A Logarithmic Linear Model for Fisheries and Aquaculture Products in EU26

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Abstract — In fisheries production, aquaculture sector is characterised as a "blue revolution" as it is the fastest developing food industry in the world. Fish farming and aquaculture products are constantly gaining ground than ever before on our daily dishes. Fishes are a great source of affordable protein which the human body needs in regular and specific quantities and also it serves as a major pharmaceutical ingredient such as fish oil soap, body cream and perfume. Moreover, fishes are now being used as raw materials for fillets, canning for eateries and fish feeds. Statisticians and Nutrition/Dietician experts predict that much of the vital protein food necessary to nourish an increasing global population of which pathetically, many are underfed even today will come from marine (saltwater) fisheries. With a total production of 52 million tons in 2017, aquaculture is seen by many as the only solution to replenish the vacuum created in fishes due to an increase in consumption and overfishing. Aquaculture is important because it offers an alternative to overburdening and depleting marine fishery stocks. Currently the depletion rate of European fish stocks is 88%. This study considers the use of a logarithmic linear model to analyse fisheries and aquaculture products in EU26. We consider using data from the European Market Observatory for fisheries and aquaculture, estimated on actual base year from 2006-2017. The analysis of association table (ANOAS) is given to ascertain the percentage of the data which is covered by each model. We investigate and estimate the association model with the best fit and in conclusion, find out that the Row-Column Effects Association Model (RC) of the multivariate model (M=8) has the best fit among all, covering almost 91% of the total data observed.

Index Terms — Association Model, Log-Linear and Non-Linear Models, Fisheries and aquaculture products, EU26.

I. INTRODUCTION

The European market for seafood is one of the largest in the world. However, compared to the 1980s and 1990s, when there was much growth in aquaculture fisheries, the continuation has not been encouraging. The European Commission has been making efforts to fight this stagnation with its new strategy. The most important countries engaged in the development of aquaculture fisheries as a whole are

those of Asia and Latin America. In the European Union, a country like Greece has the biggest challenge from neighbouring country – Turkey, which, contrary to EU law, subsidises its fish production by 0.60 cents per kilo, which often times creates conditions of unfair competition for Greek fisheries production. Purposely aimed with the program of withdrawal of fishing products, an 80% of the stocks in the European seas have been fished beyond their maximum sustainable performance.

Consumers' limited information is attributed to their cautious attitude towards fish farming both in terms of health effects and the environment. However, there are regular inspections and if there is any pollution or violation, the damages are paid by the producers themselves which ranges to a loss of many millions of euro. The fish grow in healthy and hygienic conditions and measurements show that at a distance of 50 meters around the cages, there is no adverse effect on the aquatic environment and the seabed.

Fighters (opponents) of fish farming argue or claim that the food which are being used in this production end up in a large proportion of marine resources, thereby, causing them to become entropy and disrupt the stability of the ecosystem. Moreover, to augment their critique they characterise fishes from fish farming and aquaculture as less healthy. Despite the disagreements that exist, most people agree that fish farming and aquaculture ensure jobs in rural and coastal population and enable investment at the local level.

Aquaculture produces know-how (expertise), which is essential for research and development in a country. But the most important of all is the fact that fish farming and aquaculture helps to reduce overfishing.

A. Aquaculture Production in the EU

Aquaculture refers to the farming of aquatic (freshwater or saltwater) organisms, such as fish, molluscs, crustaceans, and aquatic plants. Aquaculture data are reported in live weight equivalent and value. The EU aquaculture producers have primarily focused on four species namely: mussels (35%), salmon (15%), trout (14%) and oysters (7%) – with other important farmed species in the EU being sea bream, carp, sea bass and clams. In EU, aquaculture accounts for 20% of fish production and directly employs some 70,000 people. The sector is mainly composed of Small and Medium-sized enterprises (SMEs) or micro-enterprises in rural and coastal areas. EU aquaculture is renowned for its high quality, sustainability, and consumer protection standards. EU overall output has been more or less constant in volume since 2000 whereas global production at the same time has been growing by nearly 7% on yearly basis.

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Fig. 1. Aquaculture production in the EU.

Fig. 2. Volumes of main commodity groups farmed in the EU and % variations 2017/2016. Source EUMOFA.

Fig. 3. Values of main commodity groups farmed in the EU and % variations 2017/2016. Source EUMOFA.

TABLE 1: FISHERIES STATISTICS OF NIGERIA [1]

	1980	1990	2000	2010	2014	2015	2016
Employment (thousands)	469.07	490.00	1177.31	1519.64	1477.65	1565.36	1190.50
Aquaculture	...	...	...	0.01	...	...	...
Capture	469.07	490.00	1177.31	1519.63	1477.65	1565.36	1190.50
Inland	...	...	716.62	831.54	713.04	782.75	652.60
Marine	469.07	490.00	460.69	688.08	764.62	782.61	537.90

The contribution of a sector to national Gross Domestic Product (GDP) is a key macroeconomic indicator frequently referred to by decision-makers when highlighting a particular sector's importance for a national economy. Information on the contribution of a natural-resource sector to GDP is useful as one of many indicators, not only to monitor the progress of sustainable resource management, but also serves as key for effective monetary policy-making. Although, often not fully recognised as a major productive activity in many African countries, the contribution of fishery and aquaculture production to national economies could not be overemphasised. In addition, the supply of food from fishery products contributes to GDP, which in turn provides income for fish farmers and processors, will give a further boost to the government revenues through fisheries taxes. Fisheries in Africa are characterised by small-scale

B. Aquaculture Production in Africa Compared to Aquaculture in the EU

Africa has increased its contribution to global production from 1.2 percent to 2.2 percent in the past decades, though on a minimum scale. However, since 2010 there has been an increase of 39.5 percent as a result of rapid development in freshwater fish farming in sub-Saharan Africa, most notably in Nigeria, Ghana, Kenya, Uganda and Zambia. In West Africa fishing activities, mostly in the marine artisanal subsector, are a major contributor to GDP with high overall contributions in Ghana, Mauritania, and Sierra Leone. In Central Africa, inland fisheries are the major contributor to GDP with high overall contributions by the Democratic Republic of the Congo and Uganda. In Southern Africa, marine industrial fisheries are the major contributor to GDP.

As shown in Table 1, about 1519.64 people were reported as employed in fishery and aquaculture in 2010 with women contributing 8% of the total workforce. In 2014, 713.04 were reported as engaged in inland fisheries with women constituting a total of 21%. In 2015, the total fisheries production was estimated at 1027000 tonnes, in which marine catches contributed 36%, inland waters catch embraced 33% while aquaculture gained 31%. In 2016, a total of 537.90 people was reported to be engaged in other fisheries by 15% of women. Statistics from Food and Agriculture Organization of the United Nations has shown that Nigeria approximately imports a valued sum of USD 1.2 billion (750.000 tons) and exports USD 284 million annually on fish products from Europe, Latin America, and African countries. Fishery sector contributes to 0.5 percent of national GDP [1].

fisheries contributing greatly to employment. However, while fishing itself is clearly a vital source of employment, a previous study by the World Bank highlighted that the bulk of fisheries employment is in the post-harvest economic activities, which includes fish processing and marketing [2].

C. AbleKristal Farms

For many Nigerian farmers like AbleKristal Farms, fishery and aquaculture is an opportunity. Everyone has the power to influence what is produced through healthy food choices, which also contributes to more sustainable food systems. Fish farming involves raising fish in tanks or enclosures, usually for private or commercial purpose. The most common fish species raised by fish farmers in Nigeria are: Carp, tilapia, and catfish. AbleKristal Farms which is located in Umunkaru Umuawa-Alocha, Umuahia north of

Abia state, Nigeria mainly deals in Catfish, Tilapia, Feeds, Poultry, Agro-Allied Products, Pond Construction and Consultancy Services. AbleKristal global venture which is owned and managed by Mr Abel Ogbonna Ezechukwu and Mrs Christiana Uzoma Ezechukwu is helping to make fish farms more productive so that they can feed more Abians and Nigerians in general. Due to the fact that there isn't constant electricity supply in the rural and urban areas in Nigeria, innovations like charcoal dryers are being used for 'Smoke Fish' products which extend the shelf-life of one of Nigeria's staple foods, while fish farming is becoming more profitable. This method makes it more advantageous than capture fisheries based on the fact that you have the control in determining what kind of fish you want to farm, the quantity, location of farm feed and the treatment of the fishes at all times. Fishery and aquaculture production just like every other business ensures high levels of tenacity, commitment, adaptability, reliability, and special skills.

Based on the natural conditions in Nigeria, it is worth saying that there are basic conditions required for fishery and aquaculture in Nigeria. However, if Nigerians could use their scarce means for alternative uses according to circumstances that persist and raise fish with scientific methods, fish products in Nigeria market will be more efficient and effective in quantity and quality.

According to United Nations data, Nigeria's strongly growing population in 2017 was 190.873.246 million and its very high demand for fish positioned the country on a much more strongly market driven path based on commercial production as a result of rapid development in rural and urban areas. With capital investment, selection of the hardy catfish for farming, development of intensively good management of fish hatcheries and use of high quality fish feeds, farmers were able to establish a new model for raising fish in concrete tanks or natural pond in their courtyard, thus, minimising poaching (illegal hunt or catch fish on land that is not one's own or in contravention of official protection) and allow farmers to reap the rewards of their labour and perseverance. Unarguably, the Nigerian government is not doing much as expected to expand fishery and aquaculture scale and maximise annual production in order to meet domestic market demand [3].

D. Artisanal Fisheries

Artisanal fisheries constitute the most significant fishery sector in terms of people who engage in it. This sector, accounts for the majority of a country's fish production. However, this sector is the poorest in terms of its standard of living, with the fishermen generally making a sustainable living.

Capture fisheries which are equivalent to hunting in forests, involves hunting for fishes in their natural habitats along the coastline and the boundary of inland water, such as: dams, lakes, rivers, lagoon, etc. By hunting on land, fishermen make use of small-medium sized canoe and make basic tools like traps, nets, and hooks to catch fishes.

E. Macroeconomic Context

a) Marine Fuel {(Average price of marine diesel in Italy, France, Spain, and the UK (Euro/Litre))}

In 2017, the fuel price in the French ports of Lorient and

Boulogne was 0.44 EUR/litre and increased 5% compared with October 2017. Compared with 2016, it was 7% higher. In the Italian ports of Ancona and Livorno, the average price of marine fuel in 2017 was 0.45 EUR/litre. It increased 5% over the previous month and 10% over 2016. The price of marine fuel in the ports of A Coruña and Vigo, Spain reached an average of 0.44 EUR/litre in 2017 and increased 5% over 2017 and 13% over 2016. The fuel price observed in the UK ports of Grimsby and Aberdeen was 0.42 EUR/litre and increased 5% over the previous month. Compared with the same month a year ago, the fuel price increased 8%.

b) Food and Fish Prices

In October 2017, annual EU inflation was 1.7%, down from 1.8% in September 2017. A year earlier, the rate was 0.5%. In October 2017, the lowest annual rates were recorded in Cyprus (+0.4%), Ireland, Greece and Finland (all +0.8%), while the highest annual rates were registered in Lithuania (+4.2%), Estonia (+4.0%), and the UK (+3.0%). Compared with September 2017, annual inflation rose in 9 Member States, remained stable in five (Croatia, Luxembourg, Poland, Slovakia and the UK), and fell in fourteen (Belgium, Denmark, Germany, Greece, Spain, Italy, Latvia, Lithuania, Hungary, Austria, Slovenia, Finland, Sweden, and the Netherlands). In October 2017, prices of food and non-alcoholic beverages increased 0.7%, while prices of fish and seafood decreased 0.4%, compared with September 2017. Compared with October 2016, both food and fish prices increased 2.9% and 3.3%, respectively. Compared with October 2015, fish and seafood prices increased 6.7%, while food and non-alcoholic beverages increased 2.7%.

F. Challenges Facing Fishery and Aquaculture in African Countries

Surrounded by water from all directions, Africa is a continent with clearly defined borders. In the north it is separated from Europe by the Mediterranean Sea, in the northeast, is separated from Asia by the Suez Canal and farther by the Red Sea. From the east and southeast, it is surrounded by the Indian Ocean, from the west by the Atlantic Ocean. The total number of independent states in Africa is 54. The transcontinental country in this region is Egypt, also having a small part of its territory in Asia, on the other side of the Suez Canal, but politically it is a member of the African Union.

Among the African countries, the biggest one is Algeria, occupying around 7% of the continent's territory. And the smallest nation is Seychelles, the worldwide famous luxurious beach holiday destination, occupying 115 islands stretching along the mainland's eastern coast. Morocco is in the first place among the most popular travel spots in Africa, the second place belongs to South Africa, followed by Egypt and Tunisia [4].

Nigeria, one of the leading African countries is located in the West of Africa, whose land area is 923.768 square kilometres (356.669 sq. mi) is bordering Niger in the north, Chad in the northeast, Cameroon in the east and Benin Republic in the west. Coastal areas receive more rain every year while annual rainfall in the eastern region is 4318 mm, western region is 1778 mm, central region records 1270 mm

and northern region records only 508 mm.

Most African countries in the sub-Saharan Africa, most notably Nigeria, Ghana, Kenya, Uganda, and Zambia have been confronted with many challenges in fishery and aquaculture such as:

- Lack of capital which hinders the necessary variety improvement and as a result, fish farmers cannot be able to supply high-yield breeding varieties.
- The high cost of operations
- The high cost of spare parts of fishery and aquatic facilities as there are no provisions for assistance from the government.
- Fish firms have to operate their own cold room run on generators due to unavailability or unreliability of power systems, thereby operating at a very high cost on daily purchase of petrol or diesel.

G. African Fishery and Aquaculture Development

African government, through its agencies, continues to be the major source of funds for aquaculture research and development. Despite the numerous agricultural, commercial, merchant, and industrial banks in the African countries, access by aquaculturists to institutional credit remains a problem. Aquaculture has been a matter of less

importance in the successive government's plans and budgets in African countries and on a state platform.

In Nigeria it's worth saying that the existence of the Land Use Decree of 1978 was transformed into an Act in 1982, and its negative effect on land acquisition for aquaculture. This Land Act provides land ownership on the state, and the state governor has statutory power to revoke common occupation rights if it is in the general public interest. The negotiation process to secure land tenure rights is time-consuming and corruption-ridden, especially for large scale fishery and aquaculture farms. By virtue, there is a need to replace what has hitherto been a haphazard method of easy access to land to any other form of agriculture.

II. STATISTICAL DATA AND PROCESSING OF THE RESULTS

The data used in this study was obtained from the European Market Observatory for fisheries and aquaculture (EUMOFA), calculated on an annual basis. The processing of observations (data) consists of Fisheries and Aquaculture products in EU26. Below in table 2 are the lists of data under our study for the subsequent years (2006-2017).

TABLE 2: SHOWING FISHERIES AND AQUACULTURE PRODUCTS (IN TONNES) IN EU26 [5]

GEO/TIME	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	95	85	85	160	187	183	183	126	74	41	13	13
Bulgaria	473	544	425	778	365	294	231	447	249	315	326	443
Czech Republic	1820	1756	1723	1878	1948	2010	1921	1967	1938	2046	2043	2045
Denmark	4192	3970	4237	4267	4361	4157	3203	3777	4281	3901	2791	3117
Germany	8324	6543	7302	7957	6589	5341	4985	7428	5723	4469	3768	4500
Estonia	27	26	26	20	23	47	26	37	25	56	70	78
Ireland	3493	3685	4238	4386	5125	6094	6257	6252	5836	6005	5312	5250
Greece	3985	4884	5993	8427	9542	9751	8793	10143	9714	10627	11317	11319
Spain	23163	23917	31370	31819	30904	30892	25473	26820	29332	21937	29489	28498
France	28553	28724	26785	26486	26680	25166	25177	23962	24267	24516	23761	23745
Italy	18937	19572	20863	21037	21653	21833	18429	19188	11822	18110	17358	18099
Cyprus	79	97	118	142	188	188	186	182	218	239	361	320
Latvia	38	35	43	47	33	46	43	64	55	54	57	73
Lithuania	154	152	152	165	200	200	175	236	270	201	223	338
Hungary	808	933	1022	1195	1289	1306	1157	1187	1274	1366	1469	1592
Malta	155	180	195	200	175	124	112	89	87	74	717	859
Netherlands	9987	9821	12009	10876	7523	5704	5443	6654	7860	7137	4220	5337
Austria	295	302	291	307	285	239	233	223	227	242	250	254
Poland	2770	2868	2979	3371	3580	3546	3271	3544	3513	3792	3587	3689
Portugal	536	719	754	627	754	821	829	803	670	670	790	747
Romania	1390	1117	961	900	973	1082	925	904	814	728	911	1031
Slovenia	87	92	91	121	118	126	129	135	157	135	137	135
Slovakia	95	125	65	87	89	100	83	88	118	96	126	120
Finland	1766	1643	1602	1545	1540	1574	1513	1256	1282	1436	1289	1303
Sweden	824	668	548	600	483	677	562	633	599	588	755	537
United Kingdom	10990	12972	13742	15480	15249	17052	17904	18184	20720	17281	17185	17420

With the help of the Categorical Data Analysis program (CDAS), we were able to ascertain the results of our data for Fisheries and Aquaculture products in EU26, estimated on actual base year from 2006-2017. Table 2 above show the volumes, values and prices of fisheries and aquaculture products of all the models to be estimated. The statistics used to compare and contrast the association (correlation) of the models are X^2 (Pearson) Chi – Square and the Likelihood-Ratio Chi - Square G^2 -probability ratio [6]. In continuation, the following results are shown below:

A. Null Association-Independence Model (O)

The analysis using the independence model has the following results:

TABLE 3: THE INDEPENDENCE MODEL

Pearson chi-square	332746.22956
Likelihood-ratio chi-square	309659.39951
Degrees of freedom	275
Index of dissimilarity	0.16244
Final iteration	3
Maximum deviation	0.00

B. Uniform Association Model (U)

The analysis using the model of uniformity has the following results:

TABLE 4: THE UNIFORM MODEL

Pearson chi-square	208471.26698
Likelihood-ratio chi-square	214019.18509
Degrees of freedom	274
Index of dissimilarity	0.12955
Final iteration	12
Maximum deviation	0.00036294

C. Row-Effects Association Model(R)

The analysis using the row-effects model gives the following results:

TABLE 5: THE ROW-EFFECTS MODEL

Pearson chi-square	164211.97186
Likelihood-ratio chi square	174101.19092
Degrees of freedom	250
Index of dissimilarity	0.11428
Final iteration	15
Maximum deviation	0.00095094

D. Column-Effects Association Model (C)

The analysis using the columns-effects model of our have the following results:

TABLE 6: THE COLUMNS-EFFECTS MODEL

Pearson chi-square	77484.70225
Likelihood-ratio chi-square	77101.44234
Degrees of freedom	264
Index of dissimilarity	0.06840
Final iteration	18
Maximum deviation	0.00045139

E. Row-Column Effects Association Model I (R+C)

The analysis using the model of the column-effects in an additive method and have the following results:

TABLE 7: THE COLUMN-EFFECTS IN AN ADDITIVE METHOD

Pearson chi-square	46641.57876
Likelihood-ratio chi-square	45805.28468
Degrees of freedom	240
Index of dissimilarity	0.05407
Final iteration	17
Maximum deviation	0.00034113

F. Row-Column Effects Association Model II (RC)

The analysis using the model of the column-effects in a multiplicative method show the following results:

TABLE 8: THE COLUMN-EFFECTS IN A MULTIPLICATIVE METHOD

Pearson chi-square	27544.46188
Likelihood-ratio chi-square	27608.77251
Degrees of freedom	240
Index of dissimilarity	0.03980
Final iteration	17
Maximum Deviation	0.00099269

III. ASSOCIATION MODEL

In the categorical data analysis system, we apply the methodology by considering six of the most commonly used association models. These are:

1. The model of Independence or null association model which is also symbolized by (O) and holds that there is no relationship between the variables. The log-linear model is:

$$\text{Log}(F_{ij}) = \lambda + \lambda_{A(i)} + \lambda_{B(j)}$$

where log denotes the natural logarithm, F_{ij} the expected frequencies under the independence model, $\lambda_{A(i)}$ are the rows main effect and $\lambda_{B(j)}$ are the columns main effect [7].

2. The Uniform association model, which is symbolized by (U) in log-linear form is:

$$\log(F_{ij}) = \lambda + \lambda_{A(i)} + \lambda_{B(j)} + \phi \chi_i y_j$$

where ϕ is a single parameter for interaction and χ_i, y_j are the scores for the row and column variables ($i = 1, \dots, I, j = 1, \dots, J$) respectively.

3. The row effects model (R) where linear-by-linear interaction holds that

$$\log(F_{ij}) = \lambda + \lambda_{A(i)} + \lambda_{B(j)} + \phi \mu_i y_j \quad [16]$$

where y_j are fixed scores for the column variable ($j = 1, \dots, J$) and μ_i are unknown scores for the row variable ($i = 1, \dots, I$).

4. The column effects model (C) is the same as the R model with a change in subscripts:

$$\text{Log}(F_{ij}) = \lambda + \lambda_{A(i)} + \lambda_{B(j)} + \phi v_j x_i,$$

where x_i are fixed scores for the row variable ($i = 1, \dots, I$) and v_j are unknown scores for the column variable ($j = 1, \dots, J$).

5. The model that allows both row and column effects in additive form is called the R+C model [8]. The log-frequency version of the above model is:

$$\log(F_{ij}) = \lambda + \lambda_{A(i)} + \lambda_{B(j)} + \sum_{K=1}^{I-1} \beta_K y_j Z_{A(K)} + \sum_{K=1}^{J-1} \gamma_K x_i Z_{B(K)}$$

where χ_i, y_j are the scores (as defined earlier), $Z_{A(i)}$ and $Z_{B(j)}$ denote to variables (dummy variables) for the row and column levels respectively.

6. The model, instead of additive row and column effects on the local odds ratios, has multiplicative effects called the R*C model or model II [9]. The log-multiplicative model is:

$$\log(F_{ij}) = \lambda + \lambda_{A(i)} + \lambda_{B(j)} + \phi \mu_i v_j,$$

where the row score parameters μ_i and column score parameters v_j are not known but are estimated in the data.

Our goal is to find out the model that has the best fit among the 6 models which we are examining, i.e., the production of aquaculture fishing products (in tonnes) in EU26 for the period 2006-2017. For this reason, we are going to first examine the Index of Dissimilarity (L2), which shows that, the lesser the number, the more our model will give the best fit to match the data under consideration.

We analyse the six association model describe above, with the help of the categorical data analysis statistical programme [10]. We used the Pearson chi-squared (X^2) statistics, the likelihood-ratio chi-square (G^2) statistics and the index of dissimilarity which is equated by:

$$D = \sum_{ij} |f_{ij}/n - F_{ij}/n|/2 \quad (1)$$

where f_{ij} are the observed frequencies and F_{ij} are the expected frequencies (under the model).

Additionally, we have the following results as shown in the table below:

TABLE 9: INDEX OF DISSIMILARITY	
Null Association-Independence Model (O)	0.16244
Uniform Association Model (U)	0.12955
Row-Effects Association Model (R)	0.11428
Column-Effects Association Model (C)	0.06840
Row+Columns Effects Association Model (R+C)	0.05407
Row Column Effects Association Model (RC)	0.03980

In Table 9 above, it seems at first sight that the Row Column Effects of the Association Model (R*C) adjusted better to the percentage of the production of fisheries products (in tonnes) in EU26 for the period 2006-2017 for the years under study (having the lowest index of dissimilarity) with $D=0.03980$.

Since we have models with similar lower ratio, we justify the model with the best fit to match both counties and years by calculating the Index BIC (Bayesian information criterion). In statistics, the Bayesian information criterion (BIC) or Schwarz criterion is a criterion for model selection among a finite set of models; the model with the lowest BIC is preferred. It is based, in part, on the likelihood function. When fitting models, it is possible to increase the likelihood by adding parameters but doing so may result in over-fitting. BIC attempt to resolve this problem by introducing a penalty term for the number of parameters in the model and gives the best solution [11].

The formula for this calculation is:

$$BIC = G^2 - (D.F.) \log(n) \quad (2)$$

Notations:

G^2 = the likelihood-ratio chi-square statistics.

d.f. = degrees of freedom of the models.

n = the size of our sample (1807901.0000).

$\log(n) = \text{Log}(1790717.6000) = 14.4077$.

When comparing a number of models, the model with the smallest index of BIC is assumed to be the best. So, we choose the models that have similar and lowest INDEX OF DISSIMILARITY out of the six models. More precisely, we will consider the 4th, 5th and 6th models respectively. Subsequently, the calculation is as follows:

$$4^{\text{th}} \text{ model: } BIC = G^2 - (d.f) \log(n) = 0.80136 - (264 \times 14.4077) = 73298.8095$$

$$5^{\text{th}} \text{ model: } BIC = G^2 - (d.f) \log(n) = 45805.28468 - (240 \times 14.4077) = 42347.59434$$

$$6^{\text{th}} \text{ model: } BIC = G^2 - (d.f) \log(n) = 27608.77251 - (240 \times 14.4077) = 24150.92451$$

From the above calculations, it could be observed that the 6th model – Row Column Effects Association Model (RC) finally accounts for the best fit from the results because it has the smallest index of BIC.

A. Analysis of Association Model

In continuation, the association model passes through several tests to ascertain the accuracy, quality, or satisfactory fit of each model. Tests are done through the use of the likelihood-ratio chi-square (G^2) statistics and the Pearson chi-squared (X^2) distribution. In the case of the X^2 distribution, the Statgraph programme will be of good help.

Initially, we observe that the likelihood-ratio chi-square statistic for the Independence model (O) which is $G^2=520884.36900$ with 275 degrees of freedom. The 95% reference point chi-square distribution is 315.233. It has unacceptable fit because the X^2 distribution is $< G^2$.

Subsequently, the Uniform association model has $G^2=465436.18993$ with 274 degrees of freedom. The 95% reference point chi-square distribution is 314.158. As it could be noticed, this statistic is not accepted and does not have a satisfactory fit since the X^2 distribution is $< G^2$.

Moreover, the statistic G^2 for the Row model (R) is reduced dramatically for 348506.13881 with 250 degrees of freedom. The 95% reference point chi-square distribution is 288.315. The row model is also not accepted because the X^2 distribution is $< G^2$.

The Column model (C) has $G^2=275030.86927$ with 264 degrees of freedom. The 95% reference point chi-square distribution is 303.398 which show even the worst fit as we could observe that the X^2 distribution is $< G^2$.

The statistics of the model R+C, that considers the effects for both Countries and Years in additive form, is $G^2=164882.12076$ with 240 degrees of freedom. The 95% reference point chi-square distribution is 277.528 has equally unacceptable fit since the X^2 distribution is $< G^2$.

Finally, the model RC, that is log multiplicative but not log-linear, the G^2 Statistics is 42921.51701 with 240 degrees of freedom. The 95% reference point chi-square distribution is 277.528. Furthermore, the statistics is dramatically reduced just as the previous model because they have identical degrees of freedom but is shown to remain unacceptable fit because the X^2 distribution is $< G^2$.

By virtue of the index of dissimilarity of the models as mentioned earlier, the model RC has the best fit. However, upon clear test to ascertain the accuracy, quality, or satisfactory fit of the model, we find out that it has a very poor fitting, making it unacceptable [12], [13].

Consequently, we have to find out the degree or level of effects on each model. To verify this, we will construct the analysis of association (ANOAS) Table.

B. Analysis of Association Table (ANOAS)

The ANOAS table in table 10 below was given by [14]. In this table, the X^2 is divided so that it can be used as two factor analysis of variance by making use of the G^2 (0) statistics for the base (zero) independence model which measures the total deviation of the variables. In other words, we can find the percentage of the baseline chi-squared X^2 distribution, which have effects on each of the models on the phenomenon being studied.

TABLE 10: ANOAS

Models	Likelihood-G ²	DF	Index of Dissimilarity
O	309659.39951	275	0.16244
U	214019.18509	274	0.12955
R	174101.19092	250	0.11428
C	77101.44234	264	0.06840
R+C	45805.28468	240	0.05407
RC	27608.77251	240	0.03980

The analysis of association table (ANOAS) has the following differences of our models: O-U is the overall or total effects of the models, U-C are the column effects model, C-CR are the column effects model which gives the effects of the column RC and the residuals of the models.

TABLE 11: ANOAS MODEL UNIFORMITY

Models	G ² Values	D.F.	P %)
1. General Effects (O-U)	95640.2145	1	30.89%
2. Rows Effects (U-C)	136917.7427	24	47.31%
3. Column-effects which gives the Row-effects (C-RC)	49492.66983	24	15.98%
4. Residual (RC)	27608.77251	240	5.82%
Total (O)	309659.39951	275	100.00%

From the ANOAS table we created, the uniform association model (U) as shown in table 11 above, covers 30.89% of the total baseline chi-squared X^2 distribution, the Row model (R) accounts for a large percentage of 47.31%, the Column-effects which gives the Row-effects (C-RC) covers a small percentage of 15.98% of the baseline chi-squared value. Finally, the row column effects (Residuals) are weaker because the RC model accounts for only 5.82% of the baseline chi-squared value.

We could therefore observe that at the rate of 5.82%, the variation which is attributed to the null-independence has been measured from the model of RC. This rate is quite satisfactory and we can say that the corresponding

percentage of population change in 25 countries of the European Union (Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden and United Kingdom), as shown from the data depended slightly positive on the association of both the countries and also from the years under our study (2006-2017).

We could as well say that the percentage of $(309659.39951 - 27608.77251) / 309659.39951 = 91\%$ of the data is explained by the column effects model (on the local odds ratios in a multiplicative way), thus, giving it a satisfactory fit but unacceptable due to its poor fit as was earlier found in our study, i.e. the value of the Pearson chi-squared X^2 distribution for the 95% reference point are bigger than the model (RC).

Furthermore, because our best model (RC) under our study is unacceptable as a result of its bad fit based on the index BIC, upon clear examination to test the accuracy, quality or satisfactory fit of the model, therefore, we'll proceed to examining the multivariate model to find the model with a satisfactory fit.

IV. THE MULTIVARIATE MODELS

In the RC (M) association model, M represents the dimension fit to be, which is utilized by the row-column dimension (RCDIM PROGRAM). As shown in table 12 below the multivariate model RC (M=8) is the acceptable model with the best fit (having the $X^2 > G^2$ and it also has the lowest degree of freedom [12].

- Model RC (4) multivariate row, column, M=4
- Model RC (5) multivariate row, column, M=5
- Model RC (6) multivariate row, column, M=6
- Model RC (7) multivariate row, column, M=7
- Model RC (8) multivariate row, column, M=8

TABLE 12: THE MULTIVARIATE MODEL

Model	RC (4)	RC (5)	RC (6)	RC (7)	RC (8)
X^2	5183.00041	2905.09828	1328.76963	492.57615	282.82138
G^2	5170.48767	2914.45914	1337.01587	490.17592	280.65305
D.F.	147	120	95	72	51
D	0.01771	0.01104	0.00636	0.00340	0.00245

A. Examination of the Multivariate Model

In the RC (M) association model, M represents the dimension to be fit, which is utilized by PROG RCDIM. As it is shown in table 12 above the multivariate model RC (M= 8) is the acceptable model with the best fit.

The multivariate model RC (4) with M=4 has likelihood-ratio chi-square statistic $G^2 = 5170.48767$ with 147 degrees of freedom (d.f.). Thus, we find out that the 95% reference point of the X^2 distribution is 5183.00041. It has a bad fit. We could conclude therefore that this model has a bad fit because the X^2 distribution is much smaller than the likelihood-ratio chi-square statistic G^2 .

Moreover, the multivariate model RC (5) with M=5 has likelihood-ratio chi-square statistic $G^2 = 2914.45914$ with 120 degrees of freedom (d.f.). The 95th percentile of the

reference chi-square distribution is 2905.09828. Similarly, this model has a bad fit since the X^2 distribution is much smaller than the likelihood-ratio chi-square statistic G^2 .

The multivariate model RC (6) with M=6, has likelihood-ratio chi-square statistic $G^2 = 1337.01587$ with 95 degrees of freedom (d.f.). Thus, we find out that the 95% reference point of the X^2 distribution is 1328.76963. It has a very bad fit, thus, making it unacceptable.

The multivariate model RC (7) with M=7, has likelihood-ratio chi-square statistic $G^2 = 490.17592$ with 72 degrees of freedom (d.f.). Thus, we find out that the 95% reference point of the X^2 distribution is 492.57615. Here we could see that the multivariable RC model with M= has a satisfactory fit since the 95% reference point of the X^2 distribution is greater than the likelihood-ratio chi-square statistic G^2 .

Finally, the multivariate model RC (8) with M=8, has

likelihood-ratio chi-square statistic $G^2 = 280.65305$ with 51 degrees of freedom (d.f.). The 95% reference point of the X^2 distribution is 282.82138. The multivariable RC model with $M = 8$ has the best fit and with the lowest degree of freedom since the 95% reference point of the X^2 distribution is greater than the likelihood-ratio chi-square statistic G^2 . We equally observed that the model $M=8$ covers $\{(309659.39951-27608.77251) / 309659.39951\} = 91\%$ of all observations.

When a multivariate model with a smaller M and with the lowest degree of freedom has a satisfactory fit, it is accepted because it gives a better explanation of the interaction between the rows and columns models. Therefore, we will prefer the multivariate model $M=8$ which has a perfect fit.

B. Evaluation of the Multivariate Model

The practical implementation of multivariate statistics to a particular problem involve several types of univariate and multivariate analysis in order to understand the relationships between variables and their relevance to the actual problem being studied. In addition, multivariate statistics is concerned with multivariate probability distributions, in terms of both: how these can be used to represent the distributions of observed data; and how they can be used as part of statistical inference, particularly where several different quantities are of interest to the same analysis [13].

The expected frequencies under the independent and column effects models for the production of Aquaculture Fisheries products in EU26 are given below:

Note: The multivariate model RC ($M=8$) seems to give much better fit, particularly at the end of nominal scale.

TABLE 13: EVALUATION OF THE MULTIVARIATE MODEL

Countries	Years	Data	Values of Model 0	Values Of Rc(M=8)
Row	Column	Data	Observed Model (Fij ¹)	Expected Model (Fij ²)
1	1	95	153	80
1	2	85	86	106
1	3	85	180	98
1	4	160	98	141
1	5	187	96	172
1	6	183	95	195
1	7	183	88	166
1	8	126	93	146
1	9	74	90	75
1	10	41	87	39
1	11	13	88	15
1	12	13	90	11
2	1	473	600	462
2	2	544	339	556
2	3	425	707	437
2	4	778	386	733
2	5	365	378	421
2	6	294	375	269
2	7	231	344	234
2	8	447	363	452
2	9	249	355	252
2	10	315	341	305
2	11	326	347	301
2	12	443	354	469
3	1	1820	2835	1804
3	2	1756	1602	1776
3	3	1723	3337	1739
3	4	1877	1825	1839
3	5	1947	1786	1967
3	6	2009	1770	2004
3	7	1921	1625	1913
3	8	1967	1716	1982

3	9	1938	1675	1941
3	10	2045	1610	2037
3	11	2043	1639	2026
3	12	2045	1671	2063
4	1	4192	5678	4230
4	2	3970	3209	3923
4	3	4237	6685	4201
4	4	4267	3655	4343
4	5	4361	3578	4340
4	6	4157	3545	4154
4	7	3203	3255	3224
4	8	3777	3437	3741
4	9	4281	3355	4275
4	10	3901	3225	3917
4	11	2791	3283	2826
4	12	3117	3348	3081
5	1	8324	8953	8327
5	2	6543	5060	6541
5	3	7302	10541	7294
5	4	7957	5764	8018
5	5	6589	5642	6462
5	6	5341	5589	5412
6	12	78	33	78
7	1	3493	7603	3572
7	2	3685	4297	3588
7	3	4238	8951	4174
7	4	4386	4895	4438
7	5	5125	4791	5333
7	6	6094	4746	5932
7	7	6257	4359	6267
7	8	6252	4602	6205
7	9	5836	4492	5816
7	10	6005	4318	6040
7	11	5312	4396	5463
7	12	5250	4483	5105
8	1	3985	12828	3902
8	2	4884	7250	4991
8	3	5993	15103	6064
8	4	8427	8258	8351
8	5	9542	8083	9376
8	6	9751	8008	9882
8	7	8793	7355	8751
8	8	10143	7764	10216
8	9	9714	7579	9730
8	10	10627	7286	10599
8	11	11317	7417	11221
8	12	11319	7564	11411
9	1	23163	40956	23199
9	2	23917	23146	23856
9	3	31370	48218	31341
9	4	31819	26365	31795
9	5	30904	25808	31100
9	6	30892	25567	30780
9	7	25473	23480	25555
9	8	26820	24788	26744
9	9	29332	24197	29332
9	10	21937	23262	21922
9	11	29489	23680	29420
9	12	28498	24148	28571
10	1	28553	37790	28460
10	2	28724	21356	28850
10	3	26785	44490	26857
10	4	26486	24327	26490
10	5	26680	23812	26292
10	6	25166	23590	25428
10	7	25177	21665	25119
10	8	23962	22872	24049
10	9	24267	22326	24285
10	10	24516	21464	24497
10	11	23761	21849	23663
10	12	23745	22281	23833
11	1	18937	27856	18978
11	2	19572	15742	19515
11	3	20863	32794	20826
11	4	21037	17932	21084
11	5	21653	17553	21709
11	6	21833	17389	21789
11	7	18429	15970	18474
11	8	19188	16859	19134
11	9	11822	16457	11817

11	10	18110	15821	18117
11	11	17358	16105	17359
11	12	18099	16423	18099
12	1	79	285	77
12	2	97	161	99
12	3	118	335	119
12	4	142	183	144
12	5	188	179	175
12	6	188	178	198
12	7	186	163	189
12	8	182	172	181
12	9	218	168	219
12	10	239	162	237
12	11	361	165	351
12	12	320	168	330
13	1	38	72	40
13	2	35	41	33
13	3	43	85	42
13	4	47	46	46
13	5	33	45	43
13	6	46	45	40
13	7	43	41	44
13	8	64	44	63
13	9	55	43	55
13	10	54	41	54
13	11	57	42	60
13	12	73	43	70
14	1	154	303	164
14	2	152	171	142
14	3	152	356	143
14	4	165	195	187
14	5	200	191	195
14	6	200	189	195
14	7	175	174	165
14	8	236	183	238
14	9	270	179	266
14	10	201	172	211
14	11	223	175	262
14	12	338	178	299
15	1	808	1792	807
15	2	933	1013	939
15	3	1022	2110	1024
15	4	1195	1154	1198
15	5	1289	1129	1281
15	6	1306	1119	1305
15	7	1157	1027	1133
15	8	1187	1085	1205
15	9	1274	1059	1271
15	10	1366	1018	1374
15	11	1469	1036	1511
15	12	1592	1057	1550
16	1	155	364	154
16	2	180	206	184
16	3	195	429	195
16	4	200	234	210
16	5	175	230	153
16	6	124	227	133
16	7	112	209	94
16	8	89	220	102
16	9	87	215	85
16	10	74	207	81
16	11	717	211	747
16	12	859	215	828
17	1	9987	11365	10017
17	2	9821	6423	9784
17	3	12010	13380	11987
17	4	10876	7316	10885
17	5	7523	7161	7626
17	6	5704	7094	5629
17	7	5443	6515	5447
17	8	6654	6878	6637
17	9	7860	6714	7852
17	10	7137	6455	7149
17	11	4220	6571	4278
17	12	5337	6701	5281
18	1	295	386	288
18	2	302	218	311
18	3	291	455	297
18	4	307	249	300
18	5	285	244	273

18	6	239	241	248
18	7	233	222	228
18	8	223	234	230
18	9	227	228	228
18	10	242	220	240
18	11	250	223	244
18	12	254	228	259
19	1	2770	4973	2755
19	2	2868	2811	2887
19	3	2979	5855	2992
19	4	3371	3201	3357
19	5	3580	3134	3550
19	6	3546	3105	3570
19	7	3271	2851	3267
19	8	3544	3010	3555
19	9	3513	2938	3516
19	10	3792	2825	3786
19	11	3587	2875	3563
19	12	3689	2932	3712
20	1	536	1071	583
20	2	719	605	656
20	3	754	1260	710
20	4	627	689	706
20	5	754	675	762
20	6	821	668	800
20	7	829	614	870
20	8	803	648	748
20	9	670	632	664
20	10	670	608	684
20	11	790	619	809
20	12	747	631	728
21	1	1390	1441	1400
21	2	1117	814	1109
21	3	961	1696	954
21	4	900	927	910
21	5	973	908	996
21	6	1082	899	1057
21	7	925	826	901
21	8	904	872	916
21	9	814	851	808
21	10	728	818	741
21	11	911	833	976
21	12	1031	849	967
22	1	87	180	85
22	2	92	102	95
22	3	91	211	93
22	4	121	116	115
22	5	118	113	123
22	6	126	112	124
22	7	129	103	127
22	8	135	109	137
22	9	157	106	157
22	10	135	102	134
22	11	137	104	136
22	12	135	106	136
23	1	95	146	97
23	2	125	83	121
23	3	65	172	63
23	4	87	94	88
23	5	89	92	96
23	6	100	91	96
23	7	83	84	88
23	8	88	89	83
23	9	118	86	118
23	10	96	83	96
23	11	126	85	123
23	12	120	86	123
24	1	1766	2179	1731
24	2	1643	1231	1693
24	3	1602	2565	1636
24	4	1545	1403	1478
24	5	1540	1373	1555
24	6	1574	1360	1572
24	7	1513	1249	1464
24	8	1256	1319	1311
24	9	1282	1287	1284
24	10	1436	1238	1431
24	11	1289	1260	1310
24	12	1303	1285	1283
25	1	824	917	816

25	2	668	518	665
25	3	548	1080	558
25	4	600	590	534
25	5	483	578	595
25	6	677	573	630
25	7	562	526	613
25	8	633	555	602
25	9	599	542	607
25	10	588	521	561
25	11	755	530	650
25	12	534	541	641
26	1	109901	51165	109888
26	2	12972	28915	12989
26	3	137421	60236	137433
26	4	15480	32937	15465
26	5	15249	32240	15229
26	6	17051	31940	17068
26	7	17904	29333	17896
26	8	18184	30966	18197
26	9	20720	30228	20722
26	10	17281	29060	17277
26	11	17185	29582	17173
26	12	17420	30166	17431

F_{ij}^1 : Expected frequencies of the independence model.

F_{ij}^2 : Expected frequencies of the multivariate model $M = 8$.

From Table 13 above, it is evident that the prices (value) of the model RC ($M = 8$) fully fitted to the data.

V. LOGARITHMS OF THE ROW COLUMN-EFFECTS ASSOCIATION MODEL - RC ($M = 8$)

TABLE 14: RC ($M=8$) FROM THE RCDIM (ROW TAU-S)

Belgium: $\hat{\tau}_1 = \log(-2.650338) = -0.9747$
Bulgaria: $\hat{\tau}_2 = \log(0.562528) = -0.5753$
Czech Repub.: $\hat{\tau}_3 = \log(0.562528) = -0.5753$
Denmark: $\hat{\tau}_4 = \log(1.249348) = 0.2226$
Germany: $\hat{\tau}_5 = \log(1.685072) = 0.5218$
Estonia: $\hat{\tau}_7 = \log(-3.44861) = -1.2380$
Ireland: $\hat{\tau}_7 = \log(1.53227) = 0.4268$
Greece: $\hat{\tau}_8 = \log(2.026636) = 0.7064$
Spain: $\hat{\tau}_9 = \log(3.227259) = 1.1716$
France: $\hat{\tau}_{10} = \log(3.152116) = 1.1481$
Italy: $\hat{\tau}_{11} = \log(2.838151) = 1.0432$
Cyprus: $\hat{\tau}_{12} = \log(-1.82367) = -0.601$
Latvia: $\hat{\tau}_{13} = \log(-3.130036) = -1.1410$
Lithuania: $\hat{\tau}_{14} = \log(-1.700391) = -0.5309$
Hungary: $\hat{\tau}_{15} = \log(0.08966) = -2.4117$
Malta: $\hat{\tau}_{16} = \ln(-1.82028) = -0.5990$
Netherlands: $\hat{\tau}_{17} = \log(1.950344) = 0.6680$
Austria: $\hat{\tau}_{18} = \log(-1.434601) = -0.3601$
Poland: $\hat{\tau}_{19} = \log(1.121537) = 0.115$
Portugal: $\hat{\tau}_{20} = \log(-0.414971) = 0.8795$
Romania: $\hat{\tau}_{21} = \log(-0.1247) = 2.0818$
Slovenia: $\hat{\tau}_{22} = \log(-2.2101) = -0.7930$
Slovakia: $\hat{\tau}_{23} = \ln(-2.41695) = -0.8825$
Finland: $\hat{\tau}_{24} = \log(0.2956) = -1.2187$
Sweden: $\hat{\tau}_{25} = \ln(-0.56996) = 0.5622$
United Kingdom: $\hat{\tau}_{26} = \ln(3.06409) = 1.1197$

VI. RESEARCH FINDINGS & COMPARISON OF THE FISHERIES AND AQUACULTURE PRODUCTS IN EU26

Based on the logarithms of the Row Column-effects Association Model - RC ($M=8$) in Table 14 above, we compared some of the countries in the EU26 to ascertain the variation in production within the aquaculture fishery products from 2006-2017. The differences were observed: If we want to compare 2 countries then we get the difference of effects. For example:

When compared Greece and France, we realised that: $\hat{\tau}_8 - \hat{\tau}_{10} = 0.7064 - 1.1481 = -0.4417$, $\exp(-0.4417) = 0.6429$. It means that Greece has 0.6429 lesser tons of fishery products than France.

We compared Sweden with Poland: $\hat{\tau}_{25} - \hat{\tau}_{19} = 0.5622 - 0.115 = 0.4472$, and $\exp(0.4472) = 1.5639$. In other words, Sweden has 1.5639 tons of fishing products in aquaculture higher than that of Poland.

Comparing two Mediterranean countries like Spain and Italy, we find that: $\hat{\tau}_9 - \hat{\tau}_{11} = 1.1716 - 1.0432 = 0.0235$, $\exp(0.0235) = 1.02379$. This means that Spain has 1.02379 tons of fishing products in aquaculture more than Italy.

The comparison of Denmark with Ireland was: $\hat{\tau}_4 - \hat{\tau}_7 = 0.2226 - 0.4268 = -0.2042$, $\exp(0.2042) = 0.8153$. The difference between the two countries shows that Denmark has 0.8153 tons below the fishery products in Ireland.

By comparing Romania and Portugal, we have: Romania: $\hat{\tau}_{21} - \hat{\tau}_{20} = 2.0818 - 0.8795 = 1.2023$, $\exp(1.2023) = 3.3278$. The difference has a remarkable significance because Romania's production of fishery products is much more with 3.3278 tons in contrast with Portugal.

In the case of France and Germany we have: $\hat{\tau}_{10} - \hat{\tau}_5 = 1.1481 - 0.5218 = 0.6263$, $\exp(0.6263) = 1.8707$. From our observation, we could say that France has 1.8707 tons of production of fishery products than that of Germany.

Finally, the contrast between United Kingdom and Netherlands are: $\hat{\tau}_{26} - \hat{\tau}_{17} = 1.1197 - 0.6680 = 0.4517$. $\exp(0.4517) = 1.5710$. As it could be observed, the United Kingdom has 1.5710 tons of production of fishery products more than the Netherlands.

As shown in Table 15, ten EU Member States and Norway in 2017, reported first-sales data for 11 commodity groups. First-sales value increased over the previous year (2016) for Italy and Latvia. An opposite trend was experienced in Belgium, Denmark, Estonia, Norway, Portugal, Sweden, and the UK. First-sales value remained stable for France. Belgium's first sales decreased in both value (-3%) and volume (-5%) in 2016. The main factors in the decrease were the drop in first-sales values and volumes for cod (-19% in value, -18% in volume), red mullet (-35% in both value and volume), and sole (-14% in value, -11% in volume). The decrease observed during the first eight months of the year ended with the sharp increase in value and volume (+33% and +22%, respectively) registered in September 2017 compared with September 2016. Of the main species, leading contributors to the increase in first-sales were sole (+40% in value, +43% in volume) and plaice (+32% in value, 17% in volume).

TABLE 15: FIRST-SALES OVERVIEW OF 11 EU COUNTRIES (VOLUME IN TONS AND VALUE IN MILLION EUR) [5]

Country	January-September 2015		January-September 2015		January-September 2015		Change from January-September 2016	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
Belgium	12.671	48.50	12.192	47.55	11.576	46.33	-5%	-3%
Denmark	193.409	229.64	179.170	263.64	183.943	249.60	3%	-5%
Estonia	38.042	8.61	33.958	8.12	33.292	7.84	-2%	-4%
France	147.072	486.12	144.096	482.57	142.767	484.32	-1%	0%
Italy	65.620	240.70	63.480	238.87	66.113	246.94	4%	3%
Latvia	37.024	9.17	36.280	7.83	41.705	8.47	15%	8%
Norway	2.127.510	1.560.64	1.935.845	1.622.97	2.047.402	1.567.18	6%	-3%
Portugal	86.591	145.40	78.590	151.08	74.034	148.63	-6%	-2%
Spain	340.396	832.43	384.751	965.01	456.177	900.21	-7%	-7%
Sweden	131.366	74.61	84.692	65.86	63.251	50.44	-25%	-23%
UK	291.407	523.88	318.109	579.67	228.030	415.23	-28%	-28%

Source: [5], volume data is reported in net weight.

The greatest increase in average prices was observed for cod and brill (both +14%). In 2017 Denmark's, first-sales value was EUR 250 million, a 5% decrease in 2016; volume increased 3% at 184.000 tonnes. Lower prices of herring (-16%), cod (-3%), and plaice (-9%) contributed to the decrease in value, whereas the larger landings of herring (+10% at 95.780 tonnes) increased overall volume. The decrease in first-sales value (-3%) in 2016 was caused by herring, cod, Norway lobster, and plaice. Higher first-sales volume of mussel *Mytilus* spp. (+160%), saithe (+17%), and hake (+14%) contributed to the overall increase in volume (+29%). Mussel volume increased significantly due to opening and closing of fishing areas in Denmark.

Estonia experienced decreases in both first-sales value and volume (-4% and -2%, respectively) from the same period a year before. Sprat (-10% in value, -6% in volume) and pikeperch (-54% in both value and volume) were most responsible for the decreases. In 2017, the trend was reversed; first-sales value and volume increased significantly (+158% and +385%, respectively), over 2016. The increases were caused by significantly higher first-sales prices as well as larger landings of herring and sprat. In addition, volume increased because of European perch (+27%). Except for European perch (+12%), average prices of herring and sprat experienced an opposite trend, and both decreased 19%.

In France, first sales remained stable: unchanged in value and 1% lower in volume, in 2016. In 2017, there was a minor rise in the average price (+2%), the first sales increased in value (+2%) but did not change in volume compared with 2016. The top four species, anchovy, albacore tuna, cuttlefish, and ling, recorded a significant increase in value (+109%, +43%, +63%, and +25%, respectively) and only cuttlefish among these four registered a rise in price, from 4,14 to 5,08 EUR/kg (+23%). Among the top ten species, the largest increase in volume was noted for anchovy (+212) due to fisheries seasonality, while the largest decreases were observed for sardine (-24%) and mackerel and monk (both -11%).

In 2017, Italy's first sales increased in both value (+3%) and volume (+4%) over the same period in 2016. Anchovy, clam, deep-water rose shrimp, hake, swordfish, octopus, and red mullet altogether represented 49% and 57% of total first-sales value and volume, respectively. A positive trend could be observed in value (+3% over 2016), whereas first-sales value decreased (-17%). The three most important species

in value in 2017 were clam, sardine, and deep-water rose shrimp, which registered increases in value (+3%, +95%, and +23%, respectively, over 2016) despite a significant fall in price (-16%) for deep-water rose shrimp, from 6,77 EUR/kg in 2016 to 5,70 EUR/kg in 2017.

Latvia experienced increases in first-sales value (+8%) and volume (+15%) in 2017, over the year 2016. This was caused by higher first-sales prices of cod (+44%), sprat (+14%), and smelt (+43%) as well as with larger landings of these species. In 2017, a greater volume of cod (+25%), European flounder (+24%), and sprat (+53%) contributed to the overall increase in volume of 16% over 2016. A drop in the first-sales price of herring and sprat (-4% and -9%, respectively) did not affect an overall rise in first-sales value (+11%) over 2016. Smelt experienced the largest drop in price (-43%) at 0,12 EUR/kg in 2017.

In 2017, Norway's, first-sales value decreased 3%, to EUR 1,6 billion, whereas volume moved in the opposite direction (+6%), ending at 2 million tonnes, compared with 2016. This was caused mainly by a lower first-sales price of mackerel, herring, and saithe, but larger catches of these species. In 2017, a negative trend was observed, with lower first-sales value and volume (-11% and -7%, respectively). This was owing mainly to a lower first-sales price of herring at 1 EUR/kg (-23%), and of saithe, at 0,70 EUR/kg (-13%). Lower first-sales volume for cod (-16%), crab (-29%), and herring (-15%) contributed to the overall decrease in volume in 2016.

In 2017, first sales of Portugal decreased in value (-2%) and volume (-6%), from the same period in 2016. The decrease in first-sales prices (-10%) of all species landed contributed to the overall drop in value mainly because of octopus, sardine, and horse mackerel (-5%, -13%, and -7%, respectively). In 2017, first sales decreased in value (-28%) and volume (-20%) from 2016. This was mainly the result of lower prices and smaller catch of anchovy (EUR -4,6 million net decrease), as well as of octopus, mackerel, scabbard fish, and sole. Of the top species, the average price decreased for clam at 1,28 EUR/kg (-44%) and increased for octopus at 7,50 EUR/kg from 4,42 EUR/kg (+70%) in September 2016.

In Spain, first sales fell 7% in both value and volume in 2017 from the same period in 2016. The trend was negative owing mainly to the lower first-sales prices and smaller volume of hake (-2% and -7%, respectively), albacore tuna (-14%, -24%, respectively) and monk (both -11%). In

2017, the first-sales value (EUR 91 million) fell 8%, and volume ended at 37.189 tonnes, a decrease of 6% in 2016. Higher prices of clam (+43%) and mackerel (+27%), among others, did not offset an overall decrease in value that was caused in major part by albacore tuna (−12%), sardine (−44%), and anchovy (−50%). A 96% increase in volume of mackerel did not reverse the overall negative volume created by horse mackerel (−7%), hake (−17%), and sardine (−56%). Average prices decreased the most for mackerel (−35%), ending at 0,36 EUR/kg in 2017. In Sweden, decreases in both value (−23%) and volume (−25%) in 2017, from the same period in 2016, was caused by cod, herring, sprat, and Norway lobster. In 2017, first sales value of cod (−24%), Norway lobster (−57%), and saithe (−34%) contributed to the overall decrease in value, whereas herring (+103% at 11.537 tonnes) was the main contributor to overall increase in volume in 2017 over the same month in 2016. The average price of herring decreased 17% and the average price of saithe registered one of the largest decreases among the major species, dropping 21% to 1,43 EUR/kg in 2017 from 1,82 EUR/kg in 2016.

In the UK, both first sales value and volume decreased 28%, from the same period in 2016, at EUR 415 million and 228.030 tonnes. Lower first-sales prices and smaller volume of haddock, Norway lobster, mackerel, and scallop were the main cause of the decrease. In 2017, the decrease in first-sales value (−14%) and volume (−3%) was caused mainly by herring with lower value and volume (−57% and −27%, respectively). Also, the overall average prices decreased for all species landed (−5%), of which herring registered the largest average price decrease of 40% (0,41 EUR/kg in 2017 compared with 0,69 EUR/kg in 2016)

VII. SUMMARY

As a first attempt to tackle the stagnation of fisheries and aquaculture production in the EU, the Commission published a communication entitled ‘A strategy for the sustainable development of European aquaculture’. The objectives of this strategy were:

1. Creating long-term secure employment, particularly in fisheries-dependent areas, and increasing employment in aquaculture by between 8 000 and 10 000 full-time job equivalents over the period 2014-2021.
2. Ensuring the availability to consumers of products that are healthy, safe and of good quality, as well as promoting high animal health and welfare standards.
3. Ensuring an environmentally sound industry.

However, the strategy did not achieve its objectives, particularly as regards increasing production and employment: neither the target of a 4% growth rate nor that of 8 000 to 10 000 new jobs were achieved.

The main problem for the aquaculture sector has been the lack of production growth, in contrast to the high growth rate observed on a global scale. The sector has, however, seen good progress in areas such as ensuring availability of quality products to the consumer and ensuring environmental sustainability. In addition to the traditional obstacles and constraints, European aquaculture has met with increased competition from production in third countries since 2002 and has had to face crises of

governance and the effects of the economic crisis after 2007.

To build a strategy on sustainable development of European aquaculture, on the 8/4/2009, the Commission published its second communication on aquaculture, seeking to identify and address the causes of the stagnation of EU aquaculture production (EMFF 2014-2020). It aimed to ensure that the EU remains a key player in a strategic sector, increasing production and employment by implementing the following actions:

A. Promoting the competitiveness of EU aquaculture production through:

- Research and technological development
- Promoting spatial planning for aquaculture in order to tackle the problem of competition over space
- Enabling the aquaculture business to cope with market demands
- Promoting aquaculture development in its international dimension

B. Establishing conditions for sustainable growth of aquaculture through:

- Ensuring compatibility between aquaculture and the environment
- Shaping a high-performance aquatic animal farming industry
- Ensuring consumer health protection and recognising the health benefits of aquatic food products

C. Improving the sector's image and governance through:

- ❖ Better implementation of EU legislation
- ❖ Reducing the administrative burden
- ❖ Ensuring proper stakeholder participation and the provision of appropriate information to the public
- ❖ Ensuring adequate monitoring of the aquaculture sector.

The strategic guidelines for the sustainable development of EU aquaculture includes that: Member States were advised to ensure effectively their own national targets, taking account of their relative starting positions, national circumstances and institutional arrangements. These guidelines addressed four priority areas:

- Simplifying administrative procedures and reducing licensing time for aquaculture farms
- Coordinated spatial planning to overcome the hindering effect of the lack of space
- Enhancing the competitiveness of EU aquaculture
- Promoting a level playing field.

Based on the EU regulation, Member States were to submit multiannual national strategic plans for the development of aquaculture activities on their territory for the period 2014-2020. The Commission encouraged the exchange of information and best practices among Member States through different workshops and meetings. Member States carried out a mid-term assessment of the implementation of their multiannual national strategic plans at the end of 2017, while final assessment reports are expected from national governments at the beginning of 2021 (www.europa.eu).

VIII. CONCLUSION

All the six association models show bad fit. Therefore we proceeded to the multivariate model in which the row column-effects RC multivariate model of RC ($M = 8$) is better than all because it covers 91% of the data, thus, giving the best fit among all. However, to be more precise, the production of aquaculture fishery products from 2006-2017 in EU26 could have been influenced by several factors; these could be as a result of:

- The standard of living of each country
- The degree of utilisation of the workforce, which is directly related to efficiency in the production of goods and services [17].
- Government intervention (the efforts of public officials to react to such monopoly [18].
- Third party distortions caused by monopoly activity, for instance, in a country with exchange controls, commodities may only be imported with an import licence [15].
- A country's geopolitical culture and
- Several other factors which are difficult to be determined in each country

We should mention that Θ , which is 0.99862, i.e. approximately equal to 1, reveal that we have independence between the variables. To determine the degree of association (correlation) between these countries and years, we use the θ of the second model, (the uniform association model which stand for (U) for calculation. More specifically, the innate correlation index in log-linear form is equal to:

$$\log(F_{ij}) = \lambda + \lambda_{A(i)} + \lambda_{B(j)} + \varphi \lambda_{ij}$$

where φ is a single parameter for interaction.

The parameter of interaction

$$\varphi = \log \theta = \log(0.99862)$$

$$\Phi = \log(0.99862) = -0.001381$$

$$|\varphi|^{1/2} = \sqrt{0.001381} = 0.037161808$$

$$\varphi^{1/2} = -\sqrt{0.001381} = -0.037161808$$

In August 2017, household consumption of fresh fisheries and aquaculture products increased over August 2016 in both volume and value in Germany (+26% and +25%, respectively), France (both +2%), Ireland (+2% and +5%), Italy (+3% and +5%), the Netherlands (+7% and 5%), and Sweden (+24% and +28%). Decreases in consumption in both volume and value were observed in Poland (-19% and -15%, respectively). In Hungary, Portugal, and Spain, volumes decreased, and value increased. In the UK, volume increased, and value decreased.

The largest increase in volume in August 2017 was observed in Germany and in value in Sweden, while the largest drop in both volume and value was registered in Poland. Compared with July 2017, among the Member States surveyed, the highest increase in value was registered in Sweden (+56%), followed by Italy (+22%). Volume decreased 12% in both Denmark and Spain, followed by

Ireland (-10%).

Finally, based on the parameter of interaction on the fisheries and aquaculture products EU26, the result reveals that there is a slightly negative association (correlation) between the 26 countries of the European Union and the years under our study.

The general observation is that, facts and figures on EU aquaculture production and consumption in an EU and global context has shown that, whereas there was an increase in fisheries and aquaculture production globally between 2006 and 2017, the aggregated production of farmed seafood in all EU Member States remained stable for a long time at around 1.2 million tonnes. EU production figures have, however, increased recently by around 24%, with the value of European aquaculture products in late 2017 reaching EUR 5.6 billion.

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