Agriculture and Food Sciences Research
Vol. 11, No. 1, 1-14, 2024
ISSN(E) 2411-6653/ ISSN(P) 2518-0193
DOI: 10.20448/aesr.v11i1.5261

Moroccan and Spanish agriculture comparative analysis 2008-2021

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Abstract

In the general context of Morocco's New Development Model, where public policies need all their credentials, and more specifically in the context of Morocco's new agricultural strategy (Green Plan), the challenge is to develop modern agriculture with high added value and high productivity, capable of competing with agricultural production in other countries. This article compares the overall characteristics of agricultural production in Spain and Morocco. To make this comparative analysis, we have focused on a set of agricultural statistical aggregates, such as cultivated area, level of production and yield in relation to each family of agricultural products. These are calculated, using the Laspeyres index, over the period 2008 to 2021. In addition, we have chosen 2008 as the base year for plotting the evolution of Moroccan agricultural performance against that of Spain. The results of our comparative analysis showed that agriculture in Spain is more stable than in Morocco, particularly in cereals and fresh vegetables. Thus, they showed that the majority of Spanish agricultural products outperform those of Morocco. On the other hand, this comparative analysis showed that Moroccan agriculture outperforms Spanish agriculture in the production of sheep, apples, fresh peas, carrots, turnips, broad beans, green beans, goat meat, dried lentils and chickpeas, and that Moroccan agriculture outperforms Spanish agriculture in the production of dates and unshelled peanuts.

Keywords: Agricultural production, Plant products, Livestock products, Laspeyres index, Morocco, Spain.

Citation | Asllam, L., Bari, A. A., & Amzil, M. (2024). Moroccan and Spanish agriculture comparative analysis 2008-2021. *Agriculture and Food Sciences Research*, *11*(1), 1–14. 10.20448/aesr.v11i1.5261
History:
Received: 18 October 2023
Revised: 4 December 2023
Accepted: 15 December 2023
Published: 22 December 2023

Publisher: Asian Online Journal Publishing Group

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

Contents

Contribution of this paper to the literature
The research makes a comparative analysis between Moroccan and Spanish agriculture, based on a set of agricultural statistical aggregates for each family of agricultural products, calculated using the Laspeyres statistical index for the first time, compared to previous studies between the two countries.

1. Introduction

The aim of this paper is to compare the overall characteristics of agricultural production between Spain and Morocco. The comparison of agricultural productivity between two countries is difficult to pin down, given the number of factors that come into play in determining the latter, namely the country's climate and geographical position, the type of farming practiced, the tools and technical arrangements put in place for each type of agricultural product and the area cultivated, as well as its fertility. It should be noted in passing that a country can only be said to be in a better position than another with regard to a given crop or agricultural product by comparing agricultural measurement metrics calculated in a similar way in the two countries in question and possessing the same unit of measurement. This paper would therefore focus on a quantitative analysis, focusing on a set of agricultural statistical aggregates such as cultivated area, level of production and yield in relation to each family of agricultural products. It is therefore a study centered on the desire to position one country in relation to another according to the indicators chosen. The indicators used in this paper are selected on the basis of their informative relevance to what they represent. For example, area under cultivation refers only to the amount of land cultivated for a given agricultural product, not to the type of area under cultivation. So, this indicator says nothing about whether a piece of land is conventionally cultivated or whether the cultivated area was an agricultural greenhouse, but simply indicates the amount of land cultivated for a given product. The first part of this comparative analysis will contain a presentation of agricultural comparison metrics, while the second part will detail the levels of these metrics between Morocco and Spain over a variable time-span, depending on data availability.

2. Methodology for Comparing Agriculture in Morocco and Spain

2.1. Data Structure

The comparative analysis of agricultural production in Morocco and Spain will be carried out between 2008 and 2021. The year 2008, at the start of the GMP (Green Morocco Plan) policy, has been chosen as the base year for tracing the evolution of the agricultural performance of one country in relation to the other. In this study, the agricultural performance of a given country for a given product or group of products is based on the level of production in tons, the harvested area in hectares, and the agricultural yield derived from the division of the two previous metrics [1, 2]. As a result, a given agricultural product or family of products is characterized by three main variables: Production, area and yield. To avoid redundancy when comparing the two countries, only production and yield will be retained. The data structure deployed in this study is organized along five dimensions:

- The size of agricultural product families.
- Size of agricultural products.
- The dimension of parameters, i.e. production in tons, yield in 100ha/ton and area in hectares.
- The geographical dimension, i.e. the realization of these parameters for agricultural products in Morocco and Spain.
- The time dimension, i.e. the achievement of the above in each year between 2008 and 2021, i.e. 14 time points in total.

Note in passing that the first dimension can itself be broken down into several other dimensions. In our case, we have decided to retain two sub-dimensions of this dimension, namely:

- The crop and livestock product dimension.
- The dimension that breaks down into
- Cereals, Oilseeds, Pulses and Sugar
- Fresh vegetables
- Fresh Fruit
- Meat
- Milk

2.2. Statistical Comparison Methodology

The dimension of agricultural product families, as well as these sub-dimensions, are distinguished by their ability to synthesize several closely related agricultural products into a single aggregate. This aggregation of agricultural products is made possible by the Laspeyres statistical index. In this way, the temporal evolution of the production and yield of several agricultural products can be tracked in a single index, for example, the citrus production index instead of the quantity of oranges produced in tons alone. The choice of weighting within each agricultural product grouping is made on the basis of their respective prices in 2008 (base year) in the geographical area of Spain that serves as the base country for the comparison. The synthetic production index Vacher [3] is thus constructed as follows:

$$I^{g}_{z_0,t} = \frac{NM_{z_0,t}}{D_{z_0}}$$

$$I^{g}_{z_1,t} = \frac{NM_{z_1,t}}{D_{z_0}}$$

With:

$$NM_{z_1,t} = \sum_{i=1}^{I_g} p^i_{z_0,t_0} * q^i_{z_1,t}$$

$$NM_{z_0,t} = \sum_{i=1}^{I_g} p^i_{z_0,t_0} * q^i_{z_0,t}$$

$$D_{z_0} = \sum_{i=1}^{G} p^i_{z_0,t_0} * q^i_{z_0,t_0}$$

$z = (z_0, z_1)$ designates the geographical area vector, z_0 being Spain, and z_1 being Morocco.

$t = (t_0, \dots, t_{14})$ is the time vector with t_0 equal to 2008 et t_{14} equal to 2021.

I_g : represents the number of agricultural products in a given grouping. There are several possible groupings g to be explained later [4].

G: gathering of all agricultural products.

i : is the agricultural product index within a grouping.

$q^i_{z_0,t_0}$: is the quantity produced in product i (or agricultural yield) year-round t_0 in the geographical areaz_0.

$p^i_{z_0,t_0}$: is the price, in dollars, of the agricultural product i year-round t_0 in the geographical areaz_0.

$NM_{z_1,t}$: is the total value, in dollars, of Morocco's agricultural production, from theI_g, in the year t in prices of respective agricultural products in Spain to the year 2008.

$NM_{z_0,t}$: is the total value, in dollars, of the agricultural production of Spain, the family I_g, in the year t in prices of respective agricultural products in Spain to the year 2008.

D_{z_0} : is the total value, in dollars, of agricultural production in Spain, of all agricultural products, in the year 2008 in prices of the respective agricultural products in Spain in the year 2008.

So far, we've outlined the method of aggregating several agricultural products into a single indicator to express their common production and yield. Now, we will proceed in the same way to express Morocco's comparative performance against Spain for a single agricultural product or group of products in a single combined index. In particular, this index would show the production and yield advantage of one over the other. The index Bernard [5] and Bernard [6] would be written as follows:

$$C^g_t = \frac{I^g_{z_1,t}}{I^g_{z_0,t}} = \frac{NM_{z_1,t}}{NM_{z_0,t}}$$

In particular, $C^g_{t_0}$ represents the advantage or disadvantage in 2008 of Morocco over Spain, in terms of production or yield, expressed in prices of Spanish agricultural products.

Table 1. Weighting[1] of agricultural products retained in each type of grouping.

Agricultural product groups			Agricultural products	Weighting	
First	**Second**	**Third**		**Yield**	**Production**
Plant products	Cereals, oilseeds, pulses and sugar crops	Cereals	Oats	1	8
			Wheat	2	61
			Corn	5	27
			Barley	2	79
			Rice	7	10
			Triticale	1	1
		Oilseeds	Unshelled peanuts	12	1
			Soybeans	2	1
			Rapeseed	1	1
			Sunflower seeds	1	14
			Olives	3	121
		Legume	Broad and fava beans, dry	1	1
			Dry lentils	1	1
			Chickpeas, dried	2	1
			Dry peas	1	1
		Sugar crops	Sugar, beet	8	6
	Fresh vegetables[2]	Fresh vegetables	Fresh garlic	30	7
			Asparagus	18	3
			Eggplants	98	5
			Carrots and turnips	45	5
			Broad and fava beans, green	24	3
			Onions, shallots, fresh	56	1
			Fresh peas	34	6
			Tomatoes, fresh	121	99

[1] LUND, P.J. The Combination of Agricultural Output and Input Price Indices, Journal of Agricultural Economics, September 1994.
Bonnays Guy, Floch Jean-Michel - L'indice des prix des produits agricoles à la production, méthodologie et séries longues - Insee, Archives et documents n° 122 - novembre 1987, 122 pages.
Bourgey Guy - L'indice des prix des produits agricoles à la production : méthodologie base 1975 - Insee, Archives et documents n° 33 - octobre 1981, 88 pages.

[2]AGRESTE - Série D n° 17 - avril 1979 - L'IPPAP fruits et légumes en base 1970.
AGRESTE - données chiffrées n° 73 - novembre 1995 - 15 ans d'indice des prix des fruits et légumes.
AGRESTE - chiffres et données n° 132 - mars 2001 - IPPAP fruits et légumes base 1995.
AGRESTE - chiffres et données n° 165 - février 2005 - IPPAP fruits et légumes base 2000.
AGRESTE - chiffres et données à paraître fin 2009 - IPPAP fruits et légumes base 2005.
Fourastier Jean (sous la direction de) - L'évolution des prix à long terme, PUF 1969 (pp 121 à 170 pour les prix agricoles et alimentaires).

Agricultural product groups			Agricultural products	Weighting	
First	Second	Third		Yield	Production
	Fresh fruit[3]	Fruits except citrus, almonds, walnuts and dates red fruit	Apples	22	11
			Pears	30	13
			Apricots	11	3
			Peaches and nectarines	28	31
			Plums and sloes	15	4
			Bananas	53	7
			Figs	8	1
			Grapes	8	132
		Citrus	Lemons and limes	20	14
			Oranges	14	33
			Tangerines, mandarins	13	24
		Almonds, walnuts and dates	Unshelled almonds	1	6
			Unshelled walnuts	10	1
			Dates	37	1
		Red berries	Strawberries	150	18
			Raspberries	72	2
			Cherries	15	5
Livestock products	Meats	Meats	Beef and veal	1	48
			Sheep meat	1	16
			Goat meat	1	2
			Meat chicken	5	40
	Milk	Milk	Raw ewe's milk	1	15
			Raw goat's milk	1	12
			Raw cow's milk	7	98

Note: The weights reported in this table represent the share of the dollar value of a given agricultural product in the total value of the sum of the values of all the agricultural products included in the analysis, in Spain, and in the year 2008.

The weighting of each type of agricultural product is therefore calculated according to the following formula: $w^{i}_{z_0,t_0} = 1000 * \frac{p^{i}_{z_0,t_0} * q^{i}_{z_0,t_0}}{p_{z_0}}$.

They correspond to the share of each agricultural product in the index $I^{G}_{z_0,t_0}$.

2.3. Weight of Agricultural Products in the Comparison Procedure

The rest of the study is based on this table, insofar as all the comparative indices between Spain and Morocco, C^{g}_{t}, relating to the different groupings, reported in the graphs in the following chapter, have been constructed on the basis of the weightings proposed in it. These weights represent the percentage of each agricultural product in the production and yield index for the base year and the base country, in this case 2008 in Spain.

In assessing the comparison between the agricultural performances of Morocco and Spain, we note from Table 1 that agricultural products such as grapes, olives, tomatoes, cow's milk, barley and wheat have a considerable influence, as they are the mainstays of agricultural production in Spain in 2008, so any evolution in agricultural performance, whether in Spain or Morocco, is assessed, to a large extent, in the prism of these agricultural products. The approach of establishing weightings to group agricultural products into a single index or several indices is necessary to situate Morocco's performance in relation to that of Spain in several agricultural product groupings at once[4]. The synthetic yield index, for its part, has a different weighting structure, with particular emphasis on tomatoes, strawberries, raspberries and eggplants.

3. Comparative Analysis of Agricultural Performance between Morocco and Spain

3.1. Comparative Analysis of the Overall Agricultural Difference between Morocco and Spain

Figure 1 presents a comparative analysis of the overall agricultural difference between Morocco and Spain, taking into consideration all agricultural products with different weightings; we can see that Morocco performs, on average, 32.5% of what Spain achieves in agriculture. In terms of annual fluctuations in Morocco's advantage over Spain, we note some variability around the values of 25% and 37.5% of performance compared to Spain. Spain's agricultural advantage is defined mainly by those products that have a significant weighting in the agricultural production index, namely grapes, olives, fresh tomatoes, raw cow's milk, barley, wheat, beef, chicken meat, oranges, peaches and nectarines, corn and so on (see Table 1). According to the same table, the barley production index in Morocco fluctuates considerably compared with that of Spain, with a coefficient of variation (CV) of 47.57% in Morocco versus 21.46 in Spain, indicating that barley production in Morocco is twice as unstable as that of Spain. We can also cite a basket of products that are important in the comparison, where Spain's production is much more stable over time: raw cow's milk, wheat, chicken meat, oranges, corn, strawberries, sheep meat, apples, rice and sunflower seeds, and so on (see Table 1).

[3]AGRESTE - Série D n° 17 - avril 1979 - L'IPPAP fruits et légumes en base 1970.
AGRESTE - données chiffrées n° 73 - novembre 1995 - 15 ans d'indice des prix des fruits et légumes.
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Fourastier Jean (sous la direction de) - L'évolution des prix à long terme, PUF 1969 (pp 121 à 170 pour les prix agricoles et alimentaires).

[4] Eurostat, Comparison in real values of the aggregates of ESA – 1980. Luxembourg, 1983.
Eurostat, Summary and comparison of trends in EC agricultural price indices (Output and Input) 1985-1993, Rapid Report on Agriculture, forestry and fisheries 19944. Luxemburg, 1994.
Eurostat, Agricultural land prices and rents in the EU. 1974-1995, Theme 5 Series C. Luxembourg, 1997.
Eurostat, Manual on the economic accounts for agriculture and forestry EAA/EAF 97 (Rev. 1.1), Theme 5 Series Methodology and Nomenclatures. Luxembourg, 2000.

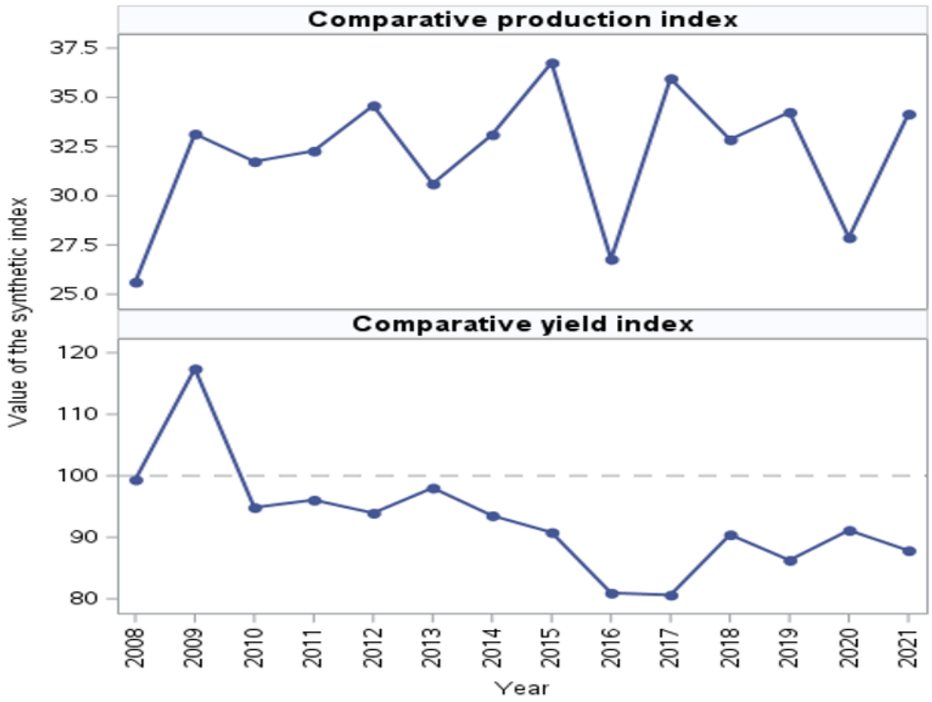

Figure 1. Evolution of agricultural performance of Morocco compared to Spain.
Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

The agricultural yield index, meanwhile, is largely driven by the following products: strawberries, fresh tomatoes, eggplants, raspberries, onions, bananas, carrots, dates and so on (see Table 1). Morocco is gradually losing its 20% advantage in 2009 to a -10% disadvantage by 2021.

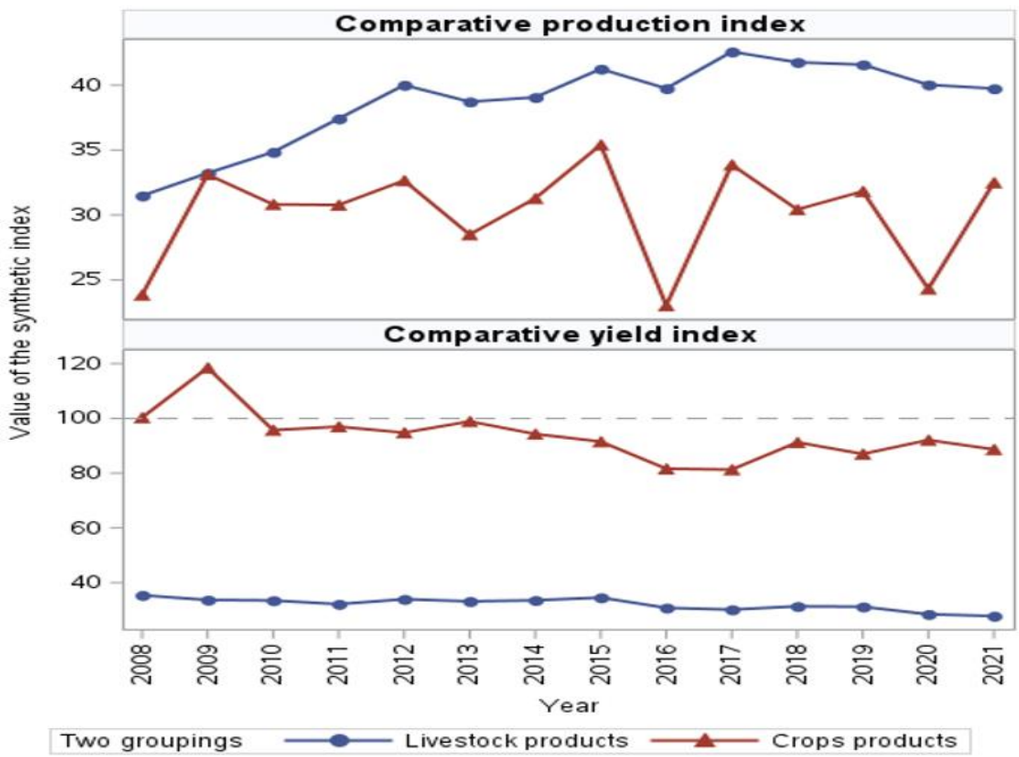

Figure 2. Evolution of agricultural performance of Morocco compared to Spain for crops and livestock products.
Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

3.2. Comparative Analysis of Morocco and Spain by First Grouping

Figure 2 presents the evolution of agricultural performance of Morocco compared to Spain for crops and livestock products. In fact Morocco's production disadvantage for livestock products is relatively stable and decreasing, with a downward trend from -70% in 2008 to around -63% in 2021. Morocco's yield performance for livestock products nevertheless remains far behind Spain, with a sustainable average disadvantage of -65%.

The comparison of agricultural performance in crop products is highly unstable, as it is dictated by agricultural products whose annual production is highly variable depending on rainfall, in Morocco's case. As already mentioned in the comparison of overall agricultural performance between the two countries, the CV of the production indices of certain agricultural products determining the comparison are very high for Morocco, which has repercussions on the annual agricultural performance of this country in relation to Spain.

The analysis of yields for plant products is more or less stable, with a downward trend for Morocco over time. However, it can be assumed that the two countries have very comparable yields for plant products.

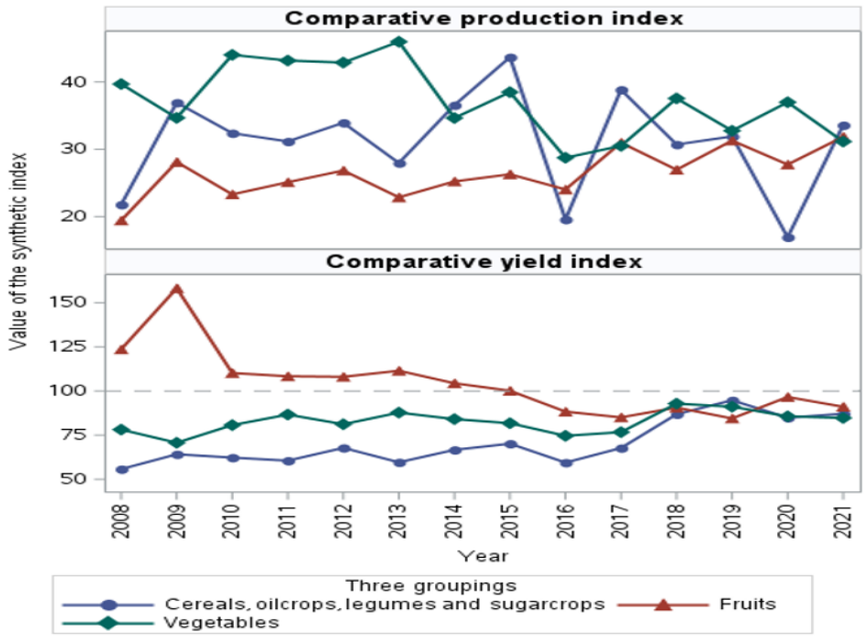

Figure 3. Evolution of agricultural performance of Morocco compared to Spain for crops products.
Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

3.2.1. Plant Products

Figure 3 presents the evolution of agricultural performance of Morocco compared to Spain for crops products. Actually Morocco is at a disadvantage to Spain in terms of production for the three selected agricultural product groupings. For the cereals, oilseeds, pulses and sugar crops group, Morocco outperforms Spain by 25%. Morocco's performance is highly fluctuating, given the CV it displays in the production index for agricultural products in this family. The main products driving the above comparative production index are: Olives, barley, wheat and, to a lesser extent, rice. Morocco is at an average disadvantage of -70% compared to Spain in fresh vegetable production. This grouping is dominated by fresh tomato production. Spain is also making strong annual progress in fresh vegetable production, at a much higher rate than Morocco, which explains the downward trend in Morocco's comparative performance index compared with Spain for this family. In the fresh fruit family, Morocco ended 2008 with a disadvantage of -80%, and progressed throughout the analysis to a disadvantage of -70% by 2021.Despite the gap in agricultural performance between the two countries in terms of this grouping, there is a clear upward trend for Morocco in fresh fruit production over the period 2008-2021. The interpretation of this agricultural family is based on viticulture production (grape production), followed by citrus production (all varieties) and peach and nectarine production. Here again, fluctuations in the comparative production index are due to the instability of agricultural production in Morocco. In terms of yield, the comparison is a little different, since Morocco had a 50% advantage in 2009 in the fresh fruit grouping, then began a consistent loss of yield advantage to Spain, ending 2021 with a -10% disadvantage in the same family. For the other two groupings, fresh vegetables and cereals, oilseeds, pulses and sugar crops, the gap between the two countries is clearly visible, but the trend is clearly increasing in Morocco's favor.

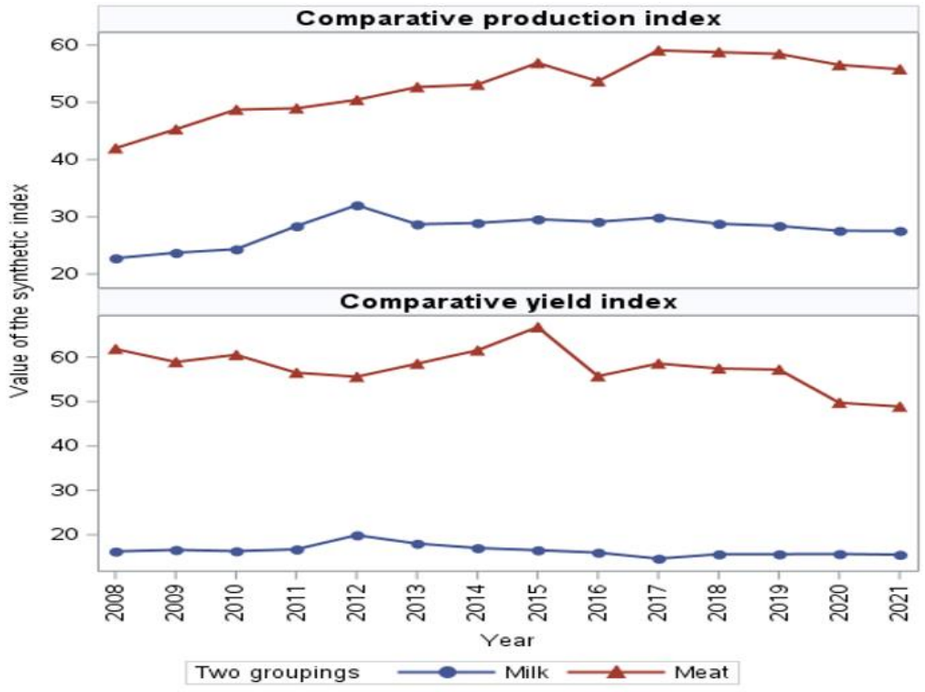

Figure 4. Evolution of agricultural performance of Morocco compared to Spain for livestock products.
Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

3.2.2. Livestock Products

Figure 4 presente the evolution of agricultural performance of Morocco compared to Spain for livestock products. In the comparison of animal products, three main products are compared: raw cow's milk for the milk category, and beef and chicken meat for the meat category, as they have the highest weights in the milk and meat production indices respectively. The evolution of the comparative milk production index can be interpreted as follows: Morocco's disadvantage is around -70% of Spain's performance in the same family. Moroccan milk production yields are also stable at under 20% of Spanish yields. When it comes to meat, Morocco achieves, on average, 50% of Spain's meat production index. It is interesting to note that Morocco's performance is improving year on year. Indeed, Morocco's meat production disadvantage in relation to Spain has been reduced by 20% between 2008 and 2021. Nevertheless, Morocco's yield is lower than Spain's. In 2008, Morocco's disadvantage was 60%, rising to 50% by 2021.

3.3. Comparative Analysis of Morocco and Spain by Second Grouping

We'll now take a closer look at another level of grouping, breaking down the components of the groupings analyzed above.

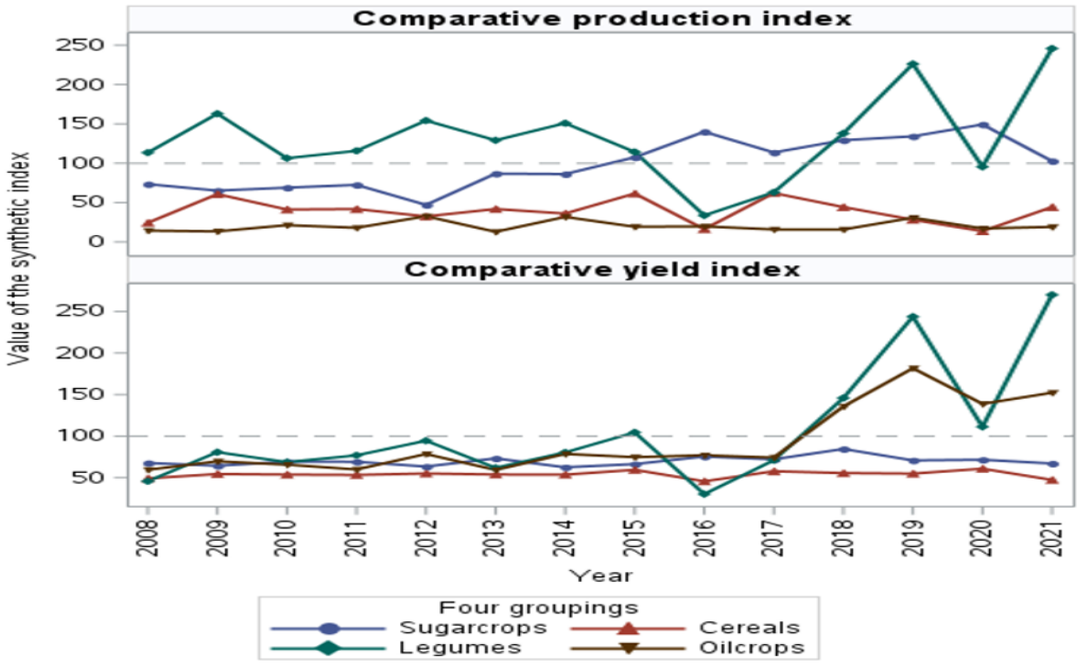

Figure 5. Evolution of agricultural performance of Morocco compared to Spain for cereals, oilcrops, legumes & sugarcrops.
Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

3.3.1. Cereals, Oilseeds, Pulses and Sugar Crops

Figure 5 presents the evolution of agricultural performance of Morocco compared to Spain for cereals, oil crops, legumes & sugar crops. We quickly notice a clear advantage for Morocco over Spain in terms of the comparative index of legume production, and a gain in advantage in terms of sugar crops over the period 2008-2021. However, these two groupings do not have a significant weighting in the composition of the comparative index of plant product production. They therefore make only a small contribution to the overall assessment of the two countries' agricultural performance. Morocco's advantage in pulses is explained by an average performance advantage of 60% in dry chickpeas compared with Spain, and an average advantage of 50% in dry lentils, as well as an advantage of 265.7% in dry broad beans and fava beans, i.e. almost four times Spain's performance in this agricultural product. For the other two remaining groupings, cereals and oilseeds, Spain produces five times more than Morocco, with a much more stable production rate than Morocco. The two key products in these two key plant family groupings are, respectively, barley for cereals and olives for oilseeds. In terms of comparative yields, Morocco has gained a lot in terms of yields for legumes and oilseeds in the last years of the 2008-2021 period, more precisely, from 2016 onwards. For cereals, Spain has twice the yield of Morocco.

3.3.2. Fresh Vegetables

Figure 6 presents the evolution of agricultural performance of Morocco compared to Spain for vegetable. The aim of this graph is to show, in more detail, all the products contained in the fresh vegetable family. The products that exceed the 100% threshold in comparative production index (start of advantage gain for Morocco) at least once in the period between 2008 and 2021 are: green beans, carrots and turnips, fresh weights and fresh onions/shallots. For other agricultural products, the comparison is of little use given Spain's enormous performance advantage. We also note that fresh tomatoes dictate the evolution of the entire fresh vegetable family, given its considerable weighting in the comparative fresh vegetable production index. If Morocco gains an advantage between 2008 and 2021, it will necessarily be in one of the above-mentioned products. Morocco has achieved a significant rise in onion production, from a -50% disadvantage in 2008 to an advantage of over 100% in 2017, i.e. double. It has also begun a process of regression in fresh pea production, moving from a comparative production advantage of 50% to a disadvantage of -40% by 2021. Carrots and turnips are very comparable in terms of production performance for both countries.

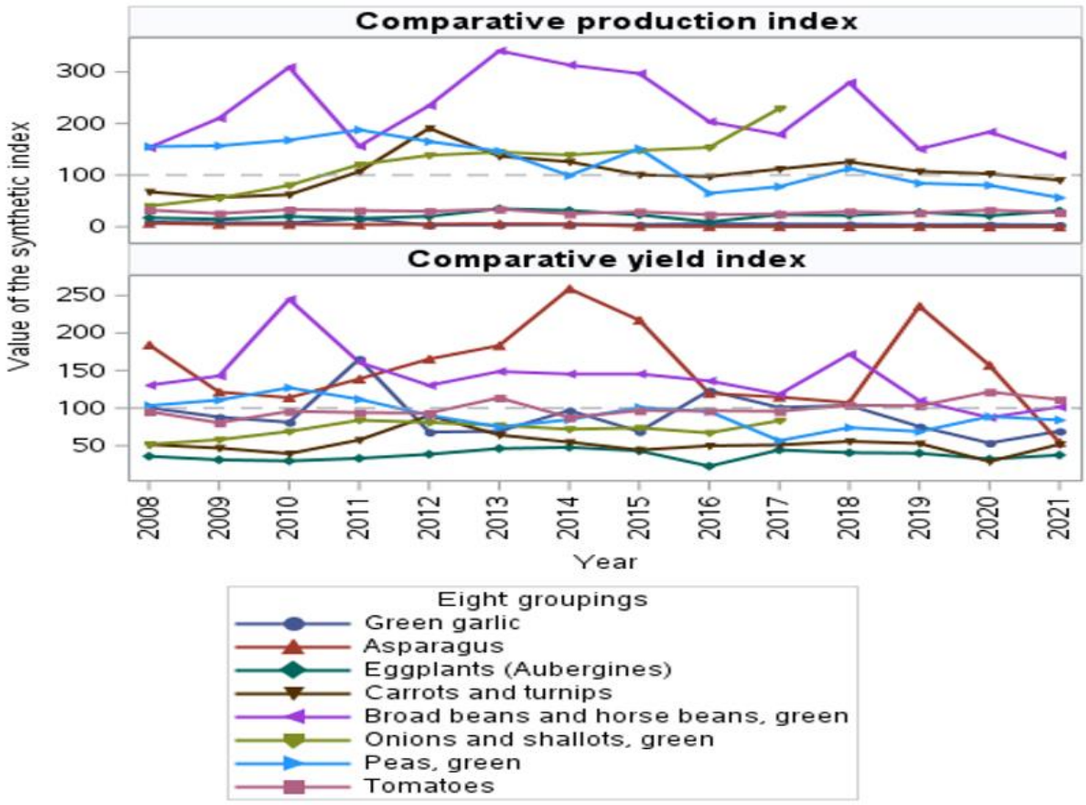

Figure 6. Evolution of agricultural performance of Morocco compared to Spain for vegetable.

Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

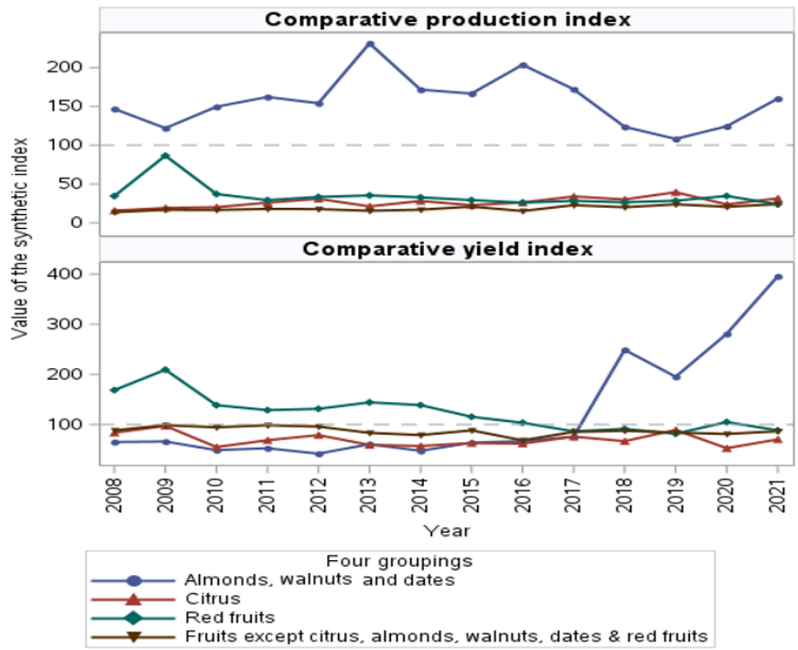

Figure 7. Evolution of agricultural performance of Morocco compared to Spain for fruits.

Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

3.3.3. Fresh Fruit

Figure 7 presents the evolution of agricultural performance of Morocco compared to Spain for fruits. The comparative production index for the fresh fruit grouping is largely influenced by citrus. When this grouping is broken down into sub-groupings, as in the figure above, there is a wide gap in performance between the two countries, with Spain benefiting in citrus fruits, red fruits and other types of fruit. Morocco outperforms Spain by an average of 50% in the production of almonds, walnuts and dates. In terms of yield, Morocco has achieved a sharp rise since 2017 in almonds, walnuts and dates. For red fruits, it has been steadily declining since 2009, falling from an advantage of 100%, i.e. double Spain's yield, to finish on a par with Spain in 2021.

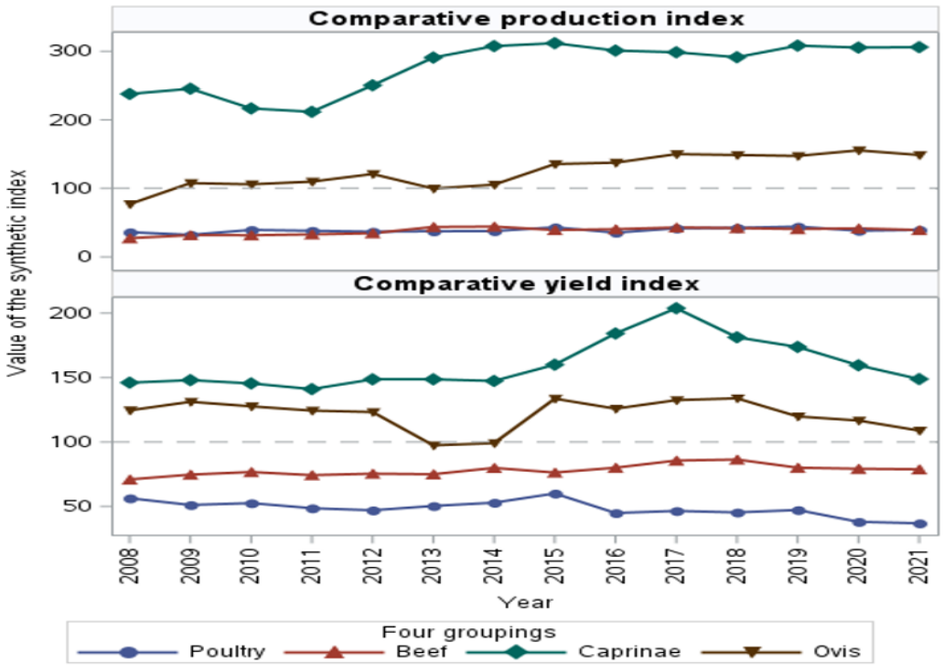

Figure 8. Evolution of agricultural performance of Morocco compared to Spain for red and white meats.
Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

3.3.4. Meats

Figure 8 presents the evolution of agricultural performance of Morocco compared to Spain for red and white meats. In the interpretation of the meat grouping, Morocco was at an average disadvantage of -40% in production performance. This was mainly due to the high weighting of beef in the composition of the meat production index. As a result, it pulls down the comparative meat production index when Spain produces large quantities of this livestock product. Given this, when we look closely at the products making up this meat production index, we quickly see that Morocco has a very interesting advantage in goat and sheep meat production, which, it has to be said, have much lower weightings than chicken and beef in the representativeness of the meat grouping. Morocco's average advantage is 177% for goat production and 25% for sheep production. The average disadvantage is -60% for chicken and beef production.

Morocco also achieves an average advantage of 25% and 50% respectively for sheep and goat meat products, and an average disadvantage of -25% and -50% respectively for beef and chicken meat products.

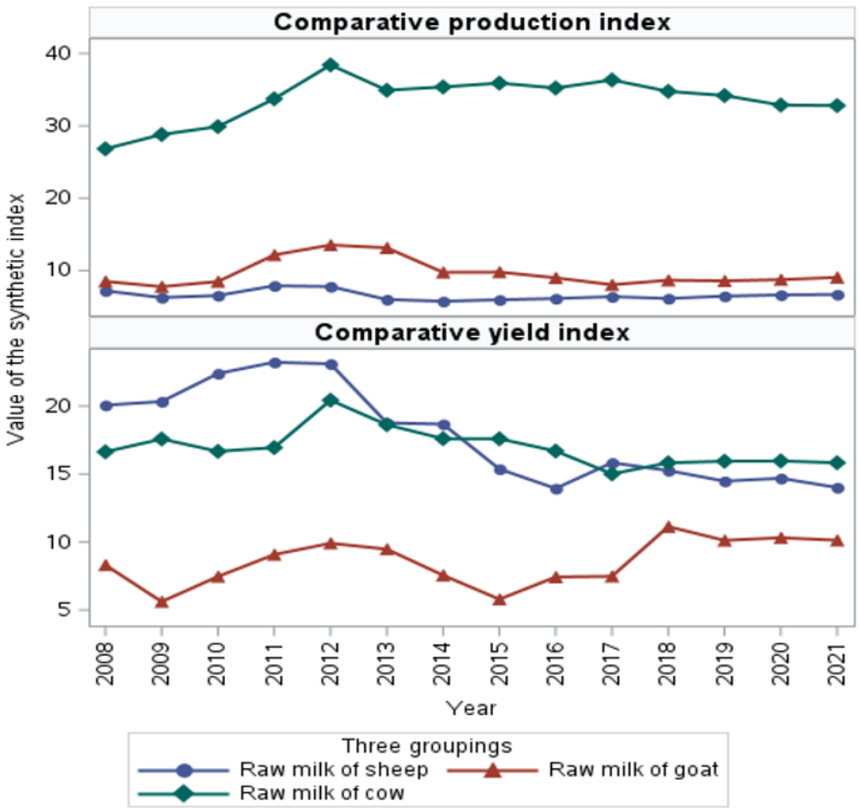

Figure 9. Evolution of agricultural performance of Morocco compared to Spain for milk.
Source: The results of production and yield indices are constructed based on data available on the website of the food and agriculture organization of the united nation (FAO).

3.3.5. Milk

Figure 9 presents the evolution of agricultural performance of Morocco compared to Spain for milk. Morocco is largely dominated by Spain in milk production, with an average disadvantage of -67% in raw cow's milk production, -90% in raw goat's milk production and -94% in raw ewe's milk production. This advantage gap is more or less stable from 2008 to 2021 for all types of milk production. The yields of these milk products are not very comparable between the two countries, since Morocco's comparative yield index is between 5% and 25% of Spain's, with a downward trend in ewe's and goat's milk and an upward trend in cow's milk since 2008.

4. Conclusion

In general, agriculture in Spain is more stable than in Morocco, especially for cereals and fresh vegetables. In the majority of agricultural products, Spain performs better than Morocco, with varying differences depending on the type of agricultural product. To sum up, Morocco produces 15% more grapes, 37% more olives, 30% more fresh tomatoes, 34% more raw cow's milk, 27% more barley and 84.5% more wheat than Spain. In terms of advantages, Morocco surpasses Spain in sheep production by 25%, 2% in apples, 20% in fresh weight, 5% in carrots and turnips, 124% in green beans, 177% in goat meat, 265% in dried beans, 238% in figs, 50% in dried lentils, 20% in onions and 60% in dried chickpeas, and far exceeds Spain in date and unshelled peanut production.

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Appendix

Appendices: production and yield index statistics

Tables 2 and 3 present production and yield index statistics for each type of agricultural product in our comparative analysis.

Table 2. Production index statistics for each type of agricultural product.

Weightings	Agricultural products	Statistics	$I^{g}_{z_0,t}$(Spain)	$I^{g}_{z_1,t}$(Morocco)	C^{g}_{t}
15	Strawberries	Average Coefficient of variation (CV)	18.9 (17.65)	21.4 (36.29)	117.8 (45.03)
		Trend	491	-512	-5937
		Minimum - maximum	15.0 - 23.9	17.3 - 48.0	75.3 - 290.3
12.1	Tomatoes, fresh	Average CV	13.3 (6.56)	13.2 (12.87)	99.4 (10.77)
		Trend	137	352	1675
		Minimum - maximum	11.9 - 14.6	9.9 - 15.5	80.6 - 121.7
9.8	Eggplants	Average CV	11.4 (10.95)	4.3 (20.96)	37.6 (18.78)
		Trend	273	128	285
		Minimum - maximum	10.0 - 13.8	2.7 - 5.2	22.9 - 48.0
7.2	Raspberries	Average CV	16.8 (43.86)	19.9 (5.12)	139.0 (38.58)
		Trend	1492	172	-10147
		Minimum - maximum	7.2 - 31.7	18.4 - 21.7	64.5 - 258.0
5.6	Onions, shallots, fresh	Average CV	5.9 (7.86)	4.4 (13.05)	71.8 (14.75)
		Trend	17	105	727
		Minimum - maximum	5.3 - 6.9	2.9 - 4.9	52.1 - 84.0
5.3	Bananas	Average CV	5.5 (6.67)	5.1 (6.57)	93.6 (10.18)
		Trend	65	-12	-1326
		Minimum - maximum	4.9 - 6.1	4.3 - 5.8	82.6 - 116.8
4.5	Carrots and turnips	Average CV	4.6 (4.82)	2.4 (25.05)	53.0 (25.79)
		Trend	33	-17	-731
		Minimum - maximum	4.2 - 5.0	1.4 - 4.0	29.2 - 90.3
3.7	Dates	Average CV	3.5 (15.83)	1.3 (13.30)	38.7 (27.60)
		Trend	-42	18	764
		Minimum - maximum	2.6 - 4.5	1.0 - 1.6	27.3 - 59.1
3.4	Fresh peas	Average CV	3.6 (7.02)	3.3 (16.44)	91.0 (20.88)
		Trend	41	-70	-3007
		Minimum - maximum	3.1 - 4.0	2.1 - 4.1	56.8 - 127.2
3	Fresh garlic	Average CV	3.3 (7.00)	2.9 (29.64)	90.5 (31.63)
		Trend	32	-43	-2138
		Minimum - maximum	3.0 - 3.7	1.8 - 5.2	53.7 - 165.5
	Pears	Average CV	2.7 (6.75)	1.7 (16.29)	63.4 (15.89)
		Trend	-29	-15	61
		Minimum - maximum	2.5 - 3.0	1.3 - 2.2	50.9 - 87.5
2.8	Peaches and nectarines	Average CV	2.9 (11.00)	2.2 (14.77)	75.7 (20.65)
		Trend	42	-52	-2936
		Minimum - maximum	2.4 - 3.6	1.7 - 2.8	58.0 - 101.4
2.4	Broad and fava beans, green	Average CV	2.3 (4.59)	3.2 (24.74)	141.1 (26.63)

Weightings	Agricultural products	Statistics	$I^{g}_{z_0,t}$(Spain)	$I^{g}_{z_1,t}$(Morocco)	C^{g}_{t}
		Trend	8	-96	-4886
		Minimum - maximum	2.1 - 2.5	2.0 - 5.2	87.5 - 244.9
2.2	Apples	Average CV	2.1 (8.31)	1.6 (15.46)	76.9 (17.03)
		Trend	6	-3	-380
		Minimum - maximum	1.7 - 2.4	0.9 - 1.9	41.5 - 98.1
2	Lemons and limes	Average CV	2.7 (19.45)	1.5 (25.59)	60.3 (42.50)
		Trend	70	-6	-2442
		Minimum - maximum	1.9 - 3.9	0.8 - 2.3	33.2 - 118.3
1.8	Asparagus	Average CV	2.0 (6.13)	3.1 (37.15)	155.2 (36.31)
		Trend	-6	-48	-1999
		Minimum - maximum	1.8 - 2.3	1.1 - 5.3	54.4 - 259.0
1.5	Cherries	Average CV	2.0 (12.68)	2.9 (41.13)	142.7 (39.88)
		Trend	14	-5	-1334
		Minimum - maximum	1.5 - 2.4	1.4 - 5.1	72.0 - 274.5
	Plums and sloes	Average CV	1.8 (9.98)	1.3 (21.10)	77.5 (25.87)
		Trend	-4	39	2436
		Minimum - maximum	1.5 - 2.0	0.9 - 1.9	45.8 - 127.1
1.4	Oranges	Average CV	1.4 (12.47)	1.1 (15.11)	76.4 (19.71)
		Trend	30	10	-946
		Minimum - maximum	1.1 - 1.7	0.7 - 1.3	52.3 - 100.6
1.3	Tangerines, mandarins, clementines	Average CV	1.3 (8.75)	1.2 (21.40)	87.5 (22.75)
		Trend	11	36	2068
		Minimum - maximum	1.2 - 1.6	0.7 - 1.5	54.4 - 122.3
1.2	Unshelled peanuts	Average CV	1.1 (12.81)	0.9 (8.37)	79.6 (18.78)
		Trend	-9	16	1347
		Minimum - maximum	0.8 - 1.3	0.7 - 1.0	59.7 - 113.2
1.1	Apricots	Average CV	1.2 (19.88)	1.8 (20.61)	153.1 (40.25)
		Trend	34	-47	-9512
		Minimum - maximum	0.8 - 1.6	1.1 - 2.4	80.0 - 274.3
1	Unshelled walnuts	Average CV	1.0 (11.77)	1.3 (30.30)	125.1 (34.44)
		Trend	-17	-4	1765
		Minimum - maximum	0.9 - 1.3	0.8 - 2.3	83.6 - 249.5
0.8	Figs	Average CV	0.9 (22.60)	0.7 (18.63)	80.2 (31.00)
		Trend	34	5	-2184
		Minimum - maximum	0.6 - 1.2	0.3 - 0.8	28.3 - 130.8
	Grapes	Average CV	0.9 (12.37)	1.3 (16.28)	138.0 (14.40)
		Trend	14	45	2722
		Minimum - maximum	0.8 - 1.2	0.9 - 1.6	100.8 - 176.8
	Sugar, beet	Average CV	0.9 (7.26)	0.6 (8.85)	69.8 (8.12)
		Trend	4	8	544
		Minimum - maximum	0.8 - 1.0	0.5 - 0.7	62.5 - 84.6
0.7	Raw cow's milk	Average CV	0.9 (10.51)	0.1 (8.03)	17.0 (8.12)
		Trend	20	2	-166
		Minimum - maximum	0.7 - 1.0	0.1 - 0.2	15.0 - 20.4
	Rice	Average CV	0.8 (3.57)	0.8 (15.69)	99.9 (17.37)
		Trend	0	15	1982
		Minimum - maximum	0.7 - 0.8	0.7 - 1.2	83.8 - 156.7
0.5	Corn	Average CV	0.6 (6.98)	0.0 (29.05)	7.0 (31.78)
		Trend	9	-1	-321
		Minimum - maximum	0.5 - 0.6	0.0 - 0.1	3.4 - 11.5
	Meat Chicken	Average CV	0.5 (6.72)	0.2 (9.36)	48.4 (13.00)
		Trend	4	-3	-1053
		Minimum - maximum	0.4 - 0.5	0.2 - 0.3	36.9 - 60.0
0.3	Olives	Average CV	0.4 (23.35)	0.2 (15.91)	55.3 (33.52)
		Trend	5	-1	-911
		Minimum - maximum	0.2 - 0.6	0.1 - 0.3	34.6 - 91.7
0.2	Wheat	Average CV	0.2 (18.27)	0.1 (30.08)	57.8 (32.73)
		Trend	4	1	-374
		Minimum - maximum	0.1 - 0.3	0.1 - 0.2	21.2 - 90.1
	Soybeans	Average CV	0.2 (11.56)	0.1 (0.00)	35.4 (12.53)
		Trend	4	0	-675
		Minimum - maximum	0.2 - 0.3	0.1 - 0.1	30.4 - 45.1
	Barley	Average CV	0.1 (20.56)	0.1 (41.74)	40.5 (44.65)
		Trend	3	1	-387
		Minimum - maximum	0.1 - 0.2	0.0 - 0.1	10.3 - 71.6
	Chickpeas, dried	Average CV	0.2 (18.46)	0.1 (32.24)	80.2 (43.48)
		Trend	1	5	794
		Minimum - maximum	0.1 - 0.2	0.1 - 0.2	45.1 - 152.6
0.1	Unshelled almonds	Average CV	0.1 (20.02)	0.2 (11.62)	161.5 (19.27)
		Trend	3	0	-4102
		Minimum - maximum	0.1 - 0.1	0.1 - 0.2	108.2 - 215.0
	Oats	Average CV	0.1 (21.34)	0.0 (44.46)	52.5 (44.40)
		Trend	2	-2	-2540
		Minimum - maximum	0.1 - 0.1	0.0 - 0.1	13.6 - 80.2

Weightings	Agricultural products	Statistics	$I^{g}_{z_0,t}$(Spain)	$I^{g}_{z_1,t}$(Morocco)	C^{g}_{t}
	Broad and fava beans, dry	Average CV	0.1 (14.86)	0.1 (33.56)	55.1 (37.79)
		Trend	-1	0	1144
		Minimum - maximum	0.1 - 0.1	0.0 - 0.1	28.2 - 111.9
	Rape or colza seeds	Average CV	0.2 (17.37)	0.1 (30.41)	64.3 (30.79)
		Trend	4	4	1504
		Minimum - maximum	0.1 - 0.2	0.1 - 0.1	39.0 - 97.1
	Sunflower seeds	Average CV	0.1 (12.22)	0.1 (18.43)	110.9 (23.99)
		Trend	1	2	231
		Minimum - maximum	0.1 - 0.1	0.1 - 0.2	73.9 - 178.1
0.1	Raw ewe's milk	Average CV	0.0 (12.59)	0.0 (9.08)	17.9 (19.50)
		Trend	1	0	-707
		Minimum - maximum	0.0 - 0.1	0.0 - 0.0	13.9 - 23.2
	Raw goat's milk	Average CV	0.1 (19.81)	0.0 (9.86)	8.6 (20.12)
		Trend	-2	0	206
		Minimum - maximum	0.0 - 0.1	0.0 - 0.0	5.6 - 11.1
	Dry lentils	Average CV	0.1 (28.09)	0.1 (42.54)	97.9 (43.50)
		Trend	2	2	-271
		Minimum - maximum	0.1 - 0.2	0.0 - 0.2	18.5 - 147.9
	Dry peas	Average CV	0.1 (26.95)	0.0 (25.89)	49.2 (38.37)
		Trend	3	0	-2131
		Minimum - maximum	0.0 - 0.1	0.0 - 0.1	17.1 - 76.6
	Beef and veal	Average CV	0.1 (2.72)	0.1 (7.22)	78.1 (5.47)
		Trend	1	2	726
		Minimum - maximum	0.1 - 0.1	0.1 - 0.1	70.9 - 86.4
	Goat meat	Average CV	0.0 (4.67)	0.0 (13.43)	159.8 (11.77)
		Trend	0	0	2405
		Minimum - maximum	0.0 - 0.0	0.0 - 0.0	141.0 - 203.8
	Sheep meat	Average CV	0.0 (3.21)	0.0 (9.53)	121.3 (9.86)
		Trend	0	0	-443
		Minimum - maximum	0.0 - 0.0	0.0 - 0.0	97.4 - 133.9

Table 2 shows production index statistics for each type of agricultural product.

Table 3. Yield index statistics for each type of agricultural product.

Weightings	Agricultural products	Statistics	$I^{g}_{z_0,t}$(Spain)	$I^{g}_{z_1,t}$(Morocco)	C^{g}_{t}
13.2	Grapes	Average CV	13.5 (10.12)	0.8 (12.50)	6.2 (14.46)
		Trend	81	20	114
		Minimum - maximum	11.8 - 16.6	0.6 - 1.0	4.6 - 1.0
12.1	Olives	Average CV	15.0 (24.33)	2.9 (23.35)	20.4 (37.27)
		Trend	281	97	281
		Minimum - maximum	8.3 - 21.3	1.7 - 4.1	12.2 - 4.1
9.9	Tomatoes, fresh	Average CV	11.1 (10.67)	3.2 (6.03)	29.0 (11.87)
		Trend	141	15	-246
		Minimum - maximum	9.2 - 12.8	3.0 - 3.5	23.5 - 3.5
9.8	Raw cow's milk	Average CV	10.8 (7.02)	3.6 (12.90)	33.6 (9.39)
		Trend	178	95	351
		Minimum - maximum	9.8 - 12.0	2.7 - 4.0	26.8 - 4.0
7.9	Barley	Average CV	5.9 (21.46)	1.5 (47.57)	26.7 (54.32)
		Trend	33	-36	-725
		Minimum - maximum	4.1 - 8.1	0.4 - 2.7	5.6 - 2.7
6.1	Wheat	Average CV	6.1 (18.97)	5.0 (33.88)	84.5 (39.44)
		Trend	141	30	-1311
		Minimum - maximum	4.4 - 7.8	2.3 - 7.3	31.5 - 7.3
4.8	Beef and veal	Average CV	4.6 (6.85)	1.7 (16.49)	38.0 (14.10)
		Trend	54	65	960
		Minimum - maximum	4.2 - 5.2	1.3 - 2.0	27.3 - 2.0
4	Meat Chicken	Average CV	4.6 (8.68)	1.8 (14.75)	38.7 (8.51)
		Trend	86	54	453
		Minimum - maximum	4.0 - 5.2	1.4 - 2.3	32.2 - 2.3
3.3	Oranges	Average CV	3.1 (9.77)	0.9 (14.97)	28.0 (14.56)
		Trend	40	21	291
		Minimum - maximum	2.6 - 3.5	0.7 - 1.1	21.5 - 1.1
3.1	Peaches and nectarines	Average CV	3.5 (12.94)	0.3 (35.86)	7.8 (36.74)
		Trend	37	20	536
		Minimum - maximum	3.0 - 4.5	0.2 - 0.4	4.7 - 0.4
2.7	Corn	Average CV	3.1 (11.46)	0.1 (57.40)	3.1 (67.82)
		Trend	34	-9	-352
		Minimum - maximum	2.5 - 3.7	0.0 - 0.2	0.7 - 0.2
2.4	Tangerines, mandarins	Average CV	2.4 (21.14)	1.0 (38.31)	42.5 (44.53)
		Trend	-7	76	3651
		Minimum - maximum	1.9 - 4.0	0.4 - 1.5	15.1 - 1.5
1.8	Strawberries	Average CV	2.1 (14.53)	1.0 (36.93)	51.5 (47.36)

Weightings	Agricultural products	Statistics	$I^{g}_{z_0,t}$(Spain)	$I^{g}_{z_1,t}$(Morocco)	C^{g}_{t}
		Trend	43	-19	-2141
		Minimum - maximum	1.7 - 2.6	0.7 - 2.3	35.5 - 2.3
1.6	Sheep meat	Average CV	1.3 (9.06)	1.6 (15.35)	125.0 (19.43)
		Trend	-18	48	5252
		Minimum - maximum	1.2 - 1.6	1.2 - 1.8	77.1 - 1.8
1.5	Raw ewe's milk	Average CV	1.9 (7.33)	0.1 (8.93)	6.6 (9.96)
		Trend	15	0	-48
		Minimum - maximum	1.5 - 2.0	0.1 - 0.1	5.7 - 0.1
1.4	Lemons and limes	Average CV	1.7 (20.65)	0.1 (24.55)	3.7 (17.89)
		Trend	70	3	43
		Minimum - maximum	1.1 - 2.2	0.0 - 0.1	2.4 - 0.1
	Sunflower seeds	Average CV	1.4 (13.59)	0.1 (39.72)	3.9 (38.83)
		Trend	-10	-2	-136
		Minimum - maximum	1.0 - 1.8	0.0 - 0.1	1.8 - 0.1
1.3	Pears	Average CV	1.0 (18.25)	0.1 (15.17)	9.6 (23.12)
		Trend	-39	0	374
		Minimum - maximum	0.8 - 1.3	0.1 - 0.1	7.1 - 0.1
1.2	Raw goat's milk	Average CV	1.2 (5.31)	0.1 (14.73)	9.6 (19.52)
		Trend	7	-1	-100
		Minimum - maximum	1.1 - 1.3	0.1 - 0.2	7.8 - 0.2
1.1	Apples	Average CV	1.0 (9.05)	1.0 (28.26)	102.4 (30.54)
		Trend	-6	58	6380
		Minimum - maximum	0.8 - 1.1	0.7 - 1.4	61.1 - 1.4
1	Rice	Average CV	1.3 (11.56)	0.1 (28.10)	6.4 (31.09)
		Trend	-18	2	288
		Minimum - maximum	0.9 - 1.4	0.0 - 0.1	1.9 - 0.1
0.8	Oats	Average CV	0.7 (25.31)	0.0 (75.76)	3.5 (77.77)
		Trend	12	-2	-309
		Minimum - maximum	0.5 - 1.1	0.0 - 0.1	0.4 - 0.1
0.7	Fresh garlic	Average CV	1.1 (30.86)	0.1 (36.85)	6.0 (56.13)
		Trend	75	0	-470
		Minimum - maximum	0.7 - 1.7	0.0 - 0.1	3.4 - 0.1
	Bananas	Average CV	0.7 (6.41)	0.6 (16.34)	78.1 (13.97)
		Trend	8	19	1668
		Minimum - maximum	0.7 - 0.8	0.4 - 0.7	57.8 - 0.7
0.6	Unshelled almonds	Average CV	0.9 (31.46)	0.4 (19.95)	44.9 (19.96)
		Trend	50	14	-720
		Minimum - maximum	0.5 - 1.5	0.3 - 0.6	30.0 - 0.6
	Fresh peas	Average CV	0.8 (19.73)	0.9 (22.69)	121.9 (36.21)
		Trend	32	-33	-8866
		Minimum - maximum	0.6 - 1.1	0.6 - 1.2	56.5 - 1.2
	Fresh peas	Average CV	0.5 (19.05)	0.5 (23.98)	98.3 (32.26)
		Trend	-18	13	6165
		Minimum - maximum	0.4 - 0.7	0.3 - 0.6	47.0 - 0.6
0.5	Eggplants	Average CV	0.6 (11.27)	0.1 (34.06)	22.4 (31.36)
		Trend	14	7	634
		Minimum - maximum	0.5 - 0.8	0.1 - 0.2	9.4 - 0.2
	Carrots and turnips	Average CV	0.5 (4.93)	0.5 (27.92)	105.9 (32.18)
		Trend	-1	8	1746
		Minimum - maximum	0.4 - 0.5	0.3 - 0.9	57.0 - 0.9
	Cherries	Average CV	0.8 (15.34)	0.1 (37.75)	11.8 (32.43)
		Trend	17	5	410
		Minimum - maximum	0.5 - 1.0	0.1 - 0.2	7.4 - 0.2
0.4	Plums and sloes	Average CV	0.4 (14.44)	0.3 (39.41)	64.5 (51.94)
		Trend	-10	21	6780
		Minimum - maximum	0.3 - 0.5	0.1 - 0.4	28.0 - 0.4
0.3	Apricots	Average CV	0.4 (22.44)	0.3 (21.49)	93.3 (45.40)
		Trend	12	-10	-7032
		Minimum - maximum	0.2 - 0.5	0.2 - 0.5	51.0 - 0.5
	Asparagus	Average CV	0.4 (13.75)	0.0 (87.59)	2.8 (92.03)
		Trend	10	-2	-557
		Minimum - maximum	0.3 - 0.4	0.0 - 0.0	0.0 - 0.0
	Broad and fava beans, green	Average CV	0.2 (15.99)	0.5 (28.81)	224.9 (31.16)
		Trend	-5	-19	-3854
		Minimum - maximum	0.2 - 0.3	0.3 - 0.8	138.8 - 0.8
0.2	Raspberries	Average CV	0.5 (70.46)	0.0 (6.84)	1.6 (53.84)
		Trend	77	0	-184
		Minimum - maximum	0.2 - 1.2	0.0 - 0.0	0.5 - 0.0
	Goat meat	Average CV	0.2 (8.42)	0.6 (14.51)	277.3 (13.18)
		Trend	1	19	7044
		Minimum - maximum	0.2 - 0.2	0.4 - 0.7	211.7 - 0.7
0.1	Unshelled peanuts	Average CV	0.0 (85.33)	0.2 (13.98)	21497.6 (133.82)
		Trend	0	-4	-2464850
		Minimum - maximum	0.0 - 0.0	0.2 - 0.3	1891.3 - 0.3

Weightings	Agricultural products	Statistics	$I^{g}_{z_0,t}$(Spain)	$I^{g}_{z_1,t}$(Morocco)	C^{g}_{t}
	Dates	Average CV	0.0 (28.10)	1.1 (19.21)	3461.4 (52.66)
		Trend	-1	43	186325
		Minimum - maximum	0.0 - 0.0	0.7 - 1.5	1622.4 - 1.5
	Soybeans	Average CV	0.0 (49.21)	0.0 (0.00)	45.2 (70.50)
		Trend	0	0	-5667
		Minimum - maximum	0.0 - 0.0	0.0 - 0.0	19.3 - 0.0
	Broad and fava beans, dry	Average CV	0.0 (34.29)	0.2 (38.66)	365.7 (46.84)
		Trend	0	-7	-15285
		Minimum - maximum	0.0 - 0.1	0.0 - 0.2	49.5 - 0.2
	Figs	Average CV	0.2 (33.37)	0.5 (23.76)	338.0 (33.03)
		Trend	12	19	-8059
		Minimum - maximum	0.1 - 0.3	0.3 - 0.7	131.0 - 0.7
	Rape or colza seeds	Average CV	0.1 (59.85)	0.0 (46.55)	1.9 (53.26)
		Trend	18	0	-162
		Minimum - maximum	0.0 - 0.3	0.0 - 0.0	0.9 - 0.0
	Dry lentils	Average CV	0.0 (28.42)	0.1 (50.54)	149.4 (47.76)
		Trend	1	1	-1286
		Minimum - maximum	0.0 - 0.1	0.0 - 0.1	6.7 - 0.1
	Unshelled walnuts	Average CV	0.1 (12.68)	0.1 (32.61)	84.3 (28.12)
		Trend	4	4	171
		Minimum - maximum	0.1 - 0.2	0.1 - 0.2	49.3 - 0.2
	Onions, shallots, fresh	Average CV	0.1 (27.07)	0.1 (38.26)	124.9 (43.81)
		Trend	-2	10	6123
		Minimum - maximum	0.1 - 0.1	0.1 - 0.2	40.3 - 0.2
	Chickpeas, dried	Average CV	0.1 (35.34)	0.1 (33.49)	159.9 (38.76)
		Trend	3	3	-4036
		Minimum - maximum	0.1 - 0.2	0.1 - 0.2	44.9 - 0.2
	Dry peas	Average CV	0.2 (26.60)	0.0 (44.59)	13.3 (47.76)
		Trend	3	-1	-773
		Minimum - maximum	0.1 - 0.2	0.0 - 0.0	2.3 - 0.0

Table 3 shows yield index statistics for each type of agricultural product.