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Agriculture export variety and the short and long run impact on agriculture export

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Abstract: In this paper, we investigated the extent to which the accession to the EU has had an effect on increasing the variety of exports of agri-food categories for two Eastern European countries, namely Romania and Bulgaria. We also assessed the impact of changes in the variety of exports of agri-food categories on the dynamics of the volume of exports of agri-food products for these two countries and used the entropy to measure the variability of exports of agri-food products by categories. The results confirm the important role played by related variety in increasing a country's long-term exports of agri-food products and show that the high concentration of exports on a small number of categories of agri-food products that include mostly agricultural raw materials cannot ensure a sustainable increase in the export of agri-food products for Romania. In the case of Bulgaria, the related variety has a positive impact on ensuring a sustainable increase in agri-food exports. The accession to the EU was an important factor for the increase of the exported agri-food goods for Romania while in the case of Bulgaria, the accession to the EU did not mark a positive or negative shock on the volume of exports of agri-food products.

Keywords: agri-food exports; concentration of exports; related variety; unrelated variety

Today, production processes are increasingly integrated internationally. International trade has grown dramatically in the last thirty years. International trade in goods increasingly includes intermediate products that are imported by a country to be assembled or processed and then exported (Huber and Nguyen 2017). With the political changes that took place in the former socialist countries, a new economic reality was created in which the economic agents carry out their activity according to the rules of the market economy. Some countries in this economic region have joined the EU. Our study is focused on two of the former socialist countries, namely Romania and Bulgaria, that joined the EU on January 1, 2007.

We aim to assess the extent to which a country's accession to an economic area with a free market has had an effect on increasing the variety of exports of agri-food categories (Guerrieri and Caffarelli 2012). We also aim to assess the impact of changes in the variety of exports of agri-food categories on the dynamics of the volume of exports of agri-food products. We used data from the official statistics of each country which allowed us to assess the volume of export of agri-food products by product categories and considered the 24 product categories according to the statistics nomenclature defined by the European Communities (1987) identified by Combined Nomenclature (CN) codes, and within them by types of agri-food products. This break-

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down of exports ensures the separation of the total variety of exports between the variety resulting from the re-distribution of exports by product categories (related variety) and the variety resulting from the distribution of exports in each category by types of agri-food products (unrelated variety).

Each of the two varieties has a different action over time on the results of an economic system (Pyka et al. 2019). Thus, related variety manifests itself through an immediate effect on the results of the economic system, while unrelated variety generates a persistent long-term effect (Saviotti and Franken 2008a, b). An increase in unrelated variety in the economy is the result of the development of an agri-food processing chain with a large number of economic agents that generate added value following the processing of agri-food raw materials in the country (Pinheiro et al. 2021). The development of the processing network allows the development of competition (intra-sector competition) to the detriment of a monopoly at the level of producers of certain categories of agri-food products (low inter-sector competition) (Saviotti and Pyka 2008; Vermeulen and Pyka 2018).

In an economy where the share of related variety in the total variety of agri-food exports is significant, we are in a situation where the exchange of products and services between economic agents that obtain and export products from different product categories is limited (Mania and Rieber 2019). This situation shows us the existence of dominance in the export of agri-food products of a small number of product categories. The situation is more unpleasant from an economic point of view if these product categories are in the category of agricultural raw materials.

MATERIAL AND METHODS

We used the entropy to measure the variability of exports of agri-food products by categories of agri-food products. We denoted by p_i the weight of the category i of agri-food products in the exports of agri-food products for a year. Thus, to measure the variability of agri-food exports for a year, we computed the entropy, based on the following equation (Shannon and Weaver 1971):

$$H\left(p_1, \ldots, p_n\right) = -\sum_{i=1}^{n} p_i \log(p_i) \quad (1)$$

where: H – entropy; p_1–p_n – weight of the category 1, ..., n of agri-food products in the exports of agri-food products.

The value of entropy increases with the increase in the number of product categories and with the uniformity of the distribution of exports by products. The maximum value of the entropy is reached if the export quotas of the products subject to trade are equal and the value of the entropy is minimal if the concentration of export of agri-food products is maximum, this happens when the total volume of exports of agri-food products is concentrated at the level of a single product. Thus, we can deduce that $H\left(p_1, \ldots, p_n\right) \in \left[0, \log(n)\right]$.

If agri-food products are grouped into categories, the use of entropy allows the breakdown of export variability according to influencing factors manifested at the level of product categories, as well as those that differentiate the volume of exports between categories of agri-food products. Thus, the agri-food products that are the object of the foreign trade activity classified at the level of four digits are divided into 24 categories of products that are indexed with two digits each. The product category is denoted by C_j, j = 1, ..., 24 and each product category comprises a certain number of products that are identified by a four-digit code. The export quota of all products that are included in the product category C_j is $P_j = \sum_{i \in C_j} p_i$, $j = 1, \ldots, 24$.

The entropy determined according to Equation (1) is decomposed as it is shown below if the products are grouped into product categories (Theil 1967, 1972; Andrei et al. 2017):

$$H\left(p_1, \ldots, p_n\right) = H_0\left(P_1, \ldots, P_{24}\right) + \sum_{j=1}^{24} P_j H_j\left(i \in C_j\right) \quad (2)$$

where: $H_0(P_1, \ldots, P_{24})$ – entropy calculated based on the export quotas of the 24 product categories (between set entropy); C_j – product category; P_j – export quota of product category C_j; i – products.

The term $H_0(P_1, \ldots, P_{24})$ from Equation (2) measures the variability of the export of agri-food products between product categories:

$$H_0\left(P_1, \ldots, P_{24}\right) = -\sum_{j=1}^{24} P_j \log\left(P_j\right) \quad (3)$$

This is part of the total entropy due to the differences between the product categories. It is also called unrelated variety in various works (Frenken et al. 2007; Naldi et al. 2020; Zabala-Iturriagagoitia et al. 2020) and quantifies the extent to which exports of agri-food products show a significant diversification by product categories.

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The second term in Equation (2) measures that part of total entropy that is due to those specific factors at the level of product categories (weighted within set entropy). The entropy for each product category is determined based on the relation:

$$H_j\left(i \in C_j\right) = -\sum_{i \in C_j}\left(\frac{p_i}{P_j}\right)\log\left(\frac{p_i}{P_j}\right) \quad (4)$$

Under these conditions, the entropy calculated based on export data at the SH4 aggregation level (four-digit level) allows the decomposition of the export variability of agri-food products into two components: unrelated variety which measures the size of the variability between product categories and related variety which is the component quantifying the variability of products in each product category (Frenken et al. 2007; Aarstad et al. 2016).

We used data on exports of agri-food products for Romania and Bulgaria to calculate the terms that appear in Equation (2). The volume of exports corresponds to the products from the SH4 classification, and we used data from 2000 to 2020. The available data allow the analysis of the variability of exports of agri-food products and its separation into the two components, related variety and unrelated variety, to highlight the degree to which the volume of the exports of the agri-food industry focuses on a small number of product categories. The results obtained for each year regarding the related and unrelated variety will be used to estimate the parameters of the econometric model that aims to highlight the extent to which the variability of exports by product categories allows competitive advantages in the short or long term.

We will consider the following hypotheses to build the econometric model.

H_1: The related variety is that component of the total variability determined by those factors that aim at the behavior of the economic agents that produce and/or export the products at the level of the agri-food product categories. Its high share in total variability as well as its increase over time leads to an increase in exports of agri-food products in the short term.

H_2: The effect of increasing the related variety over time is not particularly beneficial in view of the contribution made by the categories of products consisting of agricultural raw materials.

H_3: The unrelated variety is that part of the total variability which results from the differences which exist in the distribution of the export of agri-food products by product category.

H_4: The effect of increasing the unrelated variety over time is to increase the export of agri-food products over a long period of time.

We define the following regression model to assess to what extent the dynamics of the export of agri-food products (*Exp*) from one year to another are influenced by the variety of exports between product categories (*URV*), the variety of exports of products within product categories (*RV*), the dynamics of the economy measured by the GDP and the effect of the country's accession to the EU in 2007 (*VB*):

$$\log\left(\frac{Exp_t}{Exp_{t-1}}\right) = a + bURV_{t-h} + cRV_{t-h} + \\ + \log\left(\frac{GDP_{t-k}}{GDP_{t-k-1}}\right) + VB\left(2007\right)_t + \varepsilon_t \quad (5)$$

where: h, k – natural numbers that will be determined according to the influence exerted by the three explanatory variables in the regression model on the export of agri-food products; $VB(2007)_t$ – dummy variable that has the value 0 for 2000–2006 and 1 for 2007–2020; RV – variety of exports of products within product categories; a, b, c – parameters of the regression model; GDP – gross domestic product; ε_t – residual variable

For each product category, the entropy at the product category level is determined based on Equation (1). If there is a different number of products in each product category, the entropy of each product category will record values that are in the range: $H_j\left(p_1, \ldots, p_{n_j}\right) \in \left[0, \log\left(n_j\right)\right]$. For an analysis of the distribution of the entropy values of the product categories, considering the previous observation, it is necessary to normalize the values so that the entropies of the categories are evaluated on the same measurement scale. We denote by n_j the number of products included in a product category and the normalized entropy at the category level is calculated based on the relation given by Equation (6):

$$NH_j\left(p_1, \ldots, p_{n_j}\right) = \frac{\log\left(n_j\right) - H_j\left(p_1, \ldots, p_{n_j}\right)}{\log\left(n_j\right)} \in \left[0, 1\right] \quad (6)$$

where: NH_j – normalized entropy at the category level; n_j – number of products included in a product category.

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In the case of normalized entropy, the closer the value of the indicator is to 0, the lower the degree of concentration, and obviously the higher the value of the indicator, the higher the concentration.

RESULTS AND DISCUSSION

Using Equation (6) we computed the values of the indicator for all 24 categories of agri-food products and, subsequently, the characteristics of the distributions of the values of the normalized entropy are determined for each year from 2000 to 2020. For 2000, 2006, 2007, 2010, 2015, and 2020 we also computed the indicators that are used to characterize the distribution of normalized entropies at the level of product categories for Romania and Bulgaria and the results are presented in Table 1.

Figure 1 shows the annual values of the medians calculated for the normalized entropies at the level of product categories, for Romania and Bulgaria, for the period 2000–2020. These results show that the diversification of exports at the level of product categories increased more in the case of Romania than in that of Bulgaria during the analyzed period.

Another important aspect in assessing the entropy of the distribution of agri-food exports is its breakdown according to the contribution of each of the two categories of factors: in the first are those that determine the specialization of exports for certain categories of products and the second category of factors determines a certain concentration of exports of each category on products that are part of it (Dell'Agostino and Nenci 2018).

We determined between set entropy for the two countries using Equation (3) and the results are presented in Figure 2. The results show a degree of concentration of exports by product categories much higher in the case of Romania than in the case of Bulgaria. Moreover, with the accession to the EU, one can easily observe that Romania has continuously increased its concentration of agri-food exports on a limited

Table 1. Statistics of entropy for Romania and Bulgaria: 2000, 2006, 2007, 2010, 2015, and 2020

Statistics	Romania						Bulgaria					
	2000	2006	2007	2010	2015	2020	2000	2006	2007	2010	2015	2020
Median	0.54	0.54	0.51	0.50	0.44	0.41	0.55	0.60	0.49	0.43	0.53	0.52
SD	0.18	0.20	0.17	0.19	0.21	0.19	0.21	0.17	0.96	0.19	0.20	0.21
Skewness	0.27	0.15	0.48	0.23	0.71	0.78	–0.48	0.31	0.26	0.56	0.08	–0.12
Kurtosis	2.67	2.71	3.21	2.40	2.92	3.67	2.64	2.48	0.17	2.21	2.25	1.81
Jarque-Bera	0.39	0.17	0.95	0.58	1.99	2.85	1.04	0.66	1.01	1.89	0.60	1.48
Probability	0.82	0.92	0.62	0.75	0.37	0.24	0.59	0.72	3.89	0.39	0.74	0.48

Source: Author's own computations

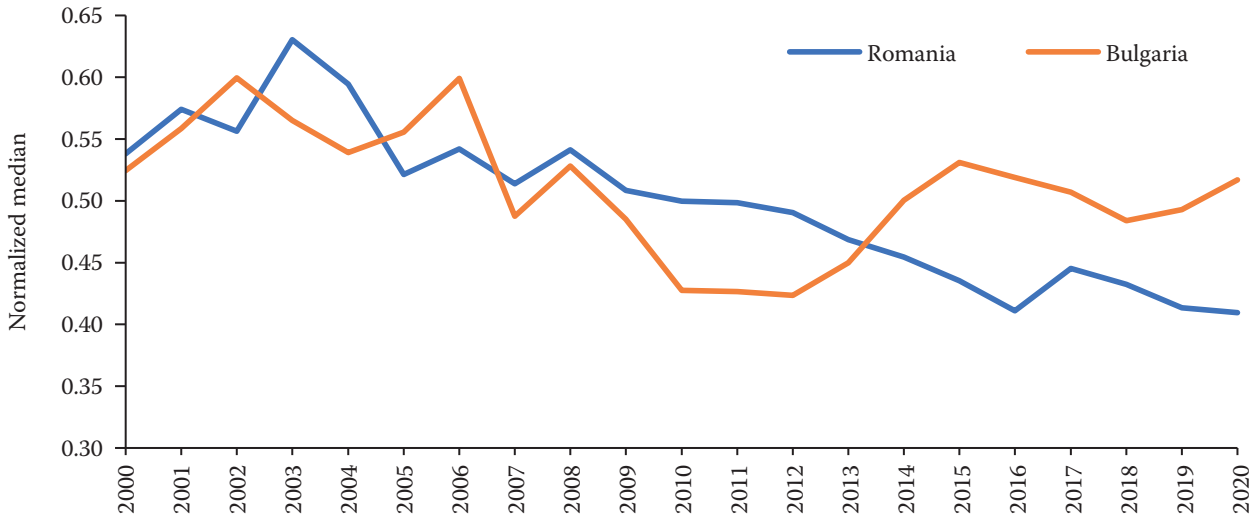

Figure 1. The normalized median of the entropy for Romania and Bulgaria

Source: Author's own computations

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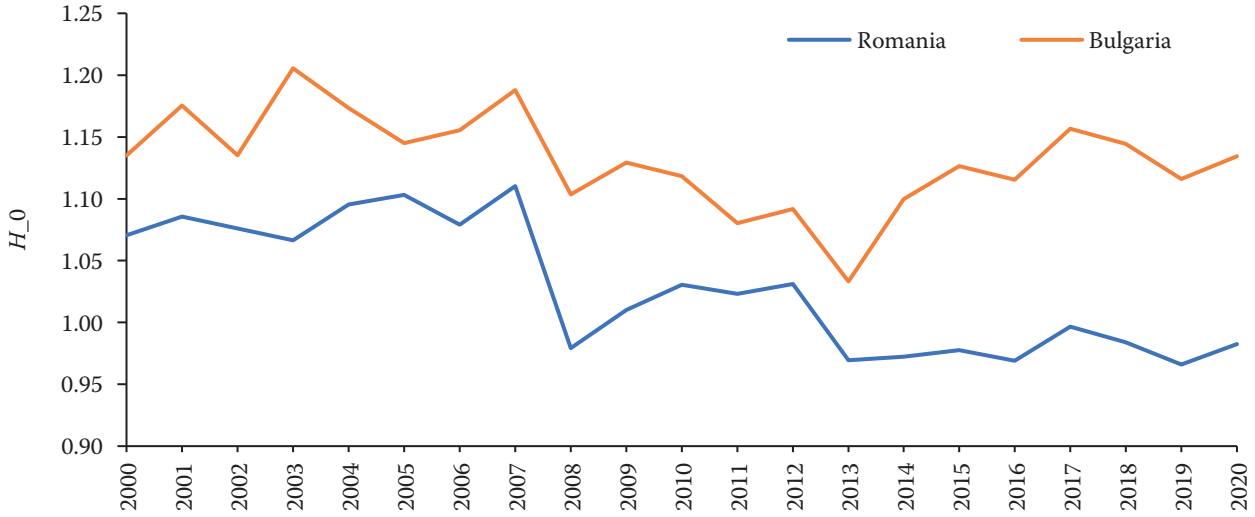

Figure 2. Between set entropy for Romania and Bulgaria (*H*_0)

Source: Author's own computations

number of categories of agri-food products. In the pre-accession period, Bulgaria has a much greater diversification of product exports by product category than in the case of Romania. In Bulgaria, between 2007 and 2013, we noted an increase in the concentration of exports to certain product categories, but since 2014 there has been a decrease in the degree of concentration of exports by product category.

The evaluation of the entropy of the distribution of agri-food exports is made based on primary data on product exports and by Equation (2) by summing up the two terms that express within set entropy and between set entropy. Figure 3 shows the entropy values of the distribution of agri-food exports that are calculated for the two countries for each year from 2000 to 2020. The results show that the level of concentration of exports on agri-food products is much higher in the case of Romania than in the case of Bulgaria throughout the period for which this analysis is performed. Moreover, in the case of Romania, 2007 marked the beginning of a period in which there is a significant increase in the degree of concentration of exports on a small number of categories of agri-food products. In contrast, Bulgaria, after a slight increase in the concentration of exports of certain agri-food products in the first years after EU accession, starting with 2017 has again seen a diversification

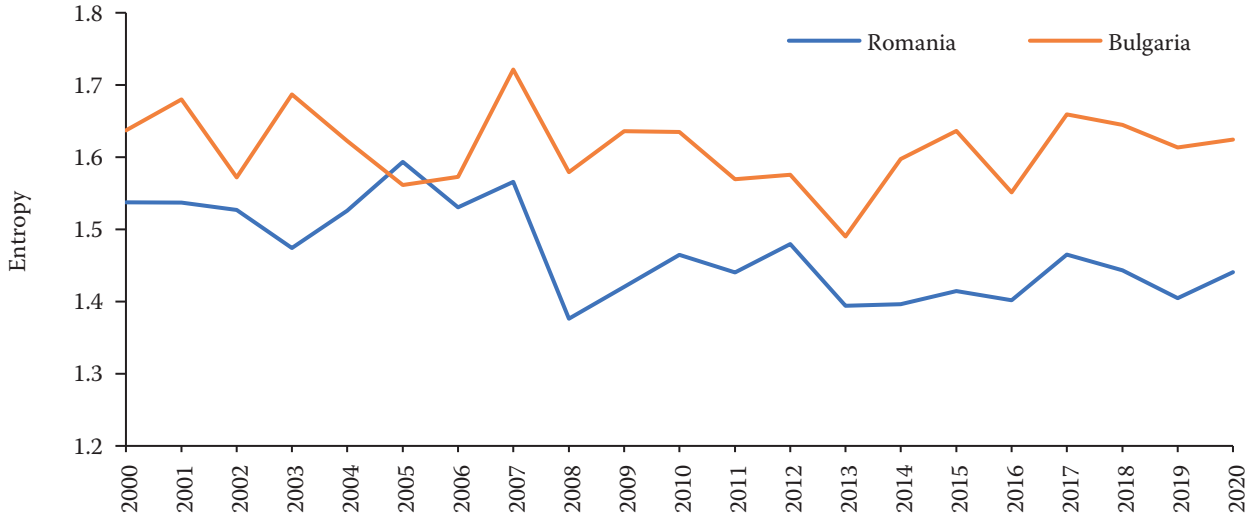

Figure 3. The entropy for Romania and Bulgaria

Source: Author's own computations

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of agri-food exports. Looking at the share of entropy due to the concentration of exports by product categories (the share of between set entropy in total entropy) in the entropy of the distribution of exports by agri-food products, we find that for both countries it is all higher than 65% which means a high degree of concentration of exports on certain categories of products.

Concentration of exports by product categories in the pre- and post-accession periods. In the following, we will analyze to what extent there are significant differences between the concentration of agri-food exports at the level of the two countries between the pre- and post-accession periods. In this sense, we calculated the volume of exports from the pre-accession, post--accession period and for the whole period 2000–2020 for the products and categories of products that are the object of the export activity by cumulating the annual values from each period considered. For these data series, we calculated the three terms that appear in Equation (2) and the results are presented in Table 2.

They allow the following comments. Firstly, we find that the degree of concentration of exports in agri--food products is higher for Romania than for Bulgaria, during both the pre-accession and the post-accession periods. With the accession to the EU, the degree of concentration of exports increased in the case of Romania and remained relatively constant for Bulgaria. In the case of Romania, the degree of concentration is higher and the variability of entropy is more accentuated, as Romania's exports of agri-food products are dependent during the entire period on three important categories of products (cereals, seeds, and live animals), while in the case of Bulgaria this dependence is much lower. In fact, Romania registered a trade surplus from the trade in agri-food products only in two years, 2013 and 2014, when the agricultural productions for the two vegetable products, respectively their exports, were quite exceptionally high.

Secondly, we find that in the case of Romania there is an increase in the degree of concentration of exports, both by increasing the concentration of exports by product categories (there is a specialization in exports of products from certain categories of agri-food products), but also by increasing the degree of concentration of exports of some products at the level of product categories (for certain product categories there is an increase in the share of exports of some products in the export volume of the respective product category). In the case of Bulgaria, on the other hand, during the post-accession period, there is an increase in the diversity of exports of agri-food products by product category and a moderate increase in specialization by product category. The results are obvious from a practical point of view, taking into account the fact that Romania's exports are dependent on unprocessed agri-food products, while in Bulgaria's exports we find products that have a certain degree of processing. By tradition, Romania is one of the important producers in Europe of products such as corn, sunflower, and wheat, and changing the structure of vegetable production in a short period of time is much more difficult to achieve (Axenciuc 2019). On the other hand, Bulgaria having a more important share of the processed products in the export structure, through the access to a free market has allowed the modernization of some production capacities in the agri-food field. The innovation process is a complex process that depends on national and regional factors, the level of development of the industry and the competitive advantage in the production of a category of products (Fritsch et al. 2019).

Next, using the data series of normalized entropies calculated at the product category level based on pre- and post-accession export data, we analyzed to what extent there is a dependence between these data series. In this sense, we define a regression model that explains the normalized entropy calculated at the level of product categories based on exports in the post--accession period [NH_j(2007_2020)] depending on the normalized entropy at the level of product catego-

Table 2. Total entropy and the two components calculated in the case of Romania and Bulgaria for various periods of time

Entropy category	Romania			Bulgaria		
	2000–2006	2007–2020	2000–2020	2000–2006	2007–2020	2000–2020
H_prim	0.491	0.466	0.477	0.476	0.525	0.535
H_zero	1.103	0.997	1.012	1.170	1.127	1.136
H_total	1.593	1.463	1.490	1.647	1.651	1.671

H_prim – related variety; *H_zero* – unrelated variety; *H_total* – total entropy

Source: Author's own computations

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ries based on exports from the pre-accession period [NH_j(2000_2006)] [Equation (7)].

In the regression model [Equation (7)], VB_j is a dummy variable that has the value 1 if the product category has a surplus in the post-accession period and zero otherwise and ε_j is the residual variable. The estimations of the parameters of the regression model for the two countries are presented in Table 3. The standard deviation of the estimator is given inside parentheses.

The results obtained after estimating the parameters of the Equation (7) show a significant influence on the increase of the concentration of exports in the case of Romania for the product categories that registered a surplus in the trade balance during the post-accession period. In the case of Bulgaria, the parameter corresponding to the dummy variable does not differ significantly from zero, which shows that EU accession did not lead to an increase in the concentration of exports for the group of product categories that generated a surplus in the post-accession period. In fact, while Bulgaria had 11 categories out of the 24 categories of products that registered a trade surplus, their number in the case of Romania was only 3. In the post-accession period, Bulgaria registered a surplus for 12 product categories, while their number in the case of Romania was only 5.

Results. We estimated the parameters of the regression model [Equation (5)] for the two countries using data from 2000 to 2020 and the results are presented in Table 4. We noticed that for both countries the positive evolution of the economy measured by the growth rate of the GDP determines an increase in the export of agri-food products and there is a two-year gap between GDP growth and the direct impact on the volume of agri-food exports.

In the case of Romania, the increase in the degree of concentration of agri-food exports determines a decrease in agri-food exports in the long run (the estimator corresponding to the variable RV_{t-1} is negative). In the case of Bulgaria, the increase in the degree of diversification of agri-food exports leads to a significant increase in agri-food exports. We can say that Bulgaria benefits from the advantage of diversifying the export of agri-food products that are produced in related sectors of activity. Instead, unrelated variety in both cases shows a positive effect on the volume of exports of agri-food products.

The results presented in Table 4 confirm the positive dependence of agri-food exports on the positive developments in the economy which are assessed in this case by GDP growth rates. We obtained a positive estimator for the parameter corresponding to the variable $\log(GDP_{t-k}/GDP_{t-k-1})$ in the regression model estimated for each of the two countries. These results show us a gap of two years between the changes in the economy assessed by the GDP growth rate and the changes in the volume of exports of agri-food products which are assessed by the growth rate of agri-food exports for both countries. The effect of the growth of the economy on the increase in the volume of exports of agri-food products is much greater in the case of Bulgaria than in the case of Romania.

$$\log\left[NH_j\left(2007\_2020\right)\right] = b + a\log\left[NH_j\left(2000\_2006\right)\right] + cVB_j + \varepsilon_j \tag{7}$$

where: VB_j – dummy variable that has the value 1 if the product category has a surplus in the post-accession period and 0 otherwise; NH_j(2007_2020), NH_j(2000_2006) – normalized entropy at the category level for 2007–2020 and 2000–2006 periods.

Table 3. Characteristics of the regression model [Equation (7)] for Romania and Bulgaria (n = 24)

	Romania	Bulgaria	
		with dummy variable	without dummy variable
log[NH_j(2000_2006)]	0.372** (0.182)	0.571* (0.275)	0.657* (0.275)
VB_j	0.419** (0.235)	0.275 (0.191)	–
constant	–0.704* (0.184)	–0.574* (0.215)	–0.438* (0.198)
R^2	0.18	0.28	0.20

*, **α < 0.05 and α < 0.1, respectively; NH_j(2000_2006) – normalized entropy at the category level for 2000–2006 period; VB_j – dummy variable that has the value 1 if the product category has a surplus in the post-accession period and 0 otherwise; standard deviations (SD) in parentheses

Source: Author's own computations

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Table 4. Estimations for the regression model [Equation (5)] (n = 18)

	Romania	Bulgaria
URV_{t-1}	0.707* (0.2256)	0.675* (0.3204)
RV_{t-1}	–0.700* (0.3194)	1.770* (0.6712)
$\log\left(\frac{GDP_{t-2}}{GDP_{t-3}}\right)$	0.466* (0.1140)	0.871* (0.4931)
$VB(2007)_t$	0.215* (0.0342)	–
constant	0.370* (0.1939)	0.330* (0.2524)
R^2	0.91	0.61
DW	1.89	1.82

*$\alpha < 0.05$; URV_{t-1} – unrelated variety; RV_{t-1} – related variety; $VB(2007)_t$ – dummy variable that has the value 1 if the product category has a surplus in the post-accession period and 0 otherwise; DW – Durbin-Watson statistics; GDP – gross domestic product; standard deviations (SD) in parentheses
Source: Author's own computations

The estimator of the parameter corresponding to the dummy variable from the regression model used to identify the effect of the country's accession to the EU [$VB(2007)_t$] differs significantly from zero and is positive for Romania, which points out that the country's accession to the EU has had a positive effect on increasing exports of agri-food products. In the case of Bulgaria, this variable is not included in the regression model as estimating the model with this variable does not allow a significant estimator to be obtained for the parameter corresponding to this variable.

CONCLUSION

The results obtained for the two countries confirm the important role played by related variety in increasing a country's long-term exports of agri-food products. The results obtained above show that in the case of Romania the high concentration of exports on a small number of categories of agri-food products that include mostly agricultural raw materials cannot ensure a sustainable increase in the export of agri-food products. The situation is much more favorable in the case of Bulgaria, where the related variety has a positive impact on ensuring a sustainable increase in agri-food exports. In the case of both countries, the unrelated variety is an important factor in increasing exports of agri-food products in the short term which is in line with other studies (ul Haq and Zhu 2019).

In the case of Romania, the accession to the EU was an important factor for the increase of the exported agri-food goods, both in the EU market and especially in the extra-EU market. In the case of Bulgaria, the accession to the EU in 2007 did not mark a positive or negative shock on the volume of exports of agri-food products, which were on the same upward trend in the post-accession period.

The diversification of exported agri-food production categories can only be a consequence of important changes in the production processes in each country (Hidalgo et al. 2007). An increase in the variety of product categories subject to export activity can be obtained only to the extent that the process of producing goods for export includes a large number of economic agents (Hummels et al. 2001).

As a future direction of research, we intend to add new variables into the analysis model of export dynamics of agri-food products to capture those factors that have a direct impact on increasing the exchange of agri-food products that are processed in production capacities at a national level. Equally, both on the analysis model presented in this paper, but also on the one improved by adding new variables, the research will be extended to other countries in the region, such as the Czech Republic, Poland, or Hungary.

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