Tudorel ANDREI, PhD (corresponding author)
andrei.tudorel@csie.ase.ro
Bucharest University of Economic Studies, Bucharest, Romania

Atanas ATANASOV, PhD
president@nsi.bg
University of National and World Economy, Sofia, Bulgaria

Marek CIERPIAŁ-WOLAN, PhD
m.cierpial-wolan@stat.gov.pl
University of Rzeszow, Poland; Statistics Poland

Export and Import Variability and Economic Determinates of Countries

Abstract. *The article is based on macroeconomic data series related to Bulgaria, Czech Republic, Hungary, Poland and Romania. The article assesses to what extent there are significant differences between countries in relation to the level of concentration of exports and imports of agri-food products. In order to assess the degree of concentration, the entropy and its breakdown by factors of influence are calculated. In this respect, the entropy calculated on the basis the of exports and imports series is broken down into two components. This decomposition allows the evaluation of related variety and unrelated variety, which are two important indicators for assessing the development potential of a country in a short and long-time horizon. By using the Granger causality tests, it is assessed to what extent the variability of exports provides support for the development of agricultural production in a short or long period of time. Equally, applying the Granger test determines to what extent the increase in population incomes has a direct impact on related variety and unrelated variety for imports of agri-food goods.*

Keywords: *Granger causality, entropy, related variety, unrelated variety.*

JEL Classification: A11, C54, F14.

Received: 16 June 2025	Revised: 6 September 2025	Accepted: 9 September 2025

1. Introduction

At the microeconomic level, competition between firms is decisive concerning two key issues. Firstly, it pertains to the ability to obtain products and services of quality at the lowest possible costs. In this respect, it is essential to increase labour productivity while improving the quality of products and services. Secondly, it involves enhancing the capacity for innovation, which will support the development of new products and services that will allow for the diversification of supply. Combining these two factors one ensures that production processes are more

DOI: 10.24818/18423264/59.3.25.13

efficient, through reducing production costs and promoting innovation that increases the variety of products and services offered to consumers (Savioti and Pyka, 2004).

At the macroeconomic level, these aspects are revealed by a certain evolution of the variety of exports and imports of a country, characteristics that have a direct impact on the balance of trade. The variety of supply demand is directly determined by the production structure by activity sectors (intersectoral variety) and, within sectors, by the distribution that exists between the component subsectors (intra-sectoral varieties). Each of the two components of the variety of exports/imports of agri-food goods has a different impact on the short-term and, respectively, medium and long-term economic growth of a sector or of the supply/demand national economy (Saviotti and Frenken, 2008; Frenken, 2007).

While the variety of production between sectors provides, for a country, prerequisites for economic development in the short term, the variety of production at the sectors level, which reveals aspects related to the complexity of the economy, offers a perspective on the economic development of the economy in the medium and long run. In an open economy, the two varieties of production in a country are highlighted by certain exports/imports characteristics. The process of accession of the Eastern European countries to the European Union has had a direct and significant impact on foreign trade activity in general and on agri-food goods, in particular. For Romania and Bulgaria, EU accession in 2007 brought significant changes in the structure of exports and imports of agri-food goods (Andrei et al., 2022).

2. Methodology and data used

In order to assess the degree of concentration of the exports/imports of agri-food goods at the level of Bulgaria, the Czech Republic, Hungary, Poland and Romania in the 2002-2023 period, data that allow a two-level aggregation were used: the first level concerns the exports/imports for 24 chapters which are specific to agri-food goods; the second one relates to the exports/imports of products that belong to each of the 24 chapters of agri-food goods (INS, 2025).

For the exports/imports of goods, the data series $x_{ijt}, i = 1, \dots, 24, j = 1, \dots, n_i, t = 2002, \dots, 2023$, is defined at country level. Each value represents the volume of exports/imports in one year for a j product that belongs to chapter i, where $i = 1, \dots 24$. For each chapter, the volume of exports/imports is calculated: $x_{it} = \sum_{j=1}^{n_i} x_{ijt}$, where n_j represents the number of products that are part of a chapter of agri-food goods.

The data used in the framework of the study for assessing certain aspects related to the variety of the exports/imports of agri-food goods for five countries (Bulgaria, the Czech Republic, Hungary, Poland and Romania) refer to the exports/imports of agri-food goods in the 2002-2023 period; these data are disaggregated into chapters of goods (24 chapters) and, within these chapters, into categories of products (the SH4 classification of external trade products was employed). The primary data relating to the exports and imports of agri-food goods in the period concerned have

the Romanian National Institute of Statistics as data source. In order to define the models of quantitative analysis, beside the indicators derived from the data series related to the exports/imports of agri-food goods, other indicators published by Eurostat were also used.

For assessing the degree of concentration of exports/imports, the entropy is calculated on two levels of aggregation. At the first level of aggregation, in order to define this index, the weight of the exports/imports of each product in the total volume of exports/imports of agri-food goods for each of the chapters from 1 to 24 is taken into account. The weights used to calculate the entropy at this level of aggregation are determined based on the relation $p_{ijt} = \frac{x_{ijt}}{x_{it}}$. The entropy is determined on the basis of the following formula (Shannon, 1971):

$$T_t = \sum_i \sum_j p_{ijt} \log(\frac{1}{p_{ijt}}) \quad (1)$$

For each category of goods, the degree of concentration of exports/imports is assessed based on the entropy that is determined according to the following relation:

$$T_{it} = \sum_{j=1}^{n_i} \frac{p_{ijt}}{p_i} \log\left(\frac{1}{\frac{p_{ijt}}{p_i}}\right), i = 1, \dots, 24 \quad (2)$$

where $p_{it} = \sum_{j=1}^{n_i} p_{ijt}$.

For the data series $T_{it}, i = 1, \dots 24$, defined at the level of one year, indicators for characterising the central tendency, the dispersion and the skewness are calculated.

The value of indicator [2] increases depending on the number of products that are included within each category of goods as well as on the degree to which the distribution of the exports/imports of products is as close to a uniform distribution as possible. In order to eliminate the influence of the number of products on the value of the indicator and to take account only of the variability of the distribution, the normalised entropy is determined:

$$N_{it} = \frac{T_{it}}{\log(n_i)} \in [0,1] \quad (3)$$

In order to assess the degree of concentration of exports/imports at the level of the categories of goods, the weighted mean of the degrees of entropy of the categories of goods is calculated:

$$T_{Wt} = \sum_{i=1}^{24} T_{it} p_{it} \quad (4)$$

In order to measure the concentration of exports/imports by categories of goods, the entropy for the data series $(x_{it}, n_{it}), i = 1, \dots, 24$, is determined:

$$T_{Bt} = \sum_{i=1}^{24} p_{it} \log(1/p_{it}) \quad (5)$$

Relations [4] and [5] each characterise aspects of the concentration of the exports/imports of agri-food goods. For example, in the case of exports, by means of relation [4], the export related variety is assessed, a variety which has a direct impact on short-term economic growth. If [5] is applied to export data, this measure characterises the export unrelated variety, a variety which has an impact on economic growth in the longer term (Saviotti and Frenken, 2008).

3. The assessment of the degree of concentration of exports and imports by categories of goods

For each country, at year level, the entropy for each chapter is calculated using the data series on exports and imports, respectively. A series on the degrees of entropy ($T_{it}, i = 1, \dots 24, t = 2002, \dots, 2023$) was obtained separately for exports and imports. As shown above, the value of each indicator depends on the number of products that belong to a chapter and, due to his reason, with a view to ensuring the comparability of the values obtained at category level, the normalised entropy is calculated on the basis of relation [3]. The data series $TN_{it}, i = 1, \dots 24, t = 2002, \dots, 2023$, is thus obtained. At the level of each year, indicators for characterising the distribution of the normalised entropy are determined, and the results achieved for a few years are presented in table 1.

The results obtained highlight the following two important aspects related to the dynamics of the variability of the imports/exports of agri-food goods:

(i) during the 2002-2023 period, in the five countries concerned, a significant diversification of both exports and imports of agri-food goods is noticed (figure 1). These results are a direct consequence of the economic changes that took place at European and world level and which stimulated the external trade exchanges. During this period, the five countries concerned were fully involved in the process of integration into European economic structures and the trade exchanges at European level were boosted;

(ii) the deepest changes in the diversification of exports and imports were noted in the trade exchanges of Romania and Bulgaria. This statement is supported by the values of the entropy, medians and means calculated for the annual series related to the entropy (central tendency indicators calculated each year based on the degrees of entropy determined for the 24 categories of goods).

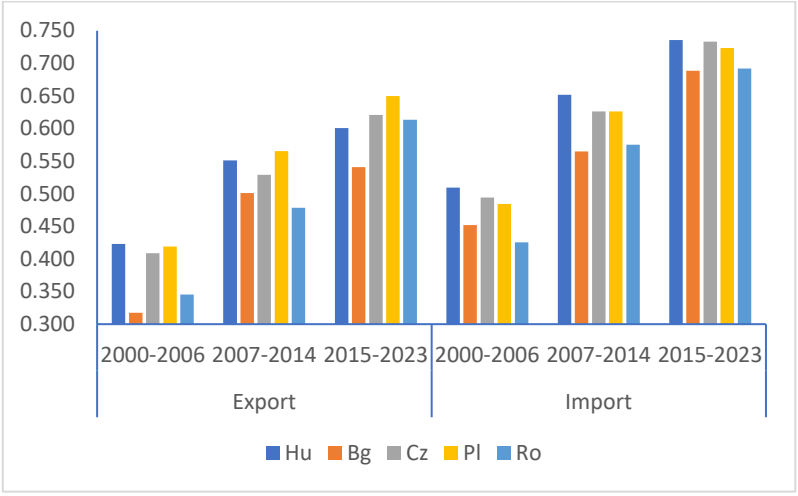

Figure 1. The normalised median for the exports and imports of goods over various time periods

Source: Author's own computations.

A greater diversification in the imports of agri-food goods compared to the diversification in the exports of such products is noticed. These results are confirmed both by calculating the median of the normalised values for the entropy of the exports and imports of goods for different years of the reference period (figure 1) and by calculating the difference between the medians determined in the case of exports and imports of agri-food goods for each year of the 2002-2023 period (figure 2). The volatility of the degrees of entropy obtained each year for the 24 categories of goods is lower if the entropy is calculated for the exports of goods than if calculated for the imports of goods. In most cases, the range of values within which the degrees of entropy fall is much greater if these levels are calculated for the export data than if calculated for the import data (table 1).

Table 1. Characteristics of the distribution of the degrees of entropy for the years 2000, 2007, 2014 and 2023

	Mean		Standard deviation		Skewness		Kurtosis		Minimum		Maximum	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Bulgaria												
2000	0.442	0.597	0.195	0.162	0.170	-0.515	-0.819	-0.969	0.147	0.301	0.772	0.826
2007	0.492	0.618	0.178	0.161	-0.871	-0.283	0.763	0.803	0.043	0.291	0.733	0.999
2014	0.544	0.630	0.184	0.162	-0.297	-0.941	-0.769	1.196	0.148	0.202	0.844	0.867
2023	0.506	0.635	0.205	0.177	0.188	-0.456	-1.291	-0.611	0.165	0.267	0.873	0.872
Czech Republic												
2000	0.563	0.670	0.191	0.144	-0.963	-0.577	1.085	-0.652	0.028	0.363	0.790	0.880
2007	0.543	0.680	0.223	0.184	-0.864	-1.203	0.758	0.828	0.023	0.241	0.877	0.945
2014	0.530	0.665	0.235	0.184	-0.654	-1.190	-0.406	1.291	0.044	0.194	0.878	0.948
2023	0.546	0.688	0.231	0.173	-0.910	-0.847	0.186	-0.057	0.016	0.294	0.844	0.906
Hungary												
2000	0.442	0.678	0.195	0.150	0.170	-0.732	-0.819	-0.039	0.147	0.322	0.772	0.888
2007	0.492	0.740	0.178	0.134	-0.871	-0.920	0.763	0.543	0.043	0.412	0.733	0.929
2014	0.544	0.711	0.184	0.145	-0.297	-1.083	-0.769	0.508	0.148	0.356	0.844	0.893
2023	0.506	0.675	0.205	0.189	0.188	-0.590	-1.291	0.153	0.165	0.212	0.873	0.970
Poland												
2000	0.549	0.611	0.208	0.184	-0.496	-0.861	0.007	0.720	0.123	0.123	0.956	0.906
2007	0.600	0.679	0.193	0.182	-0.672	-0.931	0.568	0.394	0.147	0.263	0.963	0.972
2014	0.595	0.653	0.201	0.181	-0.740	-1.128	0.082	0.270	0.147	0.231	0.908	0.846
2023	0.607	0.654	0.215	0.177	-1.045	-0.561	1.377	-1.130	0.068	0.321	0.919	0.874
Romania												
2000	0.525	0.580	0.198	0.170	0.457	-0.364	-0.507	-0.541	0.231	0.228	0.945	0.850
2007	0.509	0.603	0.193	0.175	-0.448	-0.758	0.020	-0.130	0.069	0.232	0.830	0.863
2014	0.548	0.640	0.206	0.190	-0.886	-1.067	0.412	0.576	0.051	0.184	0.820	0.884
2023	0.551	0.610	0.203	0.225	-1.114	-0.818	0.745	-0.068	0.040	0.124	0.825	0.936

Source: Author's own computations.

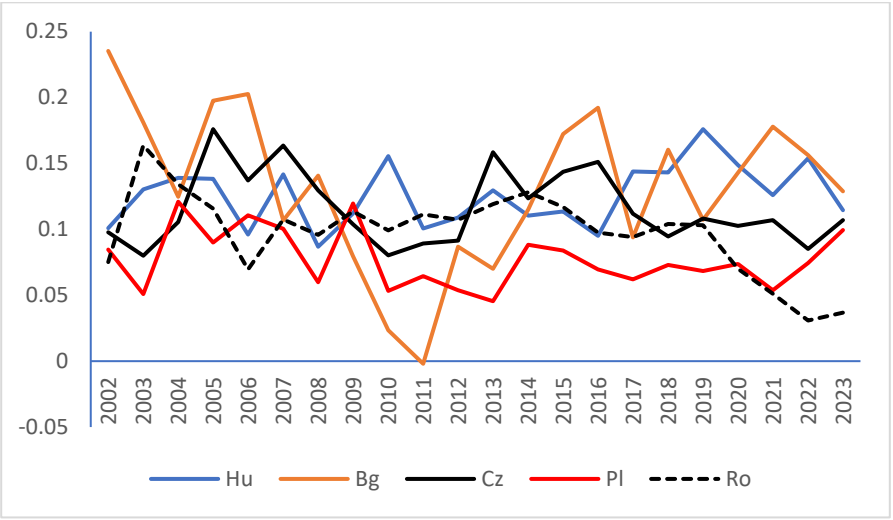

Figure 2. The difference between the normalised medians calculated for the exports and imports of goods
Source: Author's own computations.

4. Decomposition of entropy by factors of influence

Based on the results presented in the previous section, this is the case for each of the five countries, increasing diversification of exports and imports agri-food goods during the period 2002-2023. Hereafter, resorting to the decomposition of entropy into the sum of two terms, we will identify to what extent these developments are the result of diversification of exports/imports in the commodity chapters or diversification of exports/imports of goods by chapter of agri-food goods.

Taking into account the form of presentation of the primary data, on the two levels of aggregation, to identify the characteristics of the concentration of exports/imports of agri-food products the value of entropy will break down (T_T) on the following two components (Theil 1967, 1972; Andrei et al., 2017):

- the first component is that which evaluates the concentration of exports/imports of agri-food goods according to the distribution of the total volume of exports/imports on the 24 chapters of agri-food goods (T_B). This component, in the case of exports, characterises the degree of specialisation of each country for the production of products belonging to a certain category.
- the second component is used to assess the concentration of exports/imports of goods within the agri-food commodity chapters (T_W). Thus, the aggregate value of entropy decomposes on the two components:

$$T_T = T_B + T_W \quad (6)$$

A high degree of concentration of exports/imports of goods, as a result of the concentration of the total volume of exports/imports on a small number of

commodity chapters it is equivalent to a low entropy value. Component T_B it is calculated based on the distribution of exports/imports at the level of agri-food commodity chapters. Under these conditions, term $\frac{T_B}{T_T}$ characterises the degree of concentration of exports/imports explained by the differences that exist between the chapters in relation to the distribution of the total volume of export/import on the 24 chapters.

The graph in Figure 3 shows the values recorded for the report $\frac{T_B}{T_T}$, expressed as a percentage, for each year of the 2002-2023 period. A high value of this indicator highlights the important role that structural factors in concentrating exports/goods imports on a small number of chapters. In these circumstances, the specific characteristics of the categories of goods have a smaller role in defining the concentration of exports/imports. Whether the contribution of structural factors is predominant for exports, the production chain is short, and the exports of agri-food goods consist mostly of products belonging to a small number of chapters of agri-food products.

The results show a more pronounced diversification of exports due to structural factors in four of the five countries: Bulgaria, Hungary, Czech Republic and Poland. In Romania, the concentration of exports of agri-food goods, due to the influence of structural factors, is significant. However, the assessment of the structure of exports by categories of goods shows us that, most of the agri-food exports consist of raw materials, such as cereals and seeds, obtained in agriculture. Moreover, in Romania, since 2007, there has been a significant increase in the concentration of exports on a small number of categories of agri-food goods. In contrast, Poland is seeing an even more pronounced diversification of exports by categories of goods.

If in the case of Romania, the structural factors played an insignificant role in stimulating the diversification of the export of agri-food goods, in contrast, their role in the Czech Republic has increased significantly since 2015. In Hungary and Bulgaria, structural factors have made an important and constant contribution to the diversification of the export of agri-food goods, throughout the period, but especially since 2017.

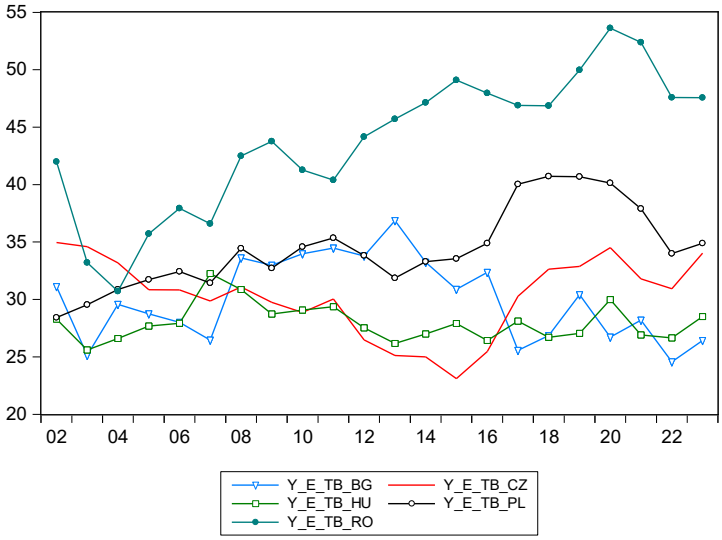

Figure 3. T_B/T_T – export for the 5 countries in the period 2002-2023
Source: Author's own computations.

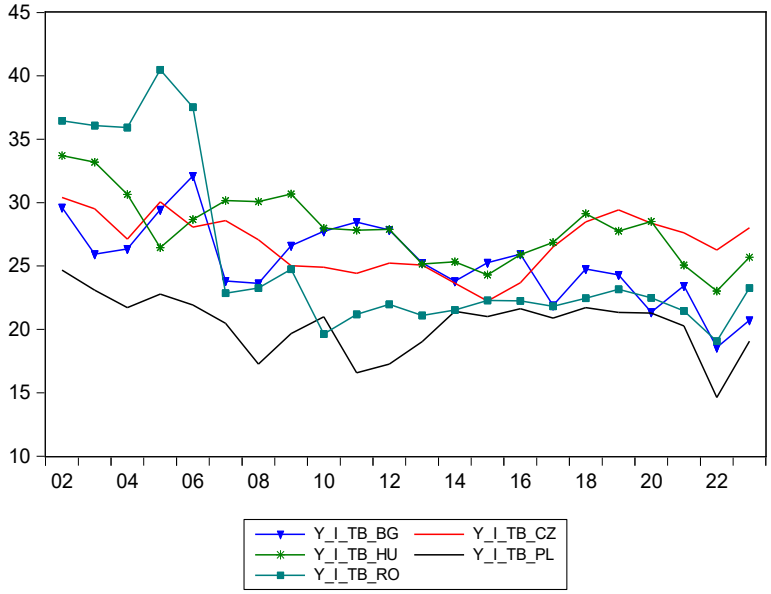

Figure 4. T_B/T_T – import for the 5 countries in the period 2002-2023
Source: Author's own computations.

For the five countries, structural factors played a much more important role in diversifying imports than in the case of agri-food exports. The results presented in the graph in figure 4 show a much lower contribution in the total entropy value of the T_B component, the statement being valid for the five countries.

For Romania, especially since 2007, there is a decrease in the influence of structural factors in the dynamics of concentration of imports of agri-food goods (figure 4). Instead, the specific factors influencing the variability of imported agri-food products at the level of commodity categories have a much more important role in the diversification of imports of agri-food goods. This development can be explained by the important changes that have occurred in the demand for agri-food products of the population, due to the increase in the incomes of the population, and part of it is satisfied by the import of these agri-food products (Vîrva, S. 2025).

5. Granger causality analysis

In the following, we will aim to assess important aspects of the concentration of exports/imports of agri-food goods at the level of the five countries:

- the extent to which there is a significant causal relationship between the variety of agri-food goods exports and labour productivity growth;
- whether the variety of imports is directly determined by the dynamics of population income;

To evaluate the two aspects, Granger causality was applied. (Asteriou, D. 20011).

To test Granger causality, the autoregressive model is used:

$$\boldsymbol{Y}_t = \boldsymbol{A}_0 + \boldsymbol{A}_1 Y_{t-1} + \cdots + \boldsymbol{A}_p \boldsymbol{Y}_{t-p} + \boldsymbol{\varepsilon}_t \quad (7)$$

where $\boldsymbol{Y}_{t-i} = \begin{bmatrix} y_{1t-i} \\ y_{2t-i} \end{bmatrix}, \boldsymbol{A}_i = \begin{bmatrix} a_{1i} \\ a_{2i} \end{bmatrix},\ i = 0,1,\dots,p,\ \boldsymbol{\varepsilon}_t = \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix}$, with ε_{1i} and ε_{1i} uncorrelated white noise.

Using the model [7], one of the following situations regarding the causal relationship that can occur between two variables can be identified: $y_1 \rightarrow y_2, y_2 \rightarrow y_1, y_1 \leftrightarrow y_2$ or there is no Granger causality relationship between the two variables. For example, in the case of checking the causal relationship $y_1 \rightarrow y_2$ the null hypothesis is tested $H_0: a_{21} = \cdots = a_{2p} = 0$, against the alternative hypothesis $H_1: \exists a_{2i} \neq 0, i = 1, \dots, p$. To test the null hypothesis, the F statistic specific to a Wald test is calculated [Green, W.,]. If the calculated value of the F-statistic is greater than the F-critical value then the null hypothesis is rejected and it results that $y_1 \rightarrow y_2$.

To assess whether there are Granger causal relationships between export variety (measured by T_B, T_W şi T_T) and labour productivity, following the application of the Wald test, the causal relationships presented in Table 2 were identified. To assess each causal relationship, growth indices were calculated for each indicator measuring the degree of concentration, with a 2020 base.

Table 2. Causal relationship between export variability and labour productivity in agriculture

Bulgaria	Czech Republic	Hungary	Poland	Romania
$W \rightarrow TB$ F=2.72 (0.09), p=2	$TT \rightarrow W$ F=3.68 (0.07), p=1	$W \rightarrow TT$ F=3.08 (0.07), p=3	$W \rightarrow TT$ F=5.19 (0.02), p=2	$W \rightarrow TW$ F=15.81 (0.00), p=2
$W \rightarrow TW$ F=3.42 (0.06), p=2	$TW \rightarrow W$ F=3.31 (0.09), p=5	$W \rightarrow TW$ F=3.39 (0.07), p=3	$W \rightarrow TW$ F=2.64 (0.10), p=2	$W \rightarrow TT$ F=3.60 (0.05), p=2
				$W \rightarrow TW$ F=3.44 (0.08), p=5

Source: Author's own computations.

The results obtained highlight the causal relationship that exists between labour productivity and the variability of agri-food exports measured by one of the indicators T_B, T_W şi T_T. In the case of four countries (Bulgaria, Hungary, Poland and Romania) it is obtained that an increase in labour productivity in the agricultural sector determined an increase in the variability of commodity categories, but also within them (Bulgaria). In the case of Hungary, Poland and Romania it is obtained that, by increasing labour productivity, a direct increase in variability was generated within commodity categories and indirectly, between agri-food commodity categories.

In the case of Czech Republic agri-food goods exports, we find that an increase in the variability of exports within categories results in an increase in labour productivity in the agricultural sector.

In the case of imports of agri-food goods, following the application of the Wald test, the results presented in Table 3 are obtained. For each of the five countries, Granger causality relationships identified between the variability of exports and population incomes are defined.

Table 3. The causal relationship between imports variability and population income

Bulgaria	Czech Republic	Hungary	Poland	Romania
$Wages \rightarrow TB$ F=5.28 (0.02), p=2	$Wages \rightarrow TT$ F=4.59 (0.03), p=2	$Wages \rightarrow TT$ F=3.06 (0.07), p=2	$Wages \rightarrow TB$ F=7.28 (0.01), p=4	$Wages \rightarrow TB$ F=6.10 (0.02), p=5
$TW \rightarrow Wages$ F=3.91 (0.06), p=1	$Wages \rightarrow TB$ F=7.76 (0.09), p=4	$Wages \rightarrow TW$ F=3.47 (0.07), p=1	$TW \rightarrow Wages$ F=2.71 (0.10), p=2	$TB \rightarrow Wages$ F=3.15 (0.10), p=5
$Wages \rightarrow TW$ F=4.20 (0.06), p=1	$Wages \rightarrow TW$ F=5.05 (0.04), p=5	$Wages \rightarrow TB$ F=4.27 (0.05), p=5	$TT \rightarrow Wages$ F=3.25 (0.09), p=1	$Wages \rightarrow TW$ F=2.76 (0.08), p=3

Source: Author's own computations.

Regarding the causal relationship between population income and import variability, it is found that, in all five countries, at least one direct causal relationship is identified between income and one or more components of the variability of goods imports. This result confirms once again that, by increasing population income in each country, there was a diversification of population demand, part of which was satisfied by importing agri-food goods.

6. Conclusions

The results obtained for the five countries highlight the important role that increasing the variety of agri-food goods exports plays in the development of agricultural production. The entropy decomposition for agri-food goods exports allows highlighting some export characteristics for each of the five countries. Thus, among all five countries, Romania records the highest level of export concentration, this situation being determined, to a large extent, by the concentration of exports on three categories of goods, two of which include agricultural raw materials.

For all five countries, imports of goods are characterised by a much lower level of concentration than that recorded in the case of agri-food exports. In this case, the diversity of imports is largely determined by the diversity of imports at the level of commodity chapters. The greater dispersion in the case of imports lies in the fact that in most countries domestic demand is satisfied to a large extent on the basis of imports of agri-food goods.

The application of Granger causality tests highlighted the important role played by increasing population incomes in increasing and diversifying the import of agri-food goods in the five countries.

Acknowledgements: *This work was partially supported by the project "Societal and Economic Resilience within multi-hazards environment in Romania" funded by European Union – NextGeneration EU and Romanian Government, under National Recovery and Resilience Plan for Romania, contract no.760050/ 23.05.2023, cod PNRR-C9-I8-CF 267/29.11.2022, through the Romanian Ministry of Research, Innovation and Digitalization, within Component 9, Investment I8.*

References

[1] Ahmed, P., Feliciano, C., Emigh, R.J. (2007), *Internal and external ethnic assessments in Eastern Europe, Social Forces*, 86(1), 231-255.

[2] Andrei, T., Oancea, B., Mirică, A. (2022), *Agriculture export variety and the short and long run impact on agriculture export, Agricultural Economics*, 68(4), 137-145.

[3] Andrei T., Oancea B., Richmond P., Dhesi G., Herteliu C. (2017), *Decomposition of the inequality of income distribution by income types - Application for Romania. Entropy*, 19, 430.

[4] Asteriou, D., Hall S.G. (2011), *Applied Econometrics,* Palgrave Macmillan, New York, USA.

[5] Greene, W.H. (2018). *Econometric Analysis, 8th Edition*. Pearson Education, Essex, UK.

[6] Frenken, K., Van Oort, F.G., Verburg, T. (2007), *Related variety, unrelated variety and regional economic growth. Regional Studies,* 41, 685-697.

[7] Shannon, C.E., Weaver, W. (1971), *The Mathematical Theory of Communication*. 16th Ed. Urbana, USA, University of Illinois Press, 12-18.

[8] Saviotti, P-P, Pyka, A (2004), *Economic development by the creation of new sectors. Journal of Evolutionary Economics*, 14(1), 1-36.

[9] Saviotti, P-P, Frenken, K (2008), *Export variety and the economic performance of countries. Journal of Evolutionary Economics*, 18, 201-2018.

[10] Theil, H. (1972), *Statistical Decomposition Analysis*. North-Holland Publishing Company, Amsterdam, the Netherlands.

[11] Theil, H. (1967), *Economics and Information Theory*. North-Holland Publishing Company, Amsterdam, the Netherlands.

[12] Vîrva, S. (2025), *Structure and Performance of Romanian Agriculture in the European Context: An Integrated Analysis of Romania's Production*, *Areas and Trade*. *Romania Statistical Review,* 2, 55-77.

[13] *** (2025), Institutul Național de Statistică, Tempo Database.