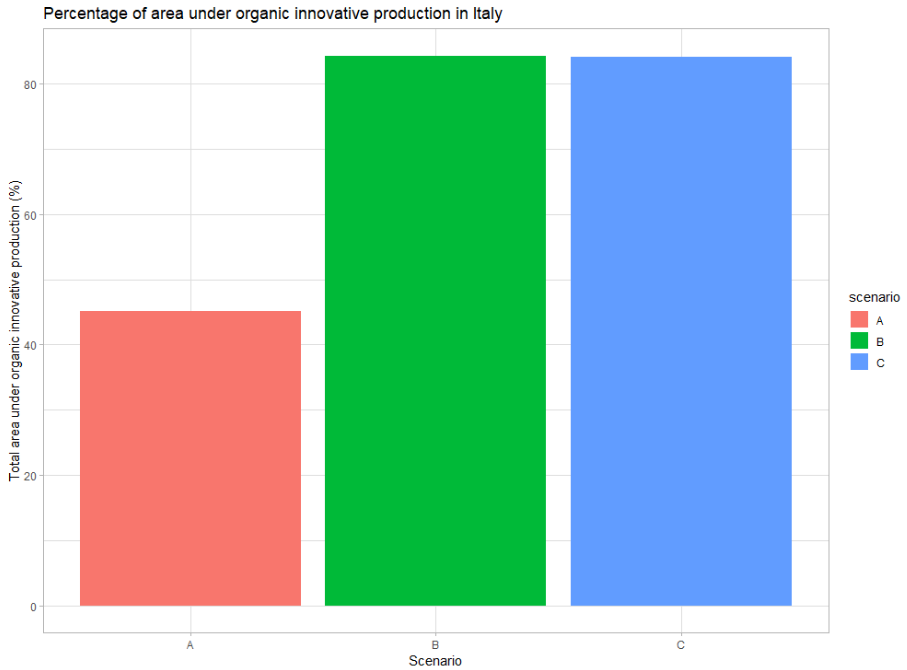

Figure 6. Percentage of agricultural area under innovative organic farming in three potential scenarios.

The innovative organic food production in Italy presents variability in all scenarios (Figure 7 left). However, food production values are higher in scenario B (6.437 ton/year), reaching its lowest in the baseline scenario A (2842.8 ton/year). In scenario C, the value of 5.894 ton/year for food production reflects the negative effect of the weather shocks on the main product eggs. On the other hand, checking the total revenues for innovative organic farms, lowest revenues are observed in the baseline scenario A with an average of 39.195€ throughout the simulation (Figure 7 right). Higher values of total revenues are observed in scenarios B and C, with an average value of 40.337€ and 46.238€, respectively. The descending curve for total revenues represent that more farms with a smaller size, hence less revenues, are scaling out into innovative organic production.

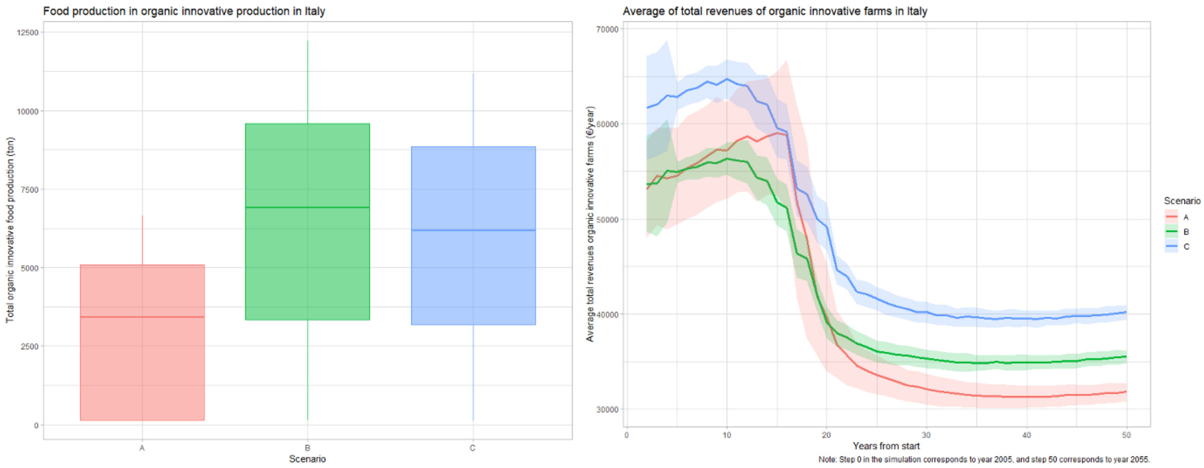

Figure 7. Average organic innovative egg production (left) and average total revenues of innovative organic farms throughout the simulation (right) for three potential scenarios.

Lastly, we checked the biodiversity values in all three scenarios (Figure 8). The baseline scenario A presents the lowest value for biodiversity. As expected, the scenario with subsidies for biodiversity and scaling out resulted in the highest biodiversity levels of all scenarios (28.04 number of species on average). Moreover, the scenario C got intermediate results, showing that they have increased biodiversity due to the subsidies but experienced weather shocks that could have worsened biodiversity levels.

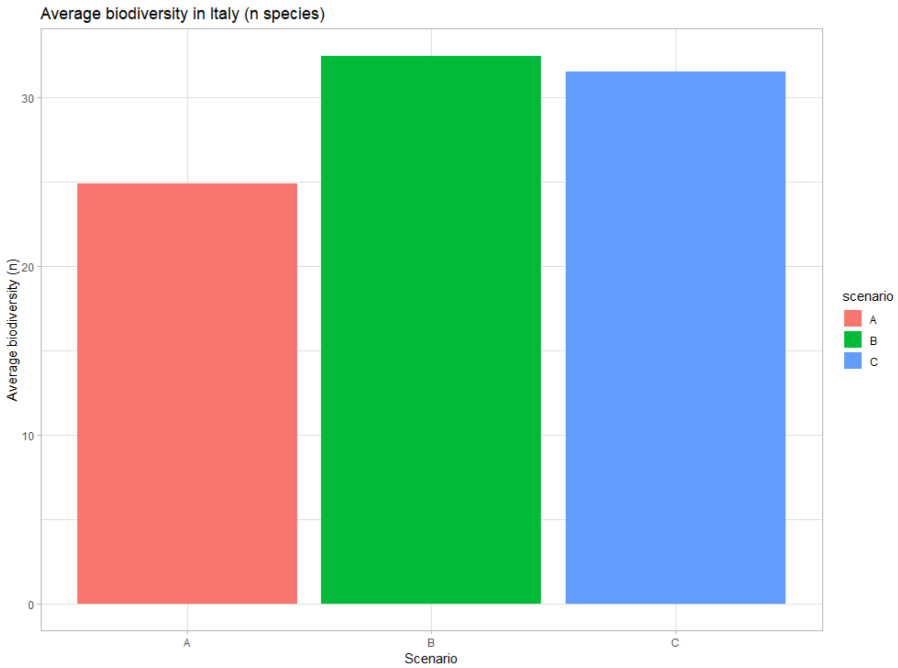

Figure 8. Average biodiversity in number of species (species richness) in three potential scenarios.

Limitations of the analysis

- The impacts on yields on the Climate Change scenario were based on the IPCC 8.5 RCP scenario. However, a more detailed analysis of the situation in Italy, as well as the determination of the main type of weather shock (e.g., drought) must be carried out to deliver more reliable results.

Conclusions

- The values of percentages of innovative and innovative organic farms are high because the innovation in the Italian case study is circularity. Currently, most organic farms also presents some kind of circularity in their system. Therefore, this innovation, unlike the case studies of Flanders and Poland, are more widespread and common in a territory with a specially high percentage of organic farms.
- Giving subsidies for scaling out and biodiversity when there is a strong trend for innovative and organic production promotes more scaling out of farms.
- Climate change seems to not negatively affect the scaling out of farms. These innovative organic farms are supposed to be more resilient to shocks.
- Subsidies for biodiversity could help increasing the biodiversity in fields without little to no negative effect for the farm.