Evaluation of policies for enhancing sustainable wheat production in Italy

ECOWHEATALY

Work Package 4: Global shocks
Deliverable D3

Global shocks

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Global shocks

Contents

Executive summary

This deliverable analyzes the impact of global shocks on wheat markets within the ECOWHEATALY agent-based model. In particular, we simulate the effects of the Russia–Ukraine war on global wheat trade and evaluate the interaction between food security concerns and environmental policies implemented under the Common Agricultural Policy. The simulations show three main results.

First, the disruption of Ukrainian exports generates a large increase in international wheat prices and induces a reallocation of trade flows towards alternative exporters.

Second, the price increase stimulates a supply response in Italy, leading to higher wheat production and greater use of productive inputs.

Third, when a green policy such as SRA20 is abandoned after the shock, production expands further, and international price pressures are partially mitigated, but this comes at the cost of worsening environmental indicators.

Overall, the results highlight a fundamental trade-off between short-run food security and long-run environmental sustainability.

1 The benchmark

The objective of this deliverable is to analyze how large geopolitical shocks affect wheat markets and agricultural policies within the ECOWHEATALY modelling framework. In particular, the study addresses the following research question:

How does a major disruption in global wheat supply interact with environmental agricultural policies, and what are the consequences of abandoning such policies in response to food-security concerns?

To answer this question, we simulate the Russia–Ukraine war shock within the agent-based model and evaluate its effects on wheat prices, Italian production, input use, and environmental indicators.

This analysis contributes to the growing literature on food-system resilience and agricultural sustainability by combining three elements that are rarely studied jointly: global trade disruptions, farm-level production decisions, and environmental policy incentives. By embedding green agricultural policies within an agent-based representation of the wheat market, the ECOWHEATALY model allows us to evaluate the trade-offs between food security and environmental sustainability under extreme geopolitical shocks.

The remainder of the report is organized as follows. Section 2 describes the structure of the ECOWHEATALY model and the representation of agricultural production and trade. Section 3 presents the simulation of the Russia–Ukraine war shock and its effects on prices and production. Section 4 analyzes the consequences of abandoning green agricultural policies after the shock. Section 5 concludes with policy implications.

1.1 No transport costs

A key methodological challenge in agent-based modeling concerns the initialization of the system and the treatment of the transient phase. Because agent-based models (ABMs) are characterized by nonlinear interactions, feedback mechanisms, and path dependence, early simulation outcomes may depend heavily on arbitrary initial conditions (Tesfatsion, 2006; Epstein, 1999). Unlike analytical equilibrium models, ABMs do not typically start from a predefined steady state; instead, macro-level regularities emerge endogenously from repeated micro-level interactions among heterogeneous agents (LeBaron and Tesfatsion, 2008).

For this reason, it is standard practice to allow the system to evolve through a sufficiently long burn-in period before collecting statistics or conducting policy experiments. During this transient phase, the model self-organizes toward a statistical steady state, often defined as a regime in which aggregate variables fluctuate around stable distributions or moments rather than converging to a fixed point (Fagiolo et al., 2007). Only after this convergence can exogenous parameter changes or shocks be meaningfully introduced.

Failing to account for the transient adjustment phase risks conflating structural responses with initialization artifacts, potentially leading to biased inference and poor reproducibility. Careful treatment of initialization, burn-in length, and convergence diagnostics is therefore essential for robust simulation analysis (Grimm et al., 2005; Wilensky and Rand, 2015).

The agent-based model simulates the interaction between international wheat producers and importing countries under the simplifying assumptions of homogeneous

product quality and zero transportation costs. In each period, importing countries allocate their demand across alternative producers, gradually shifting purchases away from higher-price suppliers toward lower-price ones. This decentralized reallocation mechanism generates competitive pressure across producers, inducing price adjustments over time. Under the absence of trade frictions and qualitative differentiation, the model implies that prices across producing countries should converge to a common equilibrium level, consistent with the law of one price. However, simulation results reveal that convergence is not immediate. During approximately the first ten periods, prices exhibit oscillatory dynamics. These fluctuations arise from the interaction between adaptive demand reallocation and price adjustments: when countries redirect demand toward relatively cheaper producers, the resulting excess demand increases those producers' prices, which in turn triggers further reallocations in subsequent periods. Such feedback effects generate temporary overshooting and cyclical movements before the system stabilizes. This initial oscillatory phase reflects the transient dynamics associated with model initialization rather than structural instability. At the start of the simulation, price levels and demand allocations are exogenously assigned and typically not consistent with the model's endogenous equilibrium configuration. The early periods, therefore, capture the adjustment process through which the system self-organizes. After approximately 50 periods, prices across producers become very close to one another, indicating convergence toward a statistical steady state in which excess demand pressures are largely eliminated and reallocations become marginal (see Figure 1). Table 1 reports the prices on the international markets at period 50 of simulations.
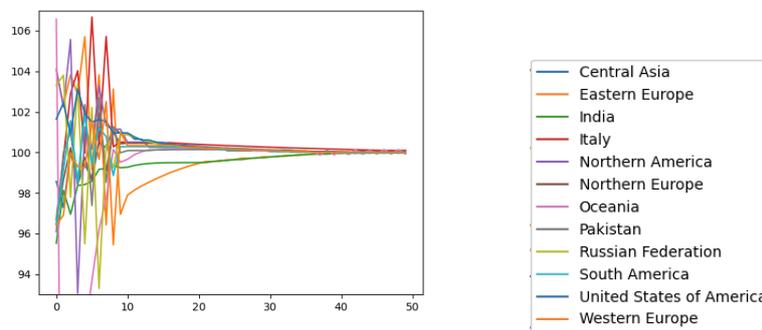
Figure 1: Transient dynamics of wheat prices associated with model initialization.

These findings highlight the importance of allowing for a sufficiently long burn-in period before conducting policy experiments or counterfactual analyses. Evaluating model outcomes during the transient phase would conflate initialization artifacts with the genuine competitive dynamics implied by the structure of the model.

1.2 Introducing transport cost

To identify the effects of transport cost, we gradually increase the transport cost by 0.0001 every 5 time steps starting from tick 50. Note that the chart of Figure 2 reports the price dynamics with a y-axis range equal to the previous chart, whereas in the chart of Figure 3, the x and y-axis ranges are set to better visualize the dynamics.

Area	price
Central Asia	100.103000
Eastern Europe	99.977000
India	99.992000
Italy	100.098000
Northern America	100.019000
Northern Europe	100.009000
Oceania	99.923000
Pakistan	100.017000
Russian Federation	100.004000
South America	99.974000
United States of America	100.018000
Western Europe	100.009000

Table 1: Prices of wheat on the international markets after 50 simulated periods.

Figure 2: Transient dynamics of wheat prices increasing the transport cost by 0.0001 every 5 time steps starting from tick 50.

Table 2 reports the prices on the international markets at period 150 of simulations with increasing transport costs by 0.0001 every 5 time steps, starting from tick 50.
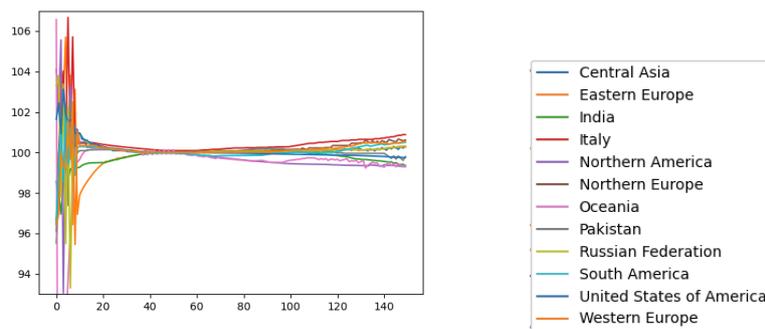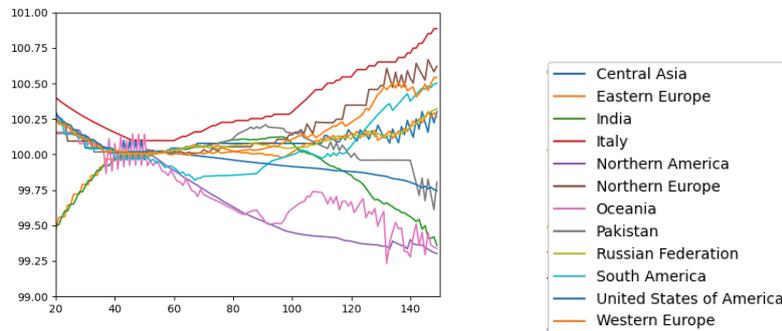
Figure 3: Transient dynamics of wheat prices increasing the transport cost by 0.0001 every 5 time steps starting from tick 50 (focus on x-axis between 20 and 150).

Area	price
Northern America	99.303000
Oceania	99.339000
India	99.359000
United States of America	99.746000
Pakistan	99.805000
Eastern Europe	100.266000
Central Asia	100.301000
Russian Federation	100.322000
South America	100.501000
Western Europe	100.542000
Northern Europe	100.621000
Italy	100.885000

Table 2: Prices of wheat on the international markets after 150 simulated periods and increasing transport costs by 0.0001 every 5 time steps, starting from tick 50.

2 From tranquil times to worldwide shocks

In order to analyze the effects of global shocks, the ECOWHEATALY model must first establish a stable benchmark configuration representing normal market conditions. The simulation therefore begins with a "tranquil" phase in which trade networks, prices, and production patterns evolve without major perturbations.

Once the system reaches a stable configuration, external shocks can be introduced and their effects on trade flows, prices, and production decisions can be analyzed. This section describes the mechanisms that govern the transition from the benchmark equilibrium to the shock simulation used in the subsequent sections.

We summarize in the following two subsections the devices we use to achieve the tranquil time benchmark.

Simulation phase	Description
Initialization phase	Model converges to a stable trade network
Tranquil phase	Prices and trade flows evolve without shocks
Shock phase	External perturbations are introduced

Table 3: Simulation phases in the ECOWHEATALY model

2.1 Price Sensitivity, Trade Networks, and Shock-Induced Reallocation

International trade flows are embedded in persistent bilateral networks shaped by sunk entry costs, search frictions, and relational capital. In stable macroeconomic environments, these features generate inertia in trade patterns: existing exporter-importer relationships tend to persist even in the presence of moderate price differentials. Firms internalize switching costs and relationship-specific investments, so adjustments primarily occur along the intensive margin (changes in traded quantities within existing links), while the overall topology of the trade network remains largely stable.

This relational persistence dampens the short-run elasticity of trade flows with respect to relative prices. In tranquil times, price signals do not immediately trigger large-scale reallocation across partners, because established commercial ties provide stability and reduce the incentives to rewire the network. As a result, aggregate trade patterns reflect both cost considerations and network embeddedness.

However, large exogenous shocks—such as geopolitical disruptions, embargoes, or major supply interruptions—can weaken relational frictions and alter the stability of trade networks. When uncertainty rises and the probability of disruption increases, the expected value of maintaining existing links declines. The effective threshold for switching partners is reduced, and firms re-optimize sourcing decisions more aggressively. In such regimes, trade flows become more responsive to relative price differentials, and reallocation along the extensive margin intensifies.

In the context of global wheat markets, systemic shocks (e.g., the disruption of Ukrainian exports during the Russia-Ukraine conflict) illustrate how established trade networks can be reconfigured. The modeling framework, therefore, distinguishes between a stable regime characterized by network persistence and a shock regime in which heightened uncertainty amplifies price-driven reallocation.

2.2 Eliminating Initialization Bias and Stabilizing the Trade Network

As stated in Section 1, agent-based models are inherently path-dependent and may exhibit sensitivity to initial conditions. Agent-based models are sensitive to initial conditions. To avoid initialization bias, the model is run for a burn-in period during which agents adjust their trading relationships and production decisions. Only once the trade network has stabilized are shocks introduced into the system. To ensure that simulated outcomes capture endogenous dynamics instead of transient artifacts, the model is first allowed to evolve under highly flexible trading conditions.

In particular, the benchmark construction proceeds in three stages:

(i) Frictionless trade phase. Initially, transportation costs are set to zero and commodity mobility is high. Wheat flows freely across regions, and agents reallocate de-

mand purely based on relative prices. Under these assumptions, the system converges toward a single global price, consistent with the law of one price in competitive equilibrium theory. In the simulations, convergence occurs around period 50, indicating that initial heterogeneity in prices and trade flows has been absorbed by arbitrage dynamics.

(ii) Gradual introduction of transport costs. After convergence, positive transportation costs are gradually introduced. Transport costs are modeled in linear form as:

$$\text{Cost} = v \times d,$$

where v is the unit cost per ton per kilometer and d is bilateral distance. The parameter v is progressively increased, generating spatial price dispersion and reducing the strength of arbitrage. This phase allows the trade network to adjust to realistic frictions while preserving overall macroeconomic stability.

(iii) Annealing phase and network stabilization. Finally, commodity mobility is progressively reduced to mimic the emergence of persistent trade relationships in tranquil times. The share of quantities reallocated across markets is governed by a bounded adjustment rule:

$$\alpha_b(R_b) = \frac{\alpha_{\max}}{1 + \exp[-0.748(R_b - 8.0)]},$$

where $\alpha_{\max}$ represents the maximum share of demand that can be reallocated, and R_b is the difference between the prices in the international markets.

The stabilization process is implemented through an annealing mechanism:

$$\alpha_{\max} \leftarrow (1 - \gamma)\alpha_{\max},$$

where γ controls the speed of cooling. Conceptually, this resembles simulated annealing: the system initially explores the state space under high mobility (high "temperature") and is then gradually cooled by increasing relational stickiness.

This procedure ensures that the final trade configuration reflects endogenous relational persistence rather than arbitrary initial conditions. The resulting benchmark represents a tranquil macroeconomic environment characterized by steady-state prices, positive transport costs, and stable trade linkages. Sensitivity analysis across different values of the annealing parameter γ confirms that the system converges to similar steady-state price levels, indicating robustness of the benchmark configuration.

2.3 Introducing shocks

The general shock mechanism described in this subsection provides the framework for the empirical experiment analyzed in Section 3, where the disruption of Ukrainian wheat exports following the Russia–Ukraine war is simulated.

We now extend the benchmark configuration of tranquil times by introducing a global shock. Conceptually, a large exogenous disturbance—such as a sudden negative supply shock affecting a major exporting region—pushes the system out of its steady-state configuration and into an "excited" state. In this regime, relational stability weakens, arbitrage activity intensifies, and the trade network becomes more responsive to price differentials.

From a theoretical perspective, a global shock reduces the effective value of existing trade relationships. Heightened uncertainty and disruption risks lower the implicit

switching costs embedded in relational capital. As a consequence, the elasticity of bilateral trade flows with respect to relative prices increases. Buyers react more aggressively to cost differentials, and reallocation along the extensive margin becomes more likely.

Within the ECOWHEATALY model, this transition to an excited state is operationalized through three coordinated mechanisms.

First, we allow for an increase in price elasticity. This is implemented by strengthening the responsiveness of demand reallocation to relative price gaps. Intuitively, given the same price differential, a larger fraction of trade flows is redirected toward cheaper producers.

Second, we increase the maximum share of demanded quantities that buyers are willing to move from more expensive to cheaper markets. Formally, this corresponds to a temporary rise in $\alpha_{\max}$ in the reallocation rule:

$$\alpha_b(R_b) = \frac{\alpha_{\max}}{1 + \exp[-0.748(R_b - 8.0)]}.$$

A higher $\alpha_{\max}$ enlarges the intensive and extensive margins of adjustment, allowing the network to rewire more rapidly in response to the shock.

Third, we temporarily suspend the annealing mechanism that governs relational stickiness in tranquil times. Recall that in the benchmark configuration the parameter $\alpha_{\max}$ is progressively reduced according to:

$$\alpha_{\max} \leftarrow (1 - \gamma)\alpha_{\max}.$$

During the shock phase, this cooling process is halted (i.e., γ is set to zero), preventing the system from immediately returning to a low-mobility state. This temporary elimination of the annealing effect mimics the breakdown of stable commercial relationships under stress conditions.

Taken together, these adjustments generate a regime characterized by higher price sensitivity, intensified arbitrage, and endogenous network reconfiguration. The system departs from its tranquil steady state and undergoes a phase of heightened volatility and trade reallocation. Once the shock dissipates, the annealing process can be gradually reinstated, allowing the network to converge toward a new steady-state configuration consistent with the post-shock environment.

From the general shock framework to the empirical experiment

The mechanisms described in this section define the general framework used to simulate external shocks within the ECOWHEATALY model. Once the trade network has stabilized and the system has reached a tranquil equilibrium, shocks can be introduced by perturbing key variables such as export capacity, production levels, or trade costs.

In the simulations presented in the next section, this framework is used to reproduce the disruption of global wheat markets generated by the Russia–Ukraine war. In particular, the shock is implemented as a sudden reduction in the export capacity of Ukraine, reflecting the collapse of wheat shipments observed after the invasion of February 2022. This perturbation propagates through the international trade network, affecting wheat prices, production decisions, and trade flows across regions.

The following section analyzes the resulting market dynamics and their implications for wheat production in Italy.

Shock type	Disruption of Ukrainian wheat exports
Shock timing	Simulation tick 120
Affected variable	Export capacity
Propagation channel	International trade network

Table 4: Summary of the simulated geopolitical shock

3 Simulating the effect of the Russia–Ukraine war

The full-scale invasion of Ukraine by Russia on 24 February 2022 generated a major disruption in global grain markets. Ukrainian Black Sea ports—most notably Odesa—were effectively blockaded, severely restricting maritime exports of wheat and other cereals. Since Ukraine is one of the largest suppliers of wheat and maize to international markets, the sudden halt in shipments triggered a sharp increase in global food prices during the spring of 2022 and raised concerns about food security, particularly in import-dependent regions of Africa and the Middle East.

In July 2022, the Black Sea Grain Initiative, brokered by Turkey and the United Nations, established a maritime corridor that partially restored Ukrainian grain exports and contributed to the stabilization of global prices. The agreement was renewed several times but ultimately collapsed in July 2023 when Russia withdrew from the arrangement. Following this event, attacks on port infrastructure resumed and uncertainty in grain markets increased again. In response, Ukraine progressively redirected exports toward alternative routes, including Danube River ports and overland corridors through the European Union. These developments also generated trade tensions within the EU, as some member states temporarily restricted Ukrainian imports in order to protect domestic farmers.

More in detail:

- **February 24, 2022:** The invasion of Ukraine leads to the blockade of Ukrainian Black Sea ports, causing a sudden interruption of maritime grain exports and a sharp increase in global wheat prices.

- **Spring 2022:** Approximately 20–25 million tons of grain remain stranded in Ukrainian silos, exacerbating food security concerns and increasing volatility in international agricultural markets.

- **July 22, 2022:** The Black Sea Grain Initiative establishes a humanitarian maritime corridor that partially restores Ukrainian grain exports.

- **Late 2022 – Mid 2023:** The agreement is renewed several times, allowing the export of more than 30 million tons of agricultural commodities.

- **July 2023:** Russia withdraws from the agreement, leading to renewed attacks on port infrastructure and heightened uncertainty in global grain markets.

- **2023–2024:** Ukraine increasingly relies on alternative export routes through the Danube River and the European Union, while tensions emerge within the EU due to temporary import restrictions imposed by some member states.

Within the ECOWHEATALY model, Ukraine is included in the *Eastern Europe* macro-region. In 2020, total wheat production in this region amounted to approximately 150 million tons (150, 139, 392 tons), while exports reached roughly 80 million

tons ($79,457,000$ tons). Ukrainian wheat exports declined by approximately 8 million tons in 2022 ($8,328,000$ tons) relative to previous years and only partially recovered in 2023. This decline corresponds to a reduction of roughly 10% in the export availability of the Eastern Europe region ($8,328,000/79,457,000 = 0.104$). Table 5 reports the evolution of Ukrainian wheat exports in recent years.

year	2020	2021	2022	2023
1000 tons	18529	19768	11444	16476

Table 5: Ukrainian wheat export from 2020 to 2023.

In the simulations, this disruption is represented as a 10% reduction in the quantity of wheat available for export from the Eastern Europe macro-region. In reality, the blockade of Ukrainian ports did not immediately reduce wheat production but prevented a substantial share of the harvest from reaching international markets. Because the model does not explicitly represent port logistics or export infrastructure, this constraint is approximated by reducing the effective production available for international trade from the affected macro-region.

3.1 Perturbing the system

The Russia–Ukraine war is represented in the model as a sudden disruption in the export capacity of Ukraine, reflecting the collapse of grain shipments observed after the invasion of February 2022. Ukraine is one of the largest wheat exporters in the world, and the interruption of its export flows generated significant instability in international markets.

In the simulation, the shock is implemented as a reduction in the export capacity of Ukrainian producers at simulation tick 120. This perturbation propagates through the international trade network, affecting wheat prices, trade flows, and production decisions in other regions.

Shock origin	Russia–Ukraine war
Affected region	Ukraine
Affected variable	Export capacity
Shock timing	Simulation tick 120
Transmission channel	Global wheat trade network

Table 6: Summary of the simulated geopolitical shock

Beyond the direct reduction in export availability, the conflict also increased uncertainty in global grain markets. Importing countries faced a higher risk of supply disruptions and therefore became more responsive to price differences across potential suppliers. To capture this mechanism, the model introduces a temporary increase in the price elasticity of demand faced by producers.

Specifically, the elasticity parameter is allowed to rise from its tranquil-time value $\bar{\eta}$ to a higher value $\eta^+ > \bar{\eta}$. The increase is assumed to be temporary and the parameter gradually returns to its baseline level through the following autoregressive adjustment process:

$$\eta \leftarrow (1 - \lambda_\eta)(\eta - \bar{\eta}) + \bar{\eta}$$

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Figure 4: Transmission mechanism of the Russia–Ukraine wheat export shock in the ECOWHEATALY model.

In addition, the maximum share of demand that buyers can reallocate across suppliers, denoted by $\alpha_{\max}$, is increased when the shock occurs. This adjustment reflects the idea that during periods of market stress buyers search more actively for alternative suppliers. As in the tranquil-time benchmark, $\alpha_{\max}$ subsequently follows an autoregressive process that gradually reduces the intensity of reallocation once market conditions stabilize.

Mechanism	Parameter	Implementation
Export disruption	Wheat availability	-10% in Eastern Europe
Demand response	Price elasticity η	$0.5 \rightarrow 2.0$
Trade flexibility	$\alpha_{\max}$	$\approx 0 \rightarrow 1\%$
Adjustment dynamics	Parameter relaxation	Autoregressive process
Shock timing	Simulation period	Tick 120

Table 7: Implementation of the Russia–Ukraine shock in the simulation.

3.2 Results

The graphics of Figure 5 illustrate the dynamics generated by the model when the shock is introduced at simulation tick 120. Prior to this event, the system converges to the tranquil-time steady state described in Section 1. At this stage, prices across regions satisfy the law of one price apart from the dispersion generated by transportation costs.

Between periods 50 and 58, transport costs are gradually introduced and the annealing mechanism governing trade network stabilization becomes active at tick 60. By period 120 the system reaches a new steady state characterized by stable prices and persistent trade relationships. At that point the shock is introduced by simultaneously reducing the export availability of Eastern Europe by 10%, increasing the demand elasticity from $\eta = \bar{\eta} = 0.5$ to $\eta = 2.0$, and raising $\alpha_{\max}$ from a near-zero level to 1%. The annealing processes governing both η and $\alpha_{\max}$ continue to operate throughout
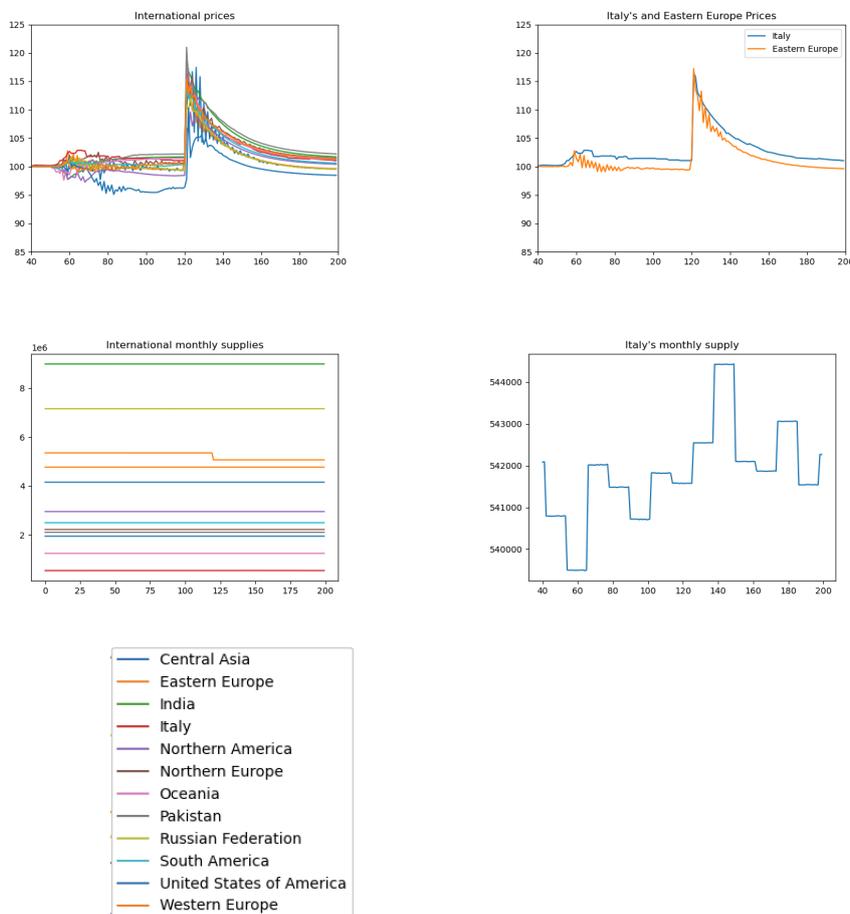
Figure 5: Effect on prices after the Ukrainian export embargo (simulated at tick 120).

the adjustment phase, gradually returning the system to a more stable configuration.

Figure 5 shows that the disruption of Ukrainian exports generates a sharp increase in international wheat prices immediately after the shock. The reduction in supply from Eastern Europe induces a reallocation of global demand toward alternative producers. As buyers search for substitute suppliers, trade flows adjust and prices gradually converge toward a new equilibrium.

Figure 6 illustrates the effects of the shock on farm management decisions in Italy. The increase in international wheat prices stimulates an expansion of domestic supply starting from the following cropping season. Since ticks in the simulation represent months, production adjustments can only be implemented in the subsequent agricultural cycle.

The expansion of wheat production requires higher levels of agricultural inputs, including tractor hours and the use of nitrogen fertilizer, herbicides, and insecticides. As a consequence, the increase in production also generates higher environmental pressures. The simulation shows a rise in environmental damage indicators, including species loss and DALY (Disability-Adjusted Life Years), highlighting the potential trade-off between short-run food supply stabilization and environmental sustainability.
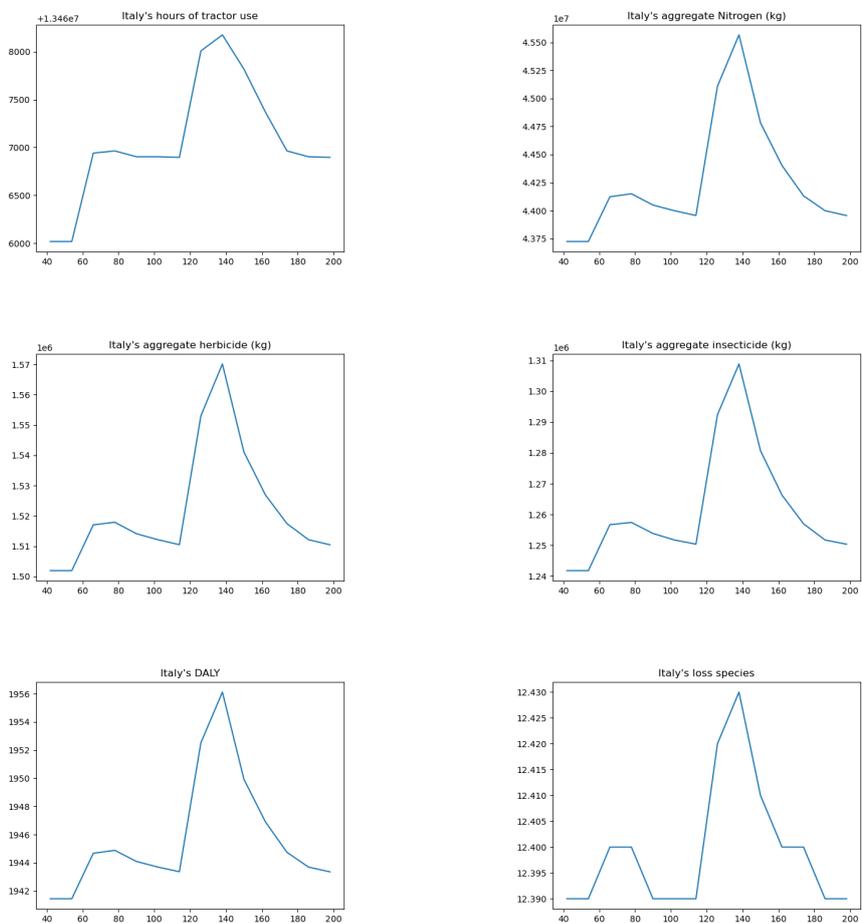
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Figure 6: Effect on input quantity and LCA indicators of the Italian wheat farms after the Ukrainian export ban (simulated at tick 120).

The simulation results show that the disruption of Ukrainian exports generates an immediate increase in international wheat prices. The price increase reflects the sudden reduction in global supply and the resulting imbalance between demand and available production.

Higher prices create incentives for producers in other regions to expand wheat production. In particular, Italian farms increase their wheat output in response to the improved profitability of the crop. This adjustment partially compensates for the reduction in Ukrainian exports, illustrating the capacity of the global wheat system to reallocate production following a major shock.

While the expansion of production contributes to stabilizing the market, it also implies greater use of agricultural inputs and increased environmental pressures. This raises an important policy question: How should environmental agricultural policies respond to large geopolitical shocks that threaten food security? The next section addresses this issue by analyzing what happens when a previously existing green policy is abandoned after the shock in order to stimulate domestic production.

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4 Abandoning policies after shock

4.1 Policy experiment and counterfactual scenario

To evaluate the consequences of abandoning green policies after a geopolitical shock, we compare two alternative policy regimes.

In the first scenario, the environmental policy SRA20 remains active after the Russia–Ukraine shock. Farmers, therefore, continue to face incentives that reduce the environmental intensity of wheat production.

In the second scenario, the policymaker abandons the policy after the shock, removing the associated constraints on input use and crop allocation. This policy reversal is intended to simulate a situation in which governments temporarily prioritize food security and supply expansion over environmental objectives.

Comparing these two scenarios allows us to quantify the trade-off between increased agricultural production and environmental outcomes following the removal of the green policy.

The removal of the environmental policy can be interpreted as a government response to a food-security emergency. When global supply disruptions generate large price increases, policymakers may perceive environmental restrictions as limiting the capacity of domestic agriculture to respond to market signals.

Relaxing these constraints can therefore stimulate additional production by increasing the profitability of wheat cultivation. However, the resulting increase in input use may also lead to greater environmental damage, highlighting the tension between short-run food security and long-run sustainability objectives.

4.2 Policy motivation

Large supply shocks in agricultural markets often generate tensions between food-security objectives and environmental sustainability. The disruption of Ukrainian grain exports following the Russia–Ukraine war increased global concerns about wheat availability, trade instability, and food prices Food and Agriculture Organization of the United Nations (2022); Lin et al. (2023); Chepeliev et al. (2023). In this context, policymakers may be tempted to relax or suspend green agricultural measures in order to stimulate domestic production more rapidly. This logic was not merely theoretical: following Russia's invasion of Ukraine, the European Commission adopted temporary derogations from certain greening requirements for the 2022 claim year with the explicit objective of increasing the arable land available for food and feed production European Commission (2022). More recently, the Commission also introduced additional flexibility in some environmental conditionalities under the CAP framework European Commission (2024).

Within the ECOWHEATALY framework, this policy dilemma is especially relevant. The simulations presented in Section 3 show that the wartime shock increases international wheat prices and stimulates an expansion of wheat production in Italy. This market adjustment helps compensate for the loss of exports from Eastern Europe, but it also leads to greater use of productive inputs and worse environmental outcomes. Such a trade-off is consistent with the broader literature showing that production expansion in response to higher prices frequently comes with higher fertilizer use, greater environmental pressures, and larger sustainability costs Searchinger et al. (2018); Springmann et al. (2018); Pe'er et al. (2020).

The aim of this section is therefore to study what happens when a large external shock convinces the policymaker to abandon a previously existing set of green policies. More specifically, we analyze the consequences of withdrawing SRA20 after the war-induced wheat-market shock, focusing on the effects on Italian wheat supply, international prices, input use, and environmental indicators.

4.3 Policy experiment design

To investigate this mechanism, we consider a setting in which the SRA20 measure is already active before the geopolitical shock occurs. Thus, the economy initially evolves under a green-policy regime in which farmers face incentives to reduce the environmental intensity of production. At simulation tick 120, the system is hit by the external shock associated with the disruption of Ukrainian exports, as described in Section 3. This shock pushes international prices upward and strengthens the incentive for Italian farms to expand wheat production.

The policy reversal takes place at tick 140. At that moment, the policymaker abandons the previously existing SRA20 measure in an attempt to facilitate a stronger production response. The idea is that, once the food-market crisis becomes evident, the environmental constraint is viewed as too costly in terms of forgone supply and is therefore removed. This experiment is meant to mimic the policy logic according to which environmental objectives are temporarily sacrificed in favor of short-run food security and price stabilization European Commission (2022, 2024).

We consider two alternative cases, corresponding to different payment levels under the initial SRA20 regime. In the first scenario, the payment is set equal to 7; in the second scenario, it is set equal to 3. Comparing these cases allows us to assess whether the consequences of policy abandonment depend on the strength of the original green incentive. If the initial payment is higher, the policy exerts a stronger effect before being removed, and its abandonment should therefore produce a larger discontinuity in farmers' incentives. If the initial payment is lower, the removal of the measure should have a more limited impact.

Conceptually, the experiment studies the interaction between two opposing forces. The war shock increases the profitability of wheat production and encourages farms to expand supply. The pre-existing green policy moderates this adjustment by discouraging input-intensive production. Abandoning the policy removes this restraint and allows the market response to become stronger. The simulation, therefore, captures a policy trade-off that has become increasingly relevant in the debate on agriculture, resilience, and sustainability after the outbreak of the war Steinbach (2023); Devadoss and Ridley (2024).

4.4 Effects on prices and production

Figure 7 reports the effects on Italy's wheat supply and on international wheat prices when the pre-existing SRA20 policy is abandoned after the shock. In both scenarios, the war first increases prices and creates incentives for Italian farms to expand production. The abandonment of the green policy at tick 140 amplifies this mechanism by removing the environmental constraint that had previously moderated the supply response.

The results show that policy withdrawal increases Italian wheat production relative to the trajectory that would have prevailed under continued policy support. This effect is stronger when the initial payment associated with SRA20 is higher. In that case,
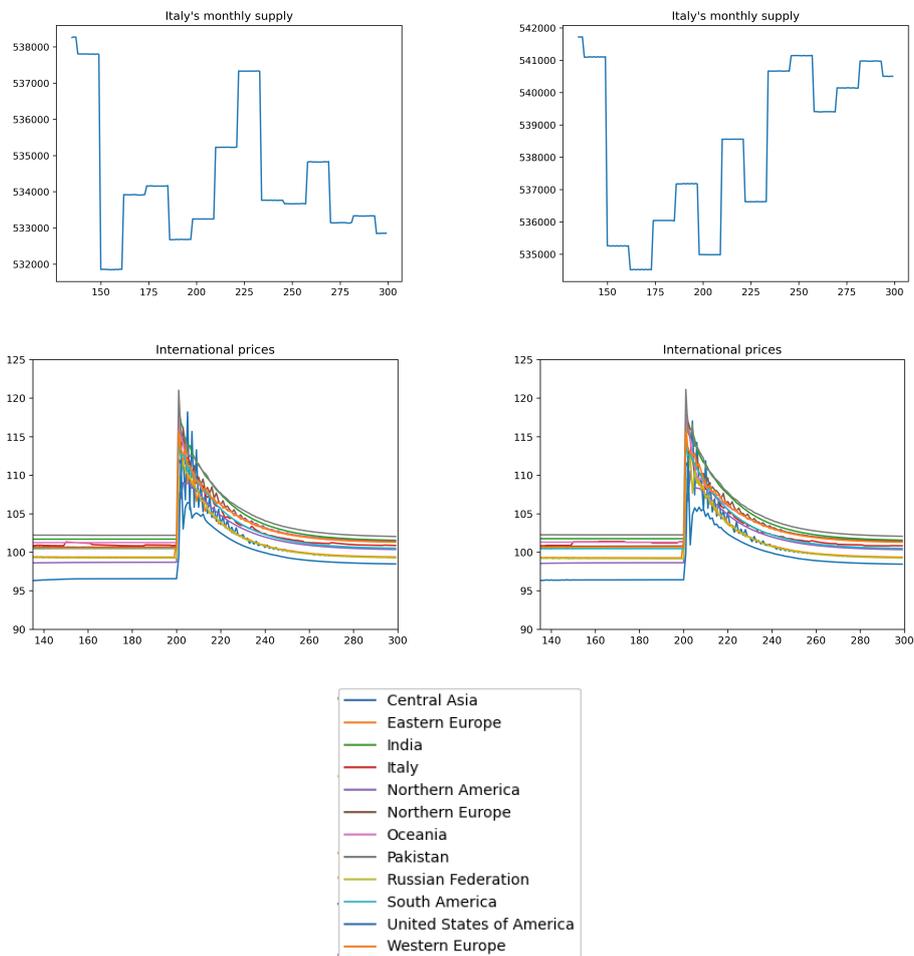
Figure 7: Effects on Italy's supply and international prices of wheat after the abandonment of SRA20 at time 140. Left side panel: initial payment set to 7. Right-hand panel: initial payment set to 3.

the policy had exerted a more substantial influence on production choices before being removed, so its abandonment generates a more pronounced increase in wheat supply. By contrast, when the initial payment is equal to 3, the original policy constraint is weaker and the discontinuity generated by its removal is correspondingly smaller.

These farm-level adjustments also affect the international market. By stimulating additional production in Italy, the abandonment of the green policy contributes to a partial easing of the price pressures caused by the wartime export disruption. This result is consistent with the broader evidence that the Russia–Ukraine war induced sizeable trade reallocation effects, with other suppliers partly compensating for the collapse in Ukrainian exports Steinbach (2023); Devadoss and Ridley (2024). In our model, abandoning SRA20 strengthens this compensating response, thereby moderating wheat prices.

Overall, the results indicate that abandoning the green policy improves short-run supply adjustment and price stabilization. However, these gains must be evaluated

together with the environmental consequences associated with the more intensive use of productive inputs.

4.5 Effects on environmental indicators

Figures 8 and 9 report the effects of policy abandonment on land allocation, input use, and environmental indicators. The removal of SRA20 increases the profitability of conventional wheat production and therefore encourages a more intensive use of land and inputs. As a consequence, the increase in wheat hectares after the shock is accompanied by higher nitrogen use and, more generally, by a more input-intensive production strategy.
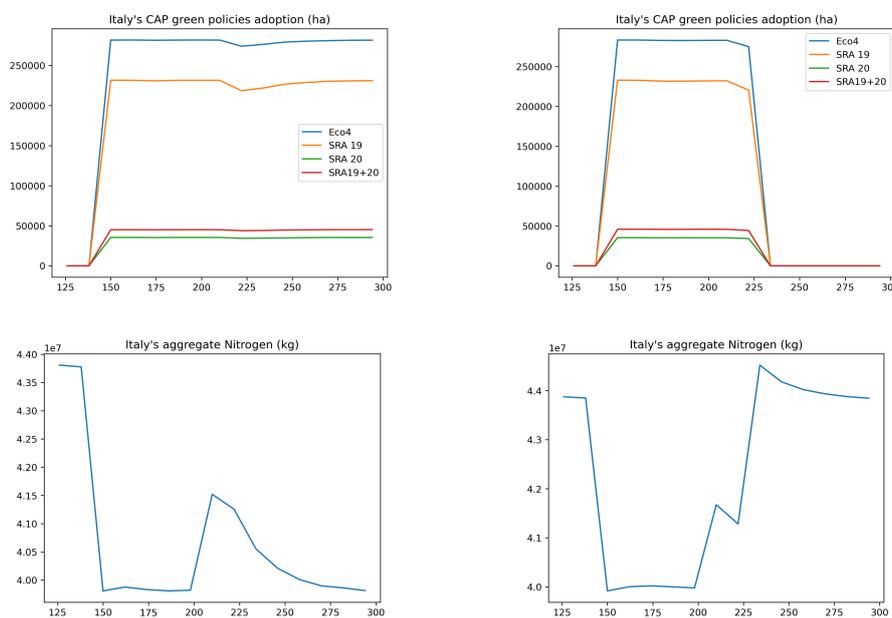

Figure 8: Effects on Italy's hectares of wheat and input quantity after the abandonment of SRA20 at time 140. Left side panel: initial payment set to 7. Right-hand panel: initial payment set to 3.

As in the case of supply, these effects are stronger when the initial policy payment is higher. A more generous pre-existing policy had previously induced a larger reduction in input-intensive production practices. Its abandonment, therefore, produces a stronger rebound in hectares and inputs. When the initial payment is lower, the response remains positive but is less pronounced because the policy had imposed a weaker restriction before being removed.

The deterioration in environmental indicators follows directly from these changes in farm management. Higher nitrogen use and more intensive production generate larger environmental and human-health damages, as reflected in the DALY and species-loss indicators. This pattern is in line with the broader literature emphasizing that production increases achieved through more intensive input use often come at the expense of environmental sustainability Searchinger et al. (2018); Springmann et al. (2018); Pe'er et al. (2020). In this sense, abandoning the green policy after the shock improves short-run productive performance, but does so by worsening environmental outcomes.

Taken together, the results highlight a clear policy trade-off. Faced with a large external shock, abandoning a previously existing green measure can strengthen the domestic supply response and contribute to moderating international wheat prices. At the same time, however, this decision increases the environmental and health costs associated with production expansion. The simulation, therefore, suggests that the short-run gains from policy abandonment should be weighed carefully against the sustainability benefits that the green policy was originally designed to provide.
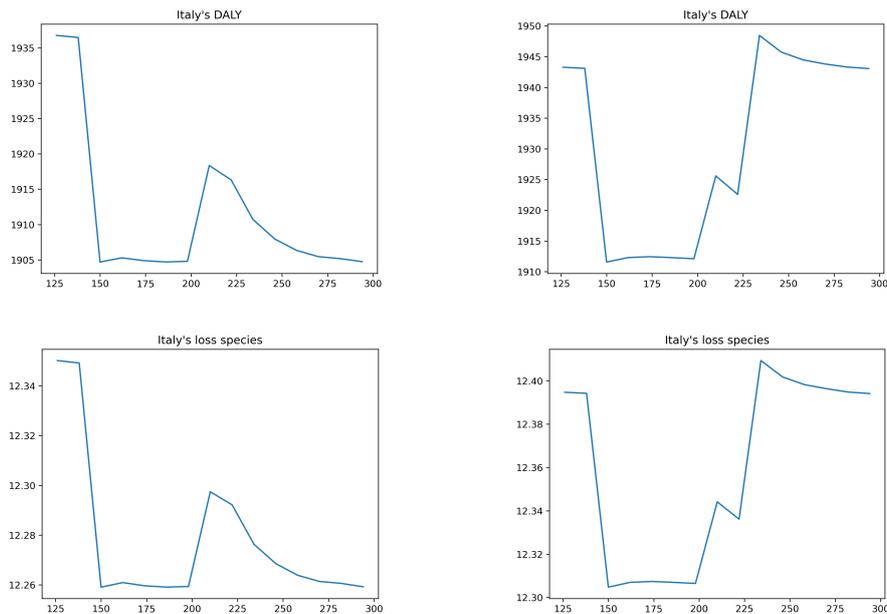

Figure 9: Effects on Italy's LCA indicators after the abandonment of SRA20 at time 140. Left side panel: initial payment set to 7. Right-hand panel: initial payment set to 3.

Overall, the simulations indicate that abandoning the green policy after the shock increases wheat production and partially mitigates the rise in international prices. However, this production expansion comes at the cost of higher input use and deteriorating environmental indicators. The results highlight the policy trade-off between improving food supply resilience and preserving environmental sustainability.

5 Conclusions

This deliverable has analyzed the effects of global supply shocks on wheat markets within the ECOWHEATALY modelling framework, with particular attention to the interaction between geopolitical shocks and environmental agricultural policies.

The analysis focused on the disruption of global wheat markets caused by the Russia–Ukraine war. Ukraine has historically been one of the largest wheat exporters in the world, and the interruption of its exports generated significant instability in international markets. By introducing this shock into the ECOWHEATALY model, the simulations illustrate how disturbances in one region propagate through the global trade network and affect prices, production decisions, and trade flows in other regions.

The results show that the reduction in Ukrainian exports generates a sharp increase in international wheat prices. This price increase creates incentives for producers in other regions to expand production. In particular, Italian farms respond to the improved profitability of wheat cultivation by increasing supply and reallocating resources towards wheat production. This adjustment partially compensates for the loss of Ukrainian exports and contributes to stabilizing the global wheat market.

However, the expansion of production is accompanied by a more intensive use of agricultural inputs, especially nitrogen fertilizers. As a result, the increase in wheat production is associated with higher environmental pressures and worsening environmental indicators. These results highlight the trade-off between market stabilization and environmental sustainability in the agricultural sector.

The policy experiment presented in Section 4 further illustrates this trade-off. When the environmental policy SRA20 is abandoned after the shock, farmers face weaker constraints on production decisions. This leads to a stronger expansion of wheat production and a partial reduction in international price pressures. At the same time, the increase in production intensifies the use of agricultural inputs and generates higher environmental and health impacts.

Overall, the simulations underline a fundamental policy dilemma. Environmental agricultural policies are designed to reduce the ecological footprint of farming systems, but they may also limit the capacity of agriculture to respond rapidly to large supply shocks. Relaxing these policies can temporarily increase food production and mitigate price spikes, but it also entails significant environmental costs.

Future research could extend the present analysis in several directions. First, additional geopolitical or climate-related shocks could be considered in order to evaluate the resilience of global wheat markets under different scenarios. Second, alternative policy instruments could be explored, including policy designs that maintain environmental objectives while improving the ability of agricultural systems to respond to supply disruptions. Finally, the integration of additional regions and more detailed environmental indicators would allow a more comprehensive assessment of the long-term sustainability of global agricultural systems.

Taken together, the results illustrate the usefulness of the ECOWHEATALY modelling framework for studying the complex interactions between agricultural markets, environmental policies, and global shocks, and provide insights that may support policy discussions on food security and sustainability in an increasingly uncertain global environment.

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