“Production and trade patterns in the world apple market”

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PRODUCTION AND TRADE PATTERNS IN THE WORLD APPLE MARKET

Abstract

Awareness of healthy food, population growth, increasing incomes, and urbanization raise the global demand for fruit, where the second position goes to apples. However, their supply is insufficient, implying the lost revenues and exacerbating nutritional food insecurity. To help growers, traders, and consumers cope with such a challenge, this research focused on revealing some world patterns in apple production and trade detailed by groups of countries, their capacities, and prices. The explored data on fresh and processed apples derived from the Food and Agriculture Organization Statistics. The methodological framework of the study engaged divisive hierarchical clustering, analysis of interval variation series, and inequality indicators. The research findings identified two major clusters of 50 out of 96 countries specialized in production and foreign sales of 83.2% and 76.9% of apples. The study outcome comparing fair trade via two triple histograms specified the prevailing deviations between –82% and 80% around farm gate apple prices in 47 exporting countries and the same between –83% and 83% in 46 importing countries. Based on the Gini coefficient, Ratio 20/20, and Hoover index, the accomplished evaluations quantified total disparity in apple trading by 13% to 40%, calculated misbalance between 20% of the top and bottom world traders, and grounded preferable market alignments ranged from 9% to 38%.

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INTRODUCTION

A rational and nutritious diet is a prerequisite for human health support. Agriculture is a core provider of nutritional food. More and more consumers become aware that food must be safe and provide sufficient calories and supply vitally important elements like protein, vitamins, and minerals. Causes of these shifts can be linked to socio-demographic and economic drivers such as globalization, urbanization, promotion of healthy lifestyle, increases in disposable income, improved marketing, and advanced food supply chains (Kearney, 2010; Knorr, Kho, & Augustin, 2018).

Concerning the supply of fruits, apples with the production of 86 million tons were ranked second after bananas with the production of 115 million tons in 2018. Simultaneously, the third and fourth most popular fruits were grapes and oranges, with 79 and 75 million tons of harvest (FAOStat, 2020). Standing temperature between –30 and +30-40 degrees Celsius, apples are grown in 96 countries for their domestic markets and export. Since 2000, apple production showed an accelerated increase by 51.1%, which is consistent with an increment of the urban world population by 50.3%, while the total population grew at a much slower rate of 25.8% (WB, 2019).

Concerning the demand for fruits, it is expected that their world average daily consumption will grow from 204 to 242 g per capita by 2025

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and 2050. The respective figures for the developing countries are 172 and 213 g of daily fruit intake in contrast to 336 and 388 g of consumed fruit per capita in the industrial countries for 2025 to 2050 (Kearney, 2010). Besides their flavoring and nutritional qualities, apples have strong benefits of being less perishable than most other fruits, they can be stored fresh for up to 12 months, and they are good transportable hard fruit. Given the ongoing COVID-19 pandemic, apples are also valued for being easily washed and optionally peeled (WHO, 2020). As the saying goes, "An apple a day keeps the doctor away".

So far, apples appear to be a beneficial product in the agricultural and food markets. Simultaneously, it manifests the emerging social and economic issue to produce and trade enough apples for providing nutritional food security. This point became the scientific focus of this paper.

1. LITERATURE REVIEW

Numerous pieces of literature examined the global production and trade of fruit, where scholars approached the various issues of horticultural production and demand.

For example, Siegel, Ali, Srinivasiah, Nugent, and Narayan (2014) showed a shortage of fruit proposition to satisfy the global health need of recommended daily servings. To tackle production's economic efficiency, Parajuli, Thoma, and Matlock (2019) focused on climate change scenarios, which could affect fruit yields and quality "in the context of elevated global temperature and carbon dioxide level, ozone depletion and changes in precipitation patterns" (p. 2863). Manfrini, Zibordi, Pierpaoli, Losciale, Morandi, and Grappadelli (2019) dealt with precise apple fruit growing techniques in operating orchards to link their profitability and resource inputs. Net present value, internal rate of return, and the payback period of apple orchard investments were discussed and evaluated by Badiu, Arion, Muresan, Lile, and Mitre (2015).

To meet customers' demands and requirements, Kohls, Uhl, and Hurt (2014) explored agricultural marketing tools, including sales promotion, pricing, and advertising. To face consumers' expectations, Bonany, Brugger, Buehler, Carbo et al. (2014) constructed a preference map of apple varieties, which is of practical use of marketers and breeders. Similarly, Wlodarska, Pawlak-Lemanska, Gorecki, and Sikorska (2016) studied a relationship between intrinsic apple juice characteristics and buyers' perception of its quality. Rekhy and McConchie (2014) delved into segmented marketing strategies based on demographic variables of gender, education, age, and income to encourage fruit consumption. Sonntag, Theuvsen, Kersting, and Otte (2016) examined the safety and quality regulations in international fruit trade concerning differences in phytosanitary and maximum residue levels of pesticides and sorting, grading, and external appearance constraints. The US Department of Agriculture and the European Commission regularly monitors global fruit markets, covering apple consumption, production, prices, stocks, and trade (EC, 2019; USDA, 2020). Mostly, these reports analyze just major countries acting in the apple market. However, a more complete picture of the global quantities and values of produced and traded apples can help to develop, improve, and adjust apple growers, suppliers, and customers. As it is said, "He who owns the information, he owns the world".

The Covid-19 pandemic brought a new global challenge to providing food security. For such reason, the Food and Agriculture Organization of the United Nations established the FAO Big Data tool to monitor food prices since February 2020. In particular, apples are among 14 basic products included into daily surveys (FAODataLab, 2021). Forecasting food and agricultural prices is a complicated scientific task with regard to the local features (Vasylieva, 2013) and nutritional values for healthy diets (Jones & Monsivais, 2016). It correlates with a wide range of apple price fluctuations between -8.9% and 91.6% observed in 164 countries by January 2021 (FAODataLab, 2021). In total, the global apple price increased by 11.4% that surpassed the growth in the world average consumer price equaled 3.2% for 2020 (IMF, 2021). Ridley and Devadoss (2020) interpreted these trends as indicators of insufficient apple growing and harvesting coupled with inflexible trade. In the same vein, Richards and Rickard (2020) concluded on mitigating the Covid-19 consequences through the shared production and trade patterns in the world fruit markets.

2. AIMS AND HYPOTHESIS

The research goal was to find some world patterns in apple production and trade detailed by groups of countries, their capacities, and prices.

The relevant research hypothesis concerned the existence of specific global patterns in producing and trading fresh and processed apples.

To reach the study objective and verify the explored hypothesis, this research reduced to solving three tasks:

1) to distribute countries that grow apples into clusters comparing their ranks in respective production, export, and import;

2) to assess patterns of pricing in the apple market by comparing deviations between farm gate, export, and import prices;

3) to identify the pattern in evaluating inequality in the world export and import markets for fresh and processed apples.

3. RESEARCH METHODS

The data to task 1 were ranks of countries engaged in production (*RankP*), export (*RankE*), and import (*RankI*) in the world apple market. The methodological basis to task 1 was the divisive hierarchical clustering (Kaufman & Rousseeuw, 2005). This procedure enabled us to create a structure of a binary tree unfolded by three conditional splits over the described ranks, namely:

- first split was subject to $RankP \leq RankE$ versus $RankP > RankE$;
- second split was under condition of $RankP \leq RankI$ versus $RankP > RankI$;
- third split was subject to $RankE \leq RankI$ versus $RankE > RankI$.

According to the transitive property of inequality:

- if $RankP > RankE > Rank$, then always $RankP > RankI$;
- if $RankP \leq RankE \leq RankI$, then always $RankP \leq RankI$.

The process entailed generating a pruned tree of $2^3 - 2 = 6$ clusters intended to visualize combining countries with common specific pattern in the apple market. For convenience, each cluster was marked by signs of the relevant conditions from the first (top) to the third (down) split (as shown in Figure 1).

Source: Composed by the authors.

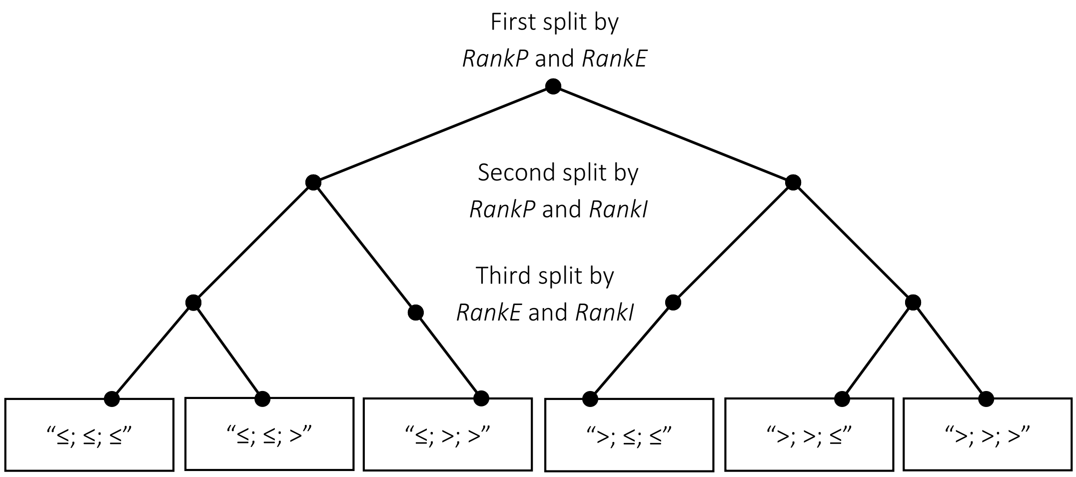

Figure 1. Pruned tree of divisive hierarchical clustering

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The theoretical foundations to task 2 were the basics of agricultural pricing and data analysis of interval variation series visualized with histograms (Norwood & Lusk, 2007; Scott, 2015). The latter were utilized over relative deviations (in %) between apple producers' farm gate prices and export (ΔPE_n) or import (ΔPI_n) prices for apples in N_E or N_I countries, respectively. The numbers of bins in production-export and production-import histograms were determined by Sturge's equations as follows:

$$K_E = \lceil 1 + \log_2 N_E \rceil, \tag{1}$$

$$K_I = \lceil 1 + \log_2 N_I \rceil. \tag{2}$$

Sizes of bin intervals were defined as follows:

$$B_E = \left(\underset{n=1..N_E}{Max}\, \Delta PE_n - \underset{n=1..N_E}{Min}\, \Delta PE_n \right) \Big/ K_E, \tag{3}$$

$$B_I = \left(\underset{n=1..N_I}{Max}\, \Delta PI_n - \underset{n=1..N_I}{Min}\, \Delta PI_n \right) \Big/ K_I. \tag{4}$$

Patterns of pricing in every bin obtained a triple assessment via:

- the number of countries distributed into this group;
- the world share of apple quantity produced by the countries from this bin;
- the world share of apple quantity exported or imported by the countries in this group.

In such a way, the offered histograms allowed unfolding patterns of price protection and competitiveness in the world apple market.

Within the methodological framework to task 3, the selected indicators of inequality were the Gini coefficient, Ratio 20/20, and Hoover index (McGregor, Smith, & Wills, 2019). The appropriate calculations were arranged as follows. The considered M countries were sorted in order of increasing export or import prices. V_i and Q_i denoted unit shares of the value and quantity associated with country i in the analyzed market. For the calculation purpose, let us put $V_0 = 0$ and $Q_0 = 0$. Then, the accumulated unit shares of the respective value and quantity looked like

$$AV_i = \sum_{j=0}^{i} V_i, \; AQ_i = \sum_{j=0}^{i} Q_i, \; i = 0 \ldots M.$$

Therefore, the Gini coefficient (GC) and Hoover index (HI) were determined by the equations

$$GC = 1 - \sum_{i=1}^{M} \left(AV_i + AV_{i-1} \right) \cdot Q_i, \tag{5}$$

$$HI = Max_{i=1..M} \left(AQ_i - AV_i \right). \tag{6}$$

The Ratio 20/20 $(R20/20)$ illuminated the imparity between 20% of bottom (AVB) and top (AVT) values of exported and imported fresh and processed apples. The supplementary indices of IT and IB were subject to

$$IB \in \{1, \ldots, M\} : AQ_{IB-1} < 0.2 \le AQ_{IB},$$

$$IT \in \{1, \ldots, M\} : AQ_{IT-1} < 0.8 \le AQ_{IT}.$$

Then, AVB and AVT equaled

$$AVB = \frac{1}{AQ_{IB} - AQ_{IB-1}} \times \left(AV_{IB-1} \cdot AQ_{IB} - \right.$$
$$\left. - AV_{IB} \cdot AQ_{IB-1} + 0.2 \cdot \left(AV_{IB} - AV_{IB-1} \right) \right),$$

$$AVT = 1 - \frac{1}{AQ_{IT} - AQ_{IT-1}} \times \left(AV_{IT-1} \cdot AQ_{IT} - \right.$$
$$\left. - AV_{IT} \cdot AQ_{IT-1} + 0.8 \cdot \left(AV_{IT} - AV_{IT-1} \right) \right)$$

At last, it resulted in the final equation of the Ratio 20/20:

$$R20/20 = AVT / AVB. \tag{7}$$

As a whole, the inequality indicators were used to assess the patterns on the total measure of misbalance and the mismatch between top 20% and bottom 20% of exporters and importers, as well as evaluate necessary transformation for mitigating disproportions between quantities and values in the explored markets of fresh and processed apples.

4. RESULTS

The calculations on task 1 were obtained using data from FAOStat (2020). The first indicator *RankP* ranked quantities of apple production in 96 countries as of 2019. The *RankE* combined export values of fresh apples, as well as of concentrated and single strength juices. These exports were ranked among 129 countries, which sell the goods mentioned above. The world export share of the apple producers accounted for 98.3% in total. The indicator *RankI* combined import values of fresh apples and concentrated and single strength juices. These imports were ranked among 203 countries that buy the named goods. Overall, the apple producers' world import share amounted to 78.1%.

Given the number of countries and the combined shares, the divisive hierarchical clustering analysis revealed two major and four minor patterns in the world apple market. Their relative characteristics are reported in Table 1.

Table 1. Clusters characteristics in the world apple market

Source: Calculated by the authors.

Cluster	Number of countries	Combined share of		
		production, %	export, %	import, %
"≤; ≤; ≤"	28	71.8	44.6	10.6
"≤; ≤; >"	11	5.7	0.5	6.1
"≤; >; >"	14	4.9	0.6	21.1
">; ≤; ≤"	22	11.4	32.3	4.4
">; >; ≤"	9	3.5	10.3	8.1
">; >; >"	12	2.7	10	27.8

The available data about prices to task 2 encompassed 63 countries producing 89% and exporting 96.4% of fresh apples (FAOStat, 2020). According to equations (1) and (3), the constructed histogram consisted of $K_E = 7$ bins with sizes equaled $B_E = 80.9\%$. The resulted triple histogram was depicted in Figure 2.

The available data about prices for the second histogram enveloped 69 countries producing 88.4% and importing 56.3% of fresh apples (FAOStat, 2020). According to equations (2) and (4), the constructed histogram comprised $K_I = 8$ bins with sizes equaled $B_I = 82.9\%$. The resulted triple histogram was disclosed in Figure 3.

Xu (2015) substantiated agricultural trade costs and productivity variations to be the crucial impediments affecting agricultural exports and imports. The research results to task 3 confirmed this inevitable inequality in the world apple market. As of 2019, the relevant indicators found via equations (5)-(7) were assembled in Table 2.

5. DISCUSSION

The areas for discussing the paper findings derived from Table 1 are as follows.

The major cluster of "≤; ≤; ≤" assembled Albania, Algeria, Armenia, Australia, Bhutan, Bosnia

Source: Developed by the authors.

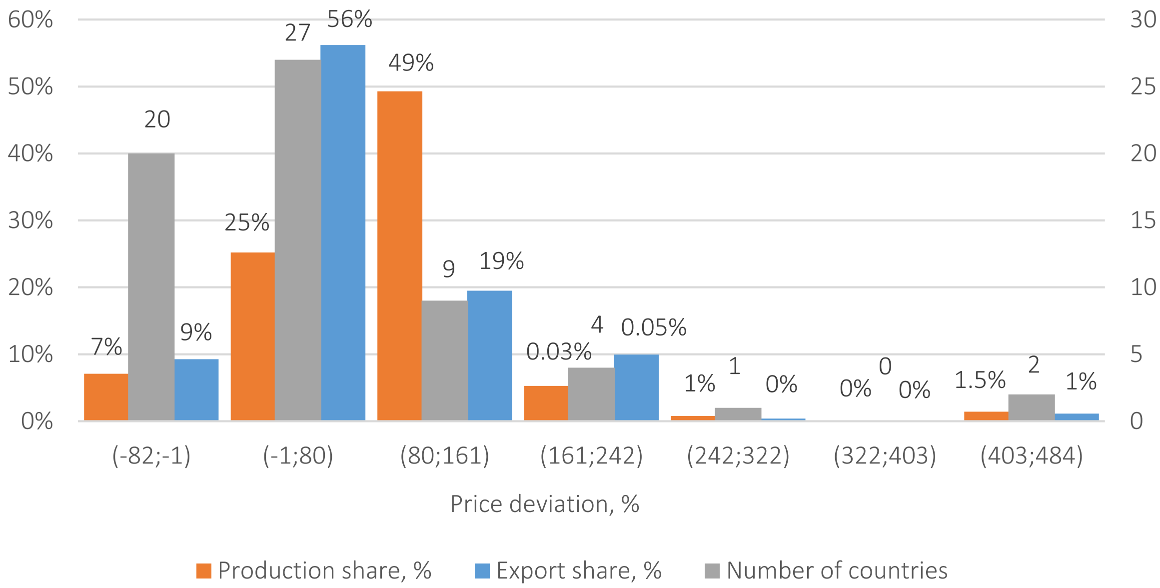

Figure 2. Histogram on deviations between production and export prices for apples

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Source: Developed by the authors.

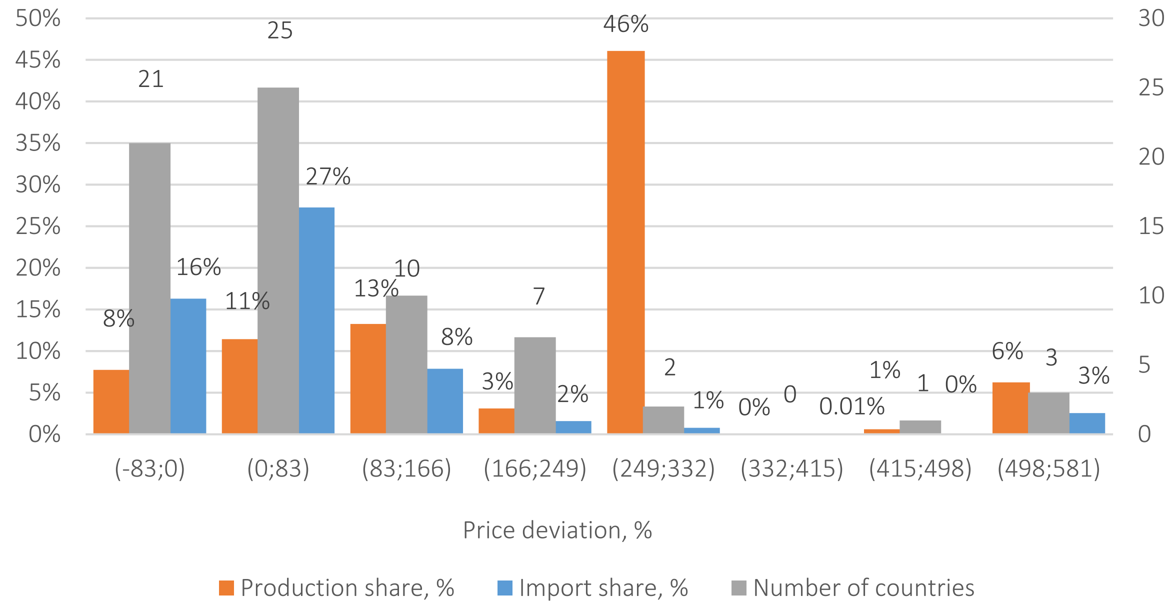

Figure 3. Histogram on deviations between production and import prices for apples

Table 2. Inequality in the world apple market

Source: Calculated by the authors.

Market	Number of countries	Value, USD billion	Quantity, million tons	Gini coefficient	Ratio 20/20	Hoover index
Export of fresh apples	105	7.73	8.36	0.23	3.59	0.17
Import of fresh apples	197	8.45	8.39	0.21	3.09	0.14
Export of apple juice, concentrated	104	1.27	0.92	0.13	2.1	0.09
Import of apple juice, concentrated	185	1.79	3.02	0.4	5.64	0.38
Export of apple juice, single strength	93	1.28	1.47	0.16	2.23	0.13
Import of apple juice, single strength	186	0.85	1.02	0.17	2.12	0.14

and Herzegovina, Brazil, China, Grenada, Iran, Kyrgyzstan, Madagascar, Malawi, Moldova, Morocco, Pakistan, Poland, Reunion, Saint Vincent and the Grenadines, South Korea, Tajikistan, Tunisia, Turkey, Ukraine, the USA, Uruguay, Uzbekistan, and Zimbabwe. Their pattern feature was a strong production in favor of the domestic markets. In compliance with findings by Ahmadi, Ghalhari, and Baaghideh (2019), Anesbury, Greenacre, Wilson, and Huang (2018), A. Kuden, A. B. Kuden, Imrak, and Sarier (2019), Wang, Wolf, and Zhang (2016), Zurawicz, Kubik, Lewandowski, Rutkowski, and Zmarlicki (2019), this cluster incorporated China, the USA, Poland, Turkey, and Iran, which were the top 5 growers of apples. Their experiences and practices may be conveyed to other cluster members, such as Ukraine, where fruit consumption is below the recommended healthy intake (Vasylieva, 2019).

The major cluster of ">; ≤; ≤" aggregated Afghanistan, Argentina, Azerbaijan, Bulgaria, Chile, Croatia, Cyprus, El Salvador, Georgia, Greece, Hungary, Italy, Japan, Latvia, Lebanon, Lithuania, New Zealand, North Macedonia, Portugal, Serbia, South Africa, and Syria. Their pattern feature was a strong export, especially practiced by Italy, Chile, New Zealand, and South Africa ranked third, fifth, seventh, and ninth prime sellers in the world apple markets (Dobbs & Rowling, 2006; EC, 2019; Meyer & Breitenbach, 2004; Retamales & Sepulveda, 2011).

The minor cluster of "≤; ≤; >" contained Belarus, Estonia, India, Malta, Montenegro, North Korea, Paraguay, Peru, Romania, Switzerland, and Turkmenistan. Their pattern feature was an essential import necessary to complement a large but insufficient domestic apple proposition. Notably, such a market profile was typical of India, which appeared to be the seventh and eighth apple world producer and importer (Negi & Anand, 2014).

The minor cluster of "≤; >; >" included Bolivia, Ecuador, Egypt, Iraq, Israel, Jordan, Kazakhstan, Libya, Mexico, Norway, Palestine, Russia, the United Kingdom, and Yemen. Their pattern feature was a strong import with a negligible export witnessed in the United Kingdom and Russia ranked third and fourth among the world apple importers (FAOStat, 2020).

The minor cluster of ">; >; ≤" involved Austria, the Czech Republic, France, Guatemala, Honduras, Luxembourg, Slovakia, Slovenia, and Spain. Their pattern feature was a weak apple production compensated by import and partly redirected to export.

Finally, the minor cluster of ">; >; >" incorporated Belgium, Canada, Colombia, Denmark, Finland, Germany, Ireland, Kenya, Nepal, the Netherlands, Sweden, and Taiwan. They stuck to the previous pattern but with a much larger import. Namely, due to first and fifth positions in importing apples, Germany and the Netherlands converted into tenth and even eighth apple exporters across the globe (FAOStat, 2020).

The avenues for discussing the paper findings retrieved from Figures 2 and 3 are as follows.

The analysis of Figure 2 shows that the major pattern by export share was presented by bin 2 where export prices surpassed farm gate prices for fresh apples by –1% to 80%. It was observed in Armenia, Australia, Austria, Belarus, Belgium, Bulgaria, Chile, Croatia, Estonia, France, Germany, Italy, Japan, Jordan, Latvia, Luxembourg, Moldova, Morocco, the Netherlands, Serbia, Slovakia, Slovenia, South Africa, Spain, Sweden, Turkey, and the USA. These countries demonstrated fair promotion of international trade balanced with the economic benefits of domestic producers and consumers of apples.

One more major pattern by the number of countries corresponded to bin 1 where export prices were mostly lower than farm gate prices in the range from –82% to –1%. Such pattern took place in Albania, Algeria, Bhutan, Colombia, the Czech Republic, Finland, Greece, Iran, Kazakhstan, Lebanon, Lithuania, North Macedonia, Norway, Portugal, Romania, Switzerland, Tajikistan, the United Kingdom, Uruguay, and Yemen. The considered pattern meant that the apple growers from these countries were aimed at domestic demand and had to gain international trade through reduced prices.

The major pattern by production share was displayed by bin 3. Principally, it is derived from the Chinese phenomenon of producing 45.5% and exporting 13.4% of fresh apples globally. However, Wang, Wolf, and Zhang (2016) notified that the bottleneck of these achievements was excessive, irrational application of N-P-K fertilizers and pesticides in apple orchards, as well as scarce capacities of cold storage facilities for apple harvests.

The analysis of Figure 3 clarified that the major pattern by import share and number of countries was specified by bin 2 where import prices mostly surpassed farm gate prices for fresh apples by up to 83%. It was located in Albania, Armenia, Australia, Belgium, Bosnia and Herzegovina, Cyprus, France, Germany, Iran, Jordan, Kazakhstan, Latvia, Luxembourg, Mexico, Nepal, the Netherlands, North Macedonia, Norway, Portugal, Slovenia, South Africa, Spain, Sweden, Switzerland, and Tunisia. The priority in these countries was to offset insufficient apple proposition and meet the domestic population's demand for healthy food.

One more major pattern by import share and number of countries corresponded to bin 1 where import prices were lower than farm gate prices in the range from –83% to 0%. Such pattern took place in Austria, Bolivia, Bulgaria, Colombia, Ecuador, Finland, Grenada, Greece, Iraq, Israel, Italy, Japan, Lebanon, Lithuania, Morocco, Romania, Serbia, the United Kingdom, Uruguay, Yemen, and Zimbabwe. The discussed pattern implied that the apple growers from these countries had solid financial protection from the external competitors.

Finally, the major pattern by production share was identified by bin 5. Like for the first histogram, it was typical of China, which imported a small quantity of expensive fresh apples of high quality and safety.

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The areas for discussing the paper findings derived from Table 2 are as follows.

Firstly, Table 2 revealed the trade in fresh apples to be threefold over the processed apples' value, which mirrors the global, ongoing consumption trend to healthy food.

Secondly, Table 2 gave evidence on the total misbalance of around 22% in trading fresh apples. According to the Ratios 20/20 equaled 3.59 and 3.09, top exporters accumulated relatively more value than top importers. Respectively, the export of fresh apples needs alignment by 17% compared to 14% in their import. Largely, it concerns China, which is the world top exporter of fresh apples possessing 13.4% of the market quantity and 16.8% of the market value (USDA, 2020). Simultaneously, "a significant difficulty in international trade in apples for Poland and the EU is the embargo introduced in August 2014 by the Russian Federation" (Kracinski, 2017, p. 32). Moldova and Belarus became dedicated to the re-export of Polish apples to mitigate this impediment.

Thirdly, the export of concentrated apple juice appeared to be rather balanced. In contrast, the import of concentrated apple juice was the most uneven by the whole set of indicators. In agreement with Luckstead, Devadoss, and Dhamodharan (2015), such a market pattern was caused by the US advantageous purchases of 67.6% of concentrated apple juice for 30.3% of the respective total value for this product.

Fourthly, trades in single strength apple juice were the most balanced. Indeed, the relevant export had more parity by the Gini coefficient and the Hoover index. Instead, the import of single strength apple juice was more uniform by the deviation between the top 20% and bottom 20% of buyers. Principally, the pillars of the discussed import market pattern were the EU countries, which acquire over 80% of single strength apple juice. Similarly, the prevailing exporter of 48.6% (in value) or 37.9% (in quantity) of this product was China, which established the considered world market pattern (Snyder & Ni, 2017).

CONCLUSION

Overall, the research hypothesis on the existence of the identifiable specific patterns in apple production, purchases, and sales was verified positively. Such patterns enable farmers and traders to trace applicable effective practices and experiences observed in the shared clusters to meet the increasing global demand for apples.

Firstly, the offered divisive hierarchical clustering bounded the world market patterns and selected groups of countries with common ranked priorities in the apple production for domestic consumption and foreign trade. The determined major clusters encompassed 50 countries with the prevailing production and export of 83.2% and 76.9% in the global markets of fresh apples and apple juices. The minor clusters of dominant importers involved 26 countries with a total share of 48.9% in the world apple purchases.

Secondly, the proposed analysis of the interval variation series was visualized using triple histograms and translated into groups of countries with similar pattern features by deviations between farm gate prices and export-import operations. Largely, the current export and import prices surpass the farm gate prices for apples by less than 80% and 83%.

Thirdly, the chosen inequality indicators detected distinguishable international trade patterns in the world market of fresh and processed apples. The fresh apple import proved to be more balanced than its export. The largest mismatch was revealed between the export and import of the concentrated apple juice.

Lastly, it is important to note that apples grow in all continents introduced by their core producers and exporters like the EU countries, the USA, Chile, China, India, New Zealand, and South Africa. The world consumption of apples is increasing every year. Apple foreign sales are valued at over USD 10 billion. Thus, the research findings are of special interest to apple-producing, exporting, and importing countries in comprehending the key market patterns among their competitors and existing or potential customers in favor of further development of the world markets of healthy food.

AUTHOR CONTRIBUTIONS

Conceptualization: Natalia Vasylieva.
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Formal analysis: Natalia Vasylieva, Harvey James.
Funding acquisition: Natalia Vasylieva.
Investigation: Natalia Vasylieva, Harvey James.
Methodology: Natalia Vasylieva, Harvey James.
Project administration: Harvey James.
Resources: Natalia Vasylieva, Harvey James.
Software: Harvey James.
Supervision: Harvey James.
Validation: Harvey James.
Visualization: Natalia Vasylieva.
Writing – original draft: Natalia Vasylieva.
Writing – review & editing: Harvey James.

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