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Energy Cost Pressure, Agricultural Input Prices and Farm Economic Resilience in Selected Market Farm Types: Comparative Evidence from Bulgaria and the EU-27

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Abstract **- The paper examines the relationship between energy cost pressure, agricultural input prices and farm economic resilience in Bulgaria compared with the EU-27 average. The empirical design combines three groups of official data sources: Eurostat non-household electricity prices, Eurostat agricultural input price indices, and Farm Sustainability Data Network (FSDN) standard results for selected specialised market farm types. The focus is on Bulgaria and the EU-27 average, with farm-type outcomes compared, energy-price dynamics analysed, and agricultural input-price developments traced for 2020–2024. Methodologically, the study applies a comparative descriptive and relational approach. Farm-type indicators are derived through weighted aggregation across economic size classes. Four indicators are used to assess resilience: income margin, energy cost share, intermediate consumption intensity and liabilities-to-assets ratio.**

The results show that the Bulgarian case cannot be interpreted as a uniform deviation from the EU-27 average. Instead, the evidence points to a strongly differentiated resilience profile across farm types. Milk and other grazing livestock display comparatively strong resilience, granivores improve between 2021 and 2023, while fieldcrops and especially mixed farms weaken markedly by 2023. The findings suggest that the main transmission mechanism operated less through direct energy cost share and more through broader pressures on intermediate consumption and financial sustainability. The paper concludes that agriculture should not be treated as a homogeneous sector when assessing resilience to energy and input price shocks, and that policy responses should be more sensitive to farm-type heterogeneity.

Keywords - agriculture, agricultural input costs, Bulgaria, energy prices, farm resilience

I. INTRODUCTION

The economic environment in which European agriculture operates has become increasingly shaped by the interaction of climate policy, energy market volatility and geopolitical instability. Farmers operate under simultaneous pressure from rising costs, climate change and supply-chain disruptions. In the European Union, the green transition is framed by the European Green Deal, which defines climate neutrality by 2050 as a strategic objective [1] , and by the European Climate Law, which translates this objective into binding commitments and intermediate emissions-reduction targets [2]. Within this broader framework, the Farm to Fork Strategy places agriculture and the food system at the centre of the transition towards sustainability, emphasising the need to reconcile environmental objectives, food security and economic viability [3]. Further European Green Deal is strongly aligned with SDG 7, SDG 12 and SDG 13, which makes the analysis of agricultural cost pressure and resilience especially relevant from both an economic and a sustainability perspective [4].

Simultaneously, the agricultural sector has been exposed to a much more unstable global economic and geopolitical environment. The war in Ukraine triggered what the IEA describes as the first truly global energy crisis, with effects that were especially severe in Europe [5]. For agriculture, this matters not only because of direct fuel and electricity use, but also because the transmission from energy markets to farm costs is amplified through fertilizer production. Ammonia is the starting point for all mineral nitrogen fertilizers, and around 70% of ammonia is used to make fertilizers [6]. FAO monitoring shows that fertilizer prices have observed extreme peaks in 2022 [7]. At the same time, the World Bank continues to identify worsening geopolitical tensions as an upside risk to oil, gas and agricultural price spikes [8].

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Against this background, literature increasingly conceptualises agriculture as a dual energy sector, simultaneously dependent on direct and indirect energy inputs and increasingly involved in renewable energy generation [9]. This perspective treats energy costs not simply as a technical production expense, but as a structural determinant of farm profitability, competitiveness and financial stability [10]. Existing studies also confirm that the burden of energy use in agriculture extends beyond fuel and electricity to fertilizers, chemicals and other intermediate inputs, which broadens the channels through which energy-price shocks affect farm performance [11]. At the same time, research on on-farm renewables suggests that self-generation can reduce operating costs and improve farm autonomy [9].

Within this context, the question of farm economic resilience becomes especially important. Resilience is often linked the capacity to absorb shocks while preserving economic viability and long-term development potential. In this paper, farm resilience is understood as the ability of different farm types to absorb energy- and cost-related shocks while retaining income, containing intermediate cost pressure and preserving financial stability. In the farm-level literature, economic viability is typically associated with the ability to cover operating costs and liabilities, remunerate production factors and sustain investment capacity over time. Evidence from EU dairy farms shows that resilience is structurally differentiated even within one production system: larger scale may improve short-term viability, while long-term viability may remain constrained by indebtedness and other structural pressures [12]. More recent resilience research broadens this view by distinguishing robustness, adaptability and transformability as complementary capacities rather than as a single continuum [13]. Related evidence also suggests that highly specialised farming systems may be less robust under declining input availability, reinforcing the need for farm-type-specific rather than purely aggregate sectoral analysis.

In the Bulgarian context, sustainability-oriented agricultural development is also discussed in relation to structural and institutional constraints, which may affect the capacity of farms to absorb rising production costs [14]. This makes the comparison between Bulgaria and the EU-27 average particularly relevant. While the macro-level shocks affecting agriculture are broadly shared across the Union, their transmission to farms may differ depending on sectoral structure, cost composition, specialisation patterns and financial vulnerability. Therefore, a comparative farm-type perspective is particularly suitable for assessing whether Bulgarian farms faced a different resilience profile than the EU-27 average.

For the price dimension, Eurostat's agricultural price indices provide a suitable framework for tracing changes in the purchase prices of the means of agricultural production [15], while Eurostat's non-household electricity statistics capture the wider energy-price environment relevant for farm businesses [16]. For the farm-level dimension, the Farm Sustainability Data Network provides a particularly appropriate empirical basis, as it gathers annual farm-level data from a harmonised EU survey and makes it possible to compare results across years, countries, farming types and economic size classes [17]. This dataset supports a differentiated assessment of how cost pressure is transmitted into farm economic performance and financial vulnerability.

The objective of this paper is to examine whether rising energy cost pressure was associated with stronger agricultural input cost pressure and differentiated farm economic resilience in Bulgaria compared with the EU-27 average. The paper addresses three questions: how energy cost pressure evolved in Bulgaria and the EU-27; to what extent this pressure was reflected in agricultural input prices; and how selected specialised market farm types performed under that pressure in terms of income retention, direct energy exposure and cost intensity. In this way, the paper contributes to the literature by linking the broader green-transition and geopolitical context to farm-level evidence on economic resilience in selected market farm types.

II. Data and Methodology

The paper is structured around three empirical blocks. The first examines the macro-level energy cost environment through Eurostat non-household electricity prices. The second traces how this pressure is transmitted into agriculture using Eurostat agricultural input indices with particular attention to the "energy and lubricants" component [18]. The third evaluates farm-type resilience through weighted indicators derived from Farm Sustainability Data Network (FSDN) standard results for selected specialised market farm types, capturing profitability, direct energy exposure, cost intensity and financial vulnerability.

Non-household electricity prices are used as a macro-level proxy for the energy cost environment faced by productive sectors. No harmonised farm-specific energy price series is available at EU level for comparative annual analysis. This indicator does not capture the full energy cost structure of agriculture, but it provides a comparable measure of economy-wide energy price pressure across countries.

The empirical focus is on Bulgaria and the EU-27 average. The core comparative window is 2021–2023, while the energy-price analysis uses the broader 2019–2024 context and the agricultural input-price analysis uses the 2020–2024 period. The FSDN-based farm-type analysis covers five specialised market farm types: fieldcrops, milk, other grazing livestock, granivores and mixed farms. Because the FSDN public database reports standard results by economic size class, farm-type indicators for each country and year were derived through weighted aggregation. The weighting variable was the number of farms represented (SYS02). For each country c, farm type f, year t and size class s, the weighted value of a basic variable X was calculated as $X\_w = \text{sum}(X\_s \times SYS02\_s) / \text{sum}(SYS02\_s)$. Size classes with missing public values were excluded from the relevant denominator. The reported resilience indicators were then derived from weighted values rather than from direct averages of row-level ratios, which avoids distortions from averaging already-transformed size-class ratios.

The four reported resilience indicators are defined as follows: income margin = SE420_w / SE131_w; energy cost share = SE345_w / SE275_w; intermediate consumption intensity = SE275_w / SE131_w; and liabilities-to-assets ratio = SE485_w / SE436_w. Higher income margins indicate stronger income resilience, whereas higher values of the other three indicators generally reflect stronger direct energy exposure, greater cost absorption relative to output, and greater financial vulnerability, respectively.

The four indicators were selected to capture complementary dimensions of economic resilience at farm-type level. Income margin reflects the capacity to retain income from output under cost pressure. Energy cost share measures direct exposure to energy-related costs within intermediate consumption. Intermediate consumption intensity captures the broader degree to which output is absorbed by current production costs. Finally, the liabilities-to-assets ratio reflects financial vulnerability and leverage. Taken together, these indicators provide a compact but multidimensional view of farm-type economic resilience under adverse cost conditions.

The empirical design is comparative and exploratory rather than causal. The paper does not claim to identify strict causal effects between macro-level energy prices and farm-level outcomes. Instead, it examines whether the observed movements in electricity prices, agricultural input prices and farm-type economic indicators display comparative patterns across Bulgaria and the EU-27.

The analysis also faces important data constraints. First, non-household electricity prices do not capture the entire energy-related burden of agriculture, which also includes fuel, transport, fertilisers and other cost channels. Second, the public FSDN database contains missing or suppressed values for some Bulgarian farm-type size classes, which limits the completeness of coverage in selected categories. These limitations do not invalidate the comparative exercise, but they require cautious interpretation of farm-type results.

III. ENERGY COST PRESSURE IN BULGARIA AND THE EU-27

Non-household electricity prices increased sharply in both Bulgaria and the EU-27 during the energy shock period. In PPS terms, Bulgaria remained above the EU-27 average throughout 2019–2024 and experienced a markedly stronger increase at the peak of the shock. In the EU-27, the PPS-based price rose from 0.1665 in 2019 to 0.2834 in 2022 and 0.2931 in 2023, before declining to 0.2598 in 2024. In Bulgaria, it increased from 0.2196 in 2019 to 0.4249 in 2022, then fell to 0.3165 in 2023 and 0.2725 in 2024. Although prices declined after the peak, the correction remained incomplete, as both Bulgaria and the EU-27 stayed above pre-shock levels by 2024 (Fig. 1). Overall, Bulgarian producers operated in a comparatively less favourable macro-level energy price environment, especially during the peak shock years.

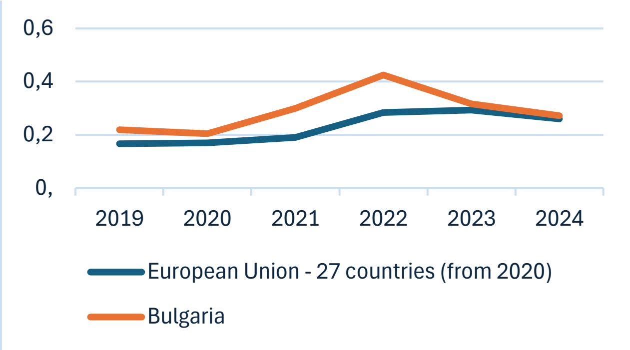

Fig. 1. Non-household electricity prices in Bulgaria and the EU-27, PPS, 2019–2024

The evidence establishes the broader energy cost environment within which agricultural producers operated during the shock period. However, higher electricity prices at the level of non-household consumers do not automatically imply an identical response within agriculture. The next analytical step is therefore to examine whether this macro-level energy pressure was transmitted into the agricultural production environment through higher input prices. In this context, particular attention is paid to the component “energy and lubricants”, as it captures the most direct energy-related channel within agricultural input costs. Comparing this component with total input prices also makes it possible to assess whether the energy shock had a distinct and disproportionate effect on agricultural cost structures in Bulgaria and the EU-27.

IV. TRANSMISSION INTO AGRICULTURAL INPUT PRICES

The agricultural input price evidence does not indicate a direct one-to-one transmission of the stronger Bulgarian macro-level energy shock into a proportionally stronger agricultural energy-input shock. According to Eurostat agricultural input price indices, both Bulgaria and the EU-27 experienced a clear peak in 2022, yet the increase in the “energy and lubricants” component was considerably stronger in the EU-27 average than in Bulgaria.

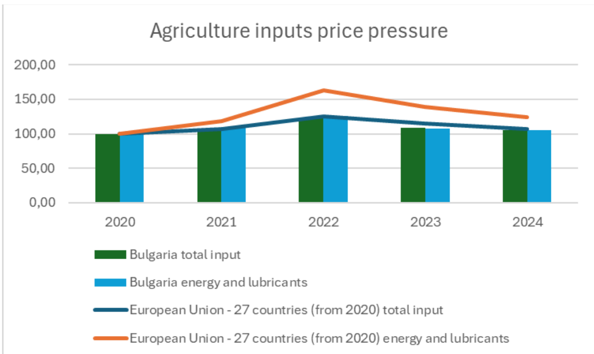

Fig. 2. Agricultural input prices in Bulgaria and the EU-27: total inputs and energy and lubricants, 2020=100, 2020–2024

Fig. 2 illustrates a sharp rise in agricultural input price pressure in both Bulgaria and the EU-27, culminating in a clear peak in 2022. In each case, the index for energy and lubricants increased more strongly than the aggregate input index, indicating that energy-related costs constituted a major channel through which the broader price shock affected agriculture. This divergence, however, is more pronounced at the EU-27 level. In the EU-27, the real index for energy and lubricants increased from 100.00 in 2020 to 162.85 in 2022, whereas the total input index rose to 124.78. In Bulgaria, the corresponding change was less intense: the energy and lubricants index reached 126.04, while the total input index rose to 123.37 in 2022. This pattern suggests that Bulgaria followed the same general upward trajectory, but without experiencing an agricultural energy-price spike of the same magnitude as the EU-27 average. By 2024, both series had moved back closer to the 2020 baseline, although the adjustment was still incomplete, particularly in the EU-27 energy and lubricants component. Taken together, these results provide the empirical basis for examining whether the observed input-price pressure was associated with weaker farm economic resilience across the selected market farm types.

This suggests that macro-level energy price pressure and sector-level agricultural input price transmission were related, but not mechanically identical. Bulgaria followed the general upward pattern, yet the agricultural energy-related input-price spike was less pronounced than the EU-27 average. The result is analytically important because it indicates that stronger macro-level energy pressure in Bulgaria did not automatically imply stronger sector-level agricultural input-price escalation.

V. FARM-TYPE RESILIENCE UNDER COST PRESSURE

Table 2 reports weighted farm-type resilience indicators derived from FSDN standard results. The interpretation of these indicators follows the broader literature linking farm income retention, direct energy exposure, cost absorption and financial position to economic resilience.

Fieldcrop farms show the clearest deterioration in Bulgaria. In 2021, the Bulgarian income margin was slightly above the EU-27 benchmark (0.380 versus 0.368), but by 2023 it had fallen sharply to 0.031, compared with 0.226 in the EU-27. At the same time, Bulgarian intermediate consumption intensity rose from 0.380 to 0.639, converging to the EU-27 level, while the liabilities-to-assets ratio increased from 0.216 to 0.251. This combination indicates a sharp deterioration in cost intensity and a substantial weakening of the capacity to retain income under pressure.

Milk farms display one of the strongest Bulgarian resilience profiles. The income margin increased from 0.429 in 2021 to 0.483 in 2023, whereas the EU-27 average declined from 0.253 to 0.215. Bulgarian milk farms also maintained lower intermediate consumption intensity and lower liabilities-to-assets ratios than the EU-27 average in both years. Although the share of direct energy costs remains higher in Bulgaria, stronger income retention, relatively lower cost intensity and a manageable level of indebtedness outline a comparatively resilient profile for milk farms.

Other grazing livestock farms show the strongest income performance in the Bulgarian sample. Income margin rose from 0.802 to 0.906, compared with a decline from 0.363 to 0.310 in the EU-27. Intermediate consumption intensity remained below the EU-27 level in both years, and the liabilities-to-assets ratio improved strongly from 0.212 to 0.104. These results indicate very strong apparent resilience, based on high income margins and relatively limited cost absorption, but the interpretation should remain cautious due to the incomplete coverage of Bulgarian size classes in the public database for this category.

Granivores improved in both Bulgaria and the EU-27, but the Bulgarian improvement is more pronounced. The Bulgarian income margin rose from 0.125 to 0.234, slightly overtaking the EU-27 value in 2023. At the same time, energy cost share declined from 0.080 to 0.071, intermediate consumption intensity declined from 0.749 to 0.652, and the liabilities-to-assets ratio improved from 0.272 to 0.237. Taken together, these changes suggest a strengthening resilience profile within the represented Bulgarian sample, associated with improved income retention, lower cost intensity and reduced direct energy burden.

Mixed farms show one of the strongest cases of deterioration. In Bulgaria, the income margin fell from 0.353 to 0.041, whereas the EU-27 declined only from 0.222 to 0.171. Intermediate consumption intensity increased sharply from 0.537 to 0.791, and the liabilities-to-assets ratio rose from 0.278 to 0.561. This combination indicates a simultaneous weakening of income retention, stronger cost absorption and a marked deterioration in the balance-sheet position of Bulgarian mixed farms by 2023.

Table 2. Weighted farm-type resilience indicators in Bulgaria and the EU-27, 2021 and 2023

Farm type	Country	IM 2021	IM 2023	ECS 2021	ECS 2023	ICI 2021	ICI 2023	LAR 2021	LAR 2023
Fieldcrops	Bulgaria	0.380	0.031	0.182	0.161	0.380	0.639	0.216	0.251
	EU-27	0.368	0.226	0.142	0.138	0.538	0.639	0.148	0.144
Milk	Bulgaria	0.429	0.483	0.112	0.104	0.569	0.578	0.085	0.173
	EU-27	0.253	0.215	0.088	0.089	0.646	0.674	0.224	0.211

Other grazing livestock	Bulgaria	0.802	0.906	0.102	0.107	0.682	0.708	0.212	0.104
	EU-27	0.363	0.310	0.096	0.099	0.718	0.743	0.112	0.110
Granivores	Bulgaria	0.125	0.234	0.080	0.071	0.749	0.652	0.272	0.237
	EU-27	0.158	0.226	0.058	0.058	0.744	0.671	0.317	0.287
Mixed	Bulgaria	0.353	0.041	0.142	0.145	0.537	0.791	0.278	0.561
	EU-27	0.222	0.171	0.102	0.105	0.677	0.708	0.192	0.186

Abbreviations: IM = income margin; ECS = energy cost share; ICI = intermediate consumption intensity; LAR = liabilities-to-assets ratio.

Overall, Table 2 points to distinct resilience profiles across farm types in Bulgaria relative to the EU-27. The most pronounced weakening is observed in fieldcrops and mixed farms, whereas milk, other grazing livestock and, to some extent, granivores show more resilient dynamics.

VI. Discussion

Beyond its agricultural-economic contribution, the paper is also relevant to data-driven system analysis because it demonstrates how harmonised public datasets can be combined into a structured framework for monitoring resilience under external shocks. In this sense, the study contributes to indicator-based analytical support for policy design, sectoral monitoring and evidence-based decision environments.

The comparison between Bulgaria and the EU-27 suggests that farm resilience under energy- and cost-related pressure cannot be inferred directly from the macro-level energy price environment alone. Although Bulgaria faced a less favorable energy price context in PPS terms, this did not translate into a uniformly weaker agricultural outcome. Instead, the evidence points to a differentiated transmission process, in which the effects of energy and input price shocks varied according to the production specialization, cost structure and financial position of farm types. This is important because aggregate agricultural indicators may conceal substantial internal differences in the capacity of farms to absorb external shocks.

The observed differences are consistent with a pattern in which cost pressure is reflected through broader changes in intermediate consumption and financial pressure. The impact of the energy-price shock was reflected in broader changes in intermediate consumption and financial pressure. In this sense, energy cost pressure should be interpreted as part of a wider inflationary environment affecting agriculture through multiple input channels. Farm types with stronger income retention and more stable cost absorption were better positioned to withstand this pressure, whereas those with rising intermediate consumption intensity or increasing leverage displayed weaker resilience. Therefore, the relationship between macro-level energy prices and farm-level outcomes is shaped by structural characteristics such as input dependence, cost absorption capacity and balance-sheet vulnerability.

From a policy perspective, these findings suggest that resilience-enhancing measures should not be designed only at the aggregate agricultural level. A more targeted approach is needed, considering the specific vulnerabilities of different farm types. For farms with rising intermediate consumption intensity, support may focus on cost efficiency, input substitution and technological modernization. For farms with increasing financial vulnerability, measures related to liquidity, investment capacity and debt management may be more relevant. Thus, strengthening resilience requires not only reducing direct energy exposure, but also improving cost management, financial sustainability and adaptive capacity across production systems.

VII. Conclusion

The paper demonstrates that energy cost pressure, agricultural input price dynamics and farm-type resilience can be meaningfully linked within a comparative Bulgaria - EU-27 framework using official Eurostat and FSDN data. The Bulgarian case does not point to a uniformly weaker or stronger position relative to the EU-27 average; instead, it reveals substantial variation across farm types.

Fieldcrops and mixed farms appear the most vulnerable, while milk and other grazing livestock show comparatively strong resilience and granivores improve over the period. This suggests that the effects of energy- and cost-related pressure were transmitted through broader changes in intermediate consumption and financial sustainability. The findings therefore indicate that policies aimed at strengthening resilience should be more differentiated and should account for variation in production specialization, cost structure and financial vulnerability across farm types.

Future research could extend the analysis to a wider country sample, additional farm types and more detailed evidence on farm-level adaptation strategies. Further work is also needed on the mechanisms through which energy-price shocks are transmitted into cost pressure and financial stress in agriculture, to identify more precisely which farm types are most exposed and what forms of support are likely to be most effective.

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