The forecasting of fish production, imports and exports with the analysis of domestic consumption and expected self-sufficiency ratio during the period 2017-2030 in Saudi Arabia. Application of VARX model

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Abstract:

The main purpose of this research is to use augmented vector autoregressive *VARX* model to forecast the production of fish, imports and exports in order to compute the expected domestic consumption and analyze the self-sufficiency ratio that expected to occur during period (2017-2030). According to (*IC*) the appropriate empirical model of these group was *VARX*(2) model with constant and quadratic trend. From the results of conditional lest squares estimates, the statistical tests proved that the linear trend terms as well quadratic improved the predictive ability of the model. Also the quantity of both production, imports and exports lagged one and two period has significant effect, and their addition improves the predictive ability of the model. The prices of both imports and exports in their logarithmic form have a significant effect and improvement predictive ability of the model. From results of prediction, quantity consumption as well self – sufficiency ratio was computed, and the results showed that self-sufficiency ratio will decrease with 2.4% annual growth rate. The market gap will be positive and tend to narrow. the research recommended that the interest in establishing of the specialized training institutes, Supplying the incentives that encourage young people to fish, improving the factors of fish production and supplying the local production of fish at appropriate prices to consumers.

Keywords: Fish, Production; Imports, exports, self-sufficiency ratio; Saudi Arabia, VARX model

1. Introduction:

Fish are important sources of animal proteins, fatty substances, vitamins and minerals. Fish contain 20% of its weight, an animal protein similar in composition to Chicken amino acids, and advantage of beef protein superiority of the coefficient of utilization, in addition to easy digestion. Fish also have fat ratios that vary in variety. Fish are also rich in vitamins, the most important of which is vitamin D. The percentage of mineral salts in fish ranges from 3% to 7% of dry weight (Ghanem and Alobaied, 2002).

Fish production has assumed an important role, contributing an alternative and economically viable protein source, especially in developing countries, where other animal-based protein sources are expensive or not available to the general population (Naylor et al. 2000). Some countries such as Bangladesh, Indonesia and the Solomon Islands depend on fish for above half of their animal protein consumption (Kawarazuka, 2010). Yet, in latest years a crisis has developed worldwide in fish resource (Watson et al., 2014).

According to Food and Agriculture Organization of the United Nations (FAO), the global per capita consumption of fishery products was approximately 18.9 kg in 2011 with an average annual growth rate of 1.62% from 2001 to 2011 (FAO, 2014).

From data published recently by Saudi Ministry of Environment, Water and Agriculture, the current status of fish production and consumption in Saudi Arabia can be reviewed, the explained that the Saudi Arabia's production of fish in year 2016 reached 107 thousand tons, a relative increase of 17.7% compared to year 2011, 23 thousand tons were exported and 213,000 tons were imported. So the domestic consumption of fish in year 2016 reached 296 thousand tons, a relative increase of 14.4% compared to year 2011. Consumption per capita of fish 9.3 kg, a relative increase of 4.4% compared to the year 2011, whiel self-sufficiency ratio is 36% and the food gap in year 2016 is 190 thousand tons, a relative increase of 12% compared to year 2011. Saudi production of fish through aquaculture amounted to 10 thousand tons during the last year 1438H, while the ministry completed 80% of the national plan to promote the consumption pattern of marine products, raising from 11.5 kg per person per year to the global average of 19.5 kg per capita per year.

One of the fisheries management initiatives in Saudi is the development of studies aim to forecast fish production and the movement of foreign trade, which includes in this field Saudi exports and imports from fish. Moreover, it is possible to calculate the expected domestic consumption from these three variables as well as description of the expectations of the self-sufficiency ratio in the subsequent period as important information provided to the Fisheries Department to identify the initial vision 2030. The studies that have used econometrics models to predict production and consumption are rare. To our knowledge, there are no other published comprehensive econometric studies that interested in using a dynamic time series models for forecasting fish production, imports and exports in Saudi Arabia dependent on more recent data, and interested in analyzing domestic consumption of fish as well as self - sufficient ratio expected during period 2017-2030. We believe that this study would be the first to fill at least part of this gap. To arrive at results with high accuracy, the problem of study in this research is determined by the choice of the optimal time series models for forecasting production, exports and imports in the long run-time. To solve the above research problem, the study aims to select the best augmented vector autoregressive (*VARX*) model which includes system of three equations to forecast production, imports and exports from fish in Saudi during the period 2017-2030. As soon the main objective above is completed, the research seeks to achieve two other objectives:

- Compute and describe the domestic consumption of fish that expected during the period (2017-2030).
- Description of the current status of the self-sufficiency ratio that expected to occur during period (2017-2030).

The research is organized in seven chapters. Chapter 2 presents, the previous studies about fish economics as well as applications of the augmented vector autoregressive *VARX* model to forecast. Chapter 3 handled the research methodology, which descript empirical *VARX* model and its assumptions, conditional lest squares estimates and its properties, criteria information, statistical tests related to significant of model coefficients as well as significant of variables addition for improving predictive ability of model and how to use model for forecasting. The 4th chapter includes data sources and statistical description of these data. Chapter 5 includes the analysis and discussion of the results, this chapter also includes the presentation and analysis of the prediction results model. Chapter 6 contains conclusions. The seventh and final chapter includes recommendations.

2. A review of the studies

First, for previous studies in fish economics, we can present the following:

- (Ahmed, 2017) introduced an economic study of the production and consumption of fish in Egypt . This study aimed to identify the factors that affect on fish production and the available consumption, the important of factors that affect on Egypt's imports and exports of fish and , the relative importance of geographic regions in terms of export and import and forecasting of production, consumption, food gap and self-sufficiency ratio until 2020. To achieve the objectives of the research, the researcher applied descriptive statistical analysis, as well as quantitative analysis methods such as multiple regression analysis and stepwise regression. To obtain the results of the applied study, secondary data from 1979-2013 were collected on the study variables from various sources, including the economic sector of the Ministry of Agriculture and Land Reclamation, Public Mobilization and Statistics and FAO. The results showed that fish farming contributes the largest share of Egyptian fish production by 59%, and significantly increases with rate 60.8 (1000 Ton) during period under study, While it was observed that fish extracted from lakes, seas and freshwater contributed to production by 41%. The results showed that the number of licensed fishing boats is one of the most important variables influencing production, the average per capita fish consumption and the quantity of local production are the most important variables that affect on imports of fish. It was also observed that domestic consumption of fish was significantly affected by both population and average retail price during the study period. In all sugested models, F test prved that these model appropriate for forecasting. From the results of prediction, domestic production from fish is expected to reach 1687 (1000 ton) in year 2020, a relative increase by 16% compared to 2013. While domestic consumption of fish is expected to reach 2073 (1000 ton) in year 2020, a relative increase by 19% compared to 2013. This indicates that the food gap will increase to reach 386,000 tons in 2020, a relative increase by b 31%.

- The study introduced by (Khan, Aldosari and Hussain, 2018), aimed to explore fish consumption behavior and fish farming attitude of the Saudi households in the Kingdom of Saudi Arabia (KSA). This study was dependent on random sample of size 100 respondents selected from Sharurah town situated in Najran province, Pearson correlation coefficient was used to see the significant and non-significant impact of the two variables (Age and Education level) on consumption of fish. The study concludes that fish consumption and preference is high in the study area and people prefer fish more than chicken and meat for consumption purposes because of their knowledge regarding the nutritional value of fish. However, the age and educational level have negative impact on the respondent's opinion about fish price in the study area.

Second, in the field of application *VARX* model for forecasting, there are many previous studies, these studies include the following:

- Alnashwan and Alderiny (2017) introduced study aimed to use augmented vector autoregressive (*VARX*) model to forecast the effect of cultivation of main crops on water security in Saudi Arabia, this study was applied to analyze the dynamic relationship between three time series which includes the areas cultivated with dates, clover and fodder in Saudi Arabia. The application study relied on time series data from 1986 to 2013. The unit root test indicated that the areas cultivated with the three crops are stationary at the first differences. Information criteria showed the optimal lag and according to results of Wald test, the model can be used. The implementation of resolution No. 335 and the linear trend has significant effect on the first difference of the areas cultivated with clover as well as cultivated with fodder. Model was used for forecasting the areas from 2014 to 2018, and noted that the areas cultivated with dates will annually increase with rate 0.3% and the expected mean of water consumption is 2837.6 million m^3 annually, the areas cultivated with clover will annually decrease with rate 1.6% and the expected mean of water consumption is 3708.4 million m^3 annually, and the areas cultivated with fodder will annually decrease with rate 15% and the expected mean of water consumption is 3999.6 million m^3 annually.

- Chena and et. (2018) presented study interested in forecasting day-ahead high-resolution natural-gas demand and supply in Germany. This paper presents a novel predictive model that provides day-ahead forecasts of the high resolution gas flow by developing a Functional AutoRegressive model with eXogenous variables (FARX). The predictive model allows the dynamic patterns of hourly gas flows to be described in a wide range of historical profiles, while also taking the relevant determinants data into account. By taking into account a richer set of information, FARX provides stronger performance in real data analysis, with both accuracy and high computational efficiency. Compared to several alternative models in out-of-sample forecasts, the proposed model can improve forecast accuracy by at least 12% and up to 5-fold for one node, 3% to 2-fold and 2-fold to 4-fold for the other two nodes. The results show that lagged 1-day gas flow and nominations are important predictors, and with their presence in the forecast model, temperature becomes insignificant for short-term predictions.
- The study that introduced by Warsono and et. (2019) defined vector autoregressive with exogenous Variable model and its application in modeling and forecasting energy data: Case Study of PTBA and HRUM Energy. In this study, PTBA and HRUM energy as endogenous variables and exchange rate as an exogenous variable were studied. The data used herein were collected from January 2014 to October 2017. The dynamic behavior of the data was also studied through IRF and Granger causality analyses. The forecasting data for the next 1 month was also investigated. On the basis of the data provided by

these different models, it was found that VARX (3,0) is the best model to assess the relationship between the variables considered in this work.

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3. Methodology

Vector autoregressive (*VAR*) models are flexible time series models that can capture complex dynamic interrelationships among macroeconomic variables (Sims, 1980) and (Litterman, 1986). When independent variables in (*VAR*) model include endogenous and exogenous variables the model is called augmented vector autoregressive (*VARX*) model. In this study using (*VARX*) model is suggested to forecast the production, imports and exports from fish in Saudi, where the exogenous independent variables determined in the prices of both fish imports and exports.

Empirical *VARX* Model

Assume that $\mathbf{Y}_t = (QP_t,\ QI_t,\ QE_t)'$ to denote the (3×1) vector of dependent variables, where QP_t, QI_t, QE_t represent the quantities of production, imports and exports respectively at time t , PI_t and PE_t to represent the price of imports and exports respectively at time t, as exogenous variables. The basic p-lag augmented vector autoregressive; $VARX(p)$ model written as.

$$\mathbf{Y}_t = \boldsymbol{\alpha}\mathbf{Z}_t + \sum_{i=1}^{p}\boldsymbol{\gamma}_i\mathbf{Y}_{t-i} + \boldsymbol{\theta}\mathbf{H}_t + \boldsymbol{\varepsilon}_t \ , \qquad (2.1)$$

$$t = p+1, p+2,...,T, \quad p = 1,2, \ T = 27$$

where $\mathbf{Z}_t$ is a $l\times 1$ vector of deterministic includes constant and time trend terms, and $\mathbf{H}_t = (PI_t, PE_t)'$ is (2×1) vector of exogenous variables, $\boldsymbol{\alpha}$, $\boldsymbol{\gamma}_i$ and $\boldsymbol{\theta}$ are $3\times l$, 3×3 and 3×2 coefficient matrices respectively , and $\boldsymbol{\varepsilon}_t$ is a sequence of 3×1 independent white noise vectors with zero mean and nonsingular contemporaneous covariance matrix given by $\boldsymbol{\Sigma}_\varepsilon$. Hence, the $VARX(p)$ model is just a seemingly unrelated regression (*SUR*) model with deterministic, exogenous variables and lagged endogenous variables as common regressors. The empirical model (2.1) is based on some assumptions determinant as follows: (Lütkepohl ,1991) and (Pesaran & Pesaran ,1997)

Assumption 1: $E(\boldsymbol{\varepsilon}_t)=\mathbf{0}$, $E(\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t')=\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}$ *for all* t,*where* $\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}=\{\sigma_{ij}^2, i, j=1,2,3\}$ is *an positive definite matrix,* $E(\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_{t'}')=\mathbf{0}$ *for all* $t\neq t'$, *and* $E(\boldsymbol{\varepsilon}_t \mid \mathbf{Z}_t, \mathbf{H}_t)=\mathbf{0}$.

Assumption 2: *All the roots of* $|\Gamma(L)|=|\mathbf{I}_3-\sum_{i=1}^{p}\boldsymbol{\gamma}_i L^i|=0$ *fall outside the unit circle, equivalently, all eigenvalues of companion matrix have modulus less than one*, *and* $\mathbf{I}_3$ is 3×3 *identity matrix.*

Assumption 3: $(\mathbf{Z}_t, \mathbf{H}_t, \mathbf{Y}_{t-1}, \mathbf{Y}_{t-2})$ *are not perfectly collinear*.

Under assumptions 2, $\mathbf{Y}_t$ would be covariance-stationary. The general form of the multivariate linear model represented by.

$$\underset{(m\times 3)}{\mathbf{Y}} = \underset{(m\times k)}{\mathbf{X}}\ \underset{(k\times 3)}{\mathbf{B}} + \underset{(m\times 3)}{\mathbf{E}} \tag{2.2}$$

where $\mathbf{Y}=(\mathbf{Y}_{p+1},\mathbf{Y}_{p+2},...,\mathbf{Y}_T)'$, $\mathbf{X}=(\mathbf{X}_{p+1}', ..., \mathbf{X}_T')'$, $\mathbf{X}_t=(\mathbf{Z}_t',\mathbf{H}_t',\mathbf{Y}_{t-1}',\mathbf{Y}_{t-p}')$, $\mathbf{B}=(\boldsymbol{\alpha},\boldsymbol{\theta},\boldsymbol{\gamma}_1, \boldsymbol{\gamma}_2)'$, $\mathbf{E}=(\boldsymbol{\varepsilon}_{p+1}, \boldsymbol{\varepsilon}_2 \dots, \boldsymbol{\varepsilon}_T)'$, $m=T-p$, and $k=l+2+3p$. The conditional least squares (CLS) estimator of $\mathbf{B}$ given by Johnson and Wichern (1992. p.316) as

$$\hat{\mathbf{B}}_{ls}=\left(\mathbf{X}'\mathbf{X}\right)^{-1}\mathbf{X}'\mathbf{Y} \tag{2.3}$$

And the estimate of $\boldsymbol{\Sigma}_{\varepsilon}$ is

$$\hat{\boldsymbol{\Sigma}}_{\varepsilon}=\frac{(\mathbf{Y}-\mathbf{X}\hat{\mathbf{B}}_{ls})'(\mathbf{Y}-\mathbf{X}\hat{\mathbf{B}}_{ls})}{m-k}=\frac{\sum_{t=p+1}^{T}\hat{\boldsymbol{\varepsilon}}_t\hat{\boldsymbol{\varepsilon}}_t'}{m-k} \tag{2.4}$$

where $\hat{\boldsymbol{\varepsilon}}_t$ is the residual vectors. Let $\hat{\boldsymbol{\beta}}_{ls}=vec(\hat{\mathbf{B}}_{ls})$ denotes the operator that stacks the columns of the $(k\times 3)$ matrix $\hat{\mathbf{B}}_{ls}$ into a long $(3k\times 1)$ vector. Under standard assumptions regarding the behavior of stationary and ergodic $VARX(p)$ models $\hat{\boldsymbol{\beta}}_{ls}$ is consistent and asymptotically normally distributed (Hamilton,1994) and (Lütkepohl, 1991). As well under assumption that the error vectors have multivariate normal distribution, the (CLS) estimator; $\hat{\boldsymbol{\beta}}_{ls}$ is equal to the maximum likelihood estimator.

Lag order selection

As soon as obtaining the (CLS) estimates for empirical model parameters (2.1), three most common information criteria (IC) ; AIC Akaike (1973), $HQIC$ Hannan & Quinn (1979), $SBIC$ Schwarz (1978) can be computed to select the lag order $(p = 1,2)$, such that the appropriate lag that correspond to minimum value of (IC).

Inference on Coefficients

According to the properties of (CLS) estimators, all statistical hypotheses tests that achieve the objective of research can be conducted, where values of t test statistics can be computed to test the significance of regression coefficients; $H_0 : \beta_{ij} = 0 \;\; vs \;\; H_I : \beta_{ij} \neq 0$, and values of partial F statistics to carry out the statistical tests related to the significance about addition group of independent variables to the model, through testing the restriction hypothesis $H_0 : \mathbf{R\beta} = \mathbf{r} \;\; vs \;\; H_1 : \mathbf{R\beta} \neq \mathbf{r}$, where $\mathbf{R}$ is restriction matrix.

The Forecasting

Using the suitable empirical model to forecast the quantities of production, imports and exports is one of the research objectives. So the best linear predictor of the dependent vector; $\hat{\mathbf{Y}}_{T+h|T} = (\hat{Q}P_{T+h}, \hat{Q}I_{T+h}, \hat{Q}E_{T+h})$ based on information available at exogenous vector; $\tilde{\mathbf{H}}_{T+h} = (\tilde{P}I_{T+h}, \tilde{P}E_{T+h})'$, deterministic vector; $\tilde{\mathbf{Z}}_{T+h}$ and the predicted dependent vector at lag order $p = 1,2$; $\hat{\mathbf{Y}}_{T+h-1}, \hat{\mathbf{Y}}_{T+h-2}$ is denoted as

$$\hat{\mathbf{Y}}_{T+h|T} = \hat{\boldsymbol{\alpha}}_{ls}\tilde{\mathbf{Z}}_{T+h} + \hat{\boldsymbol{\theta}}_{ls}\tilde{\mathbf{H}}_{T+h} + \hat{\boldsymbol{\gamma}}_{1_{ls}}\hat{\mathbf{Y}}_{T+h-1} + \hat{\boldsymbol{\gamma}}_{2_{ls}}\hat{\mathbf{Y}}_{T+h-2} \;, h = 1,2,... \qquad (2.5)$$

where $\hat{\mathbf{Y}}_{T+i} = \mathbf{Y}_{T+i}$, $for\ i \leq 0$ and h is the prediction period length. The mean square error of prediction; (MSE) introduced by Johnson and Wichern (1992. p.326) and Green, W. H. (2003. p.578), and in practices the approximate value of (MSE) at the h-step forecast is given as

$$\hat{\Sigma}(h) = \sum_{s=0}^{h-1} \hat{\Lambda}_s \Sigma_\varepsilon \hat{\Lambda}_s' \tag{2.6}$$

where the matrices $\hat{\Lambda}_s = \sum_{j=1}^{s} \hat{\Lambda}_{s-j} \boldsymbol{\gamma}_j$ are determined recursive substitution and $\Lambda_0 = \mathbf{I}_n$ and $\boldsymbol{\gamma}_j = 0$ for $j > 2$. The forecasts are unbiased since all of the forecast errors have expectation zero.

Asymptotic $(1-\alpha).100\%$ confidence intervals for the individual elements of $\hat{\mathbf{Y}}_{T+h|T}$ are then computed as

$$\hat{Y}_{k,T+h|T} - Z_{(1-\alpha/2)}.\hat{\sigma}_k(h) < Y_{k,T+h} < \hat{Y}_{k,T+h|T} + Z_{(1-\alpha/2)}.\hat{\sigma}_k(h) \tag{2.7}$$

where $Z_{1-\alpha/2}$ is the $(1-\alpha/2)$ quartile of the standard normal distribution and $\hat{\sigma}_k(h)$ denotes the square root of the k^{th} diagonal element of $\hat{\Sigma}(h)$.

4. Data description

To achieve the objectives of research, the study relied on time series data from 1990 to 2016, obtained from (Ministry of environment, Water and Agriculture, Annual Statistical Book). These series include data on the quantities of production from fish by (000 Ton) as well as the values by (million RSA) and quantities by (000 Ton) of both imports and exports. Price of both imports and exports (R/ton) was computed (Appendix 1). Table 1 displays the values of means, standard deviation and growth rate computed to quantities of production, imports and exports, as well for prices of both imports and exports.

Table (1): Descriptive statistics for production, imports and exports

	Production	Import		Exports	
	QP	Quantity *QI*	Price *PI*	Quantity *QE*	Price *PI*
Mean	69.9	107.7	1746.9	7.8	1757.0
St. Dev.	21.1	66.5	426.1	7.9	536.3
Cv	30	62	24	101	31
Min	42.6	27.4	1313.9	0.8	847.9
Max	106.8	216.3	2587.8	24.2	2935.5
Growth	0.035	0.083	0.021	0.144	-0.034
Sig	0.000	0.000	0.000	0.000	0.000

Source: computed from data in appendix 1

From table 1, we note that, Saudi Arabia's production of fish with an average of 69.9 thousand tons and significant annual growth rate of 3.5%. Saudi Arabia's imports of fish, with an average of 107.7 thousand tons and significant annual growth rate of 8.3% while the average of import prices is 1746.9 (RSA/ton) with significant annual growth rate of 2.1% . Saudi Arabia's exports of fish, with an average of 7.8 thousand tons and significant annual growth rate of 14.4% while the average of export prices is 1757 (RSA/ton) with negative significant annual growth rate of 3.4%

5. Results and discussions

SAS 9.2(2008) was used for obtaining the empirical results of the study, by using data in appendix 1.

From information criteria (Table 2), we note that the minimum values of *HQIC*, *AIC*, and *SBIC* are 9.81 ,9.36 and 10.97 respectively, so the appropriate empirical model for forecasting the dependent vector; $\mathbf{Y}_t = (QP_t,\ QI_t,\ QE_t)'$ has deterministic vector includes constant and quadratic trend; $\mathbf{Z}_t = (1, t, t^2)'$, endogenous vector at lag 1,2 ; $(\mathbf{Y}_{t-1}, \mathbf{Y}_{t-2})$ and exogenous vector includes log price of each import and export $\mathbf{H}_t = (LPI_t, LPE_t)'$.

Tabl 2: values of *HQIC*, *AIC*, and *SBIC*

Exogenous variable (PI_t, PE_t)	case	$Lag\ p=1$			$Lag\ p=2$		
		HQIC	*AIC*	*SBIC*	*HQIC*	*AIC*	*SBIC*
Using Normal price (PI_t, PE_t)	*No int*	11.56	11.35	12.07	10.81	10.49	11.66
	Const.	10.98	10.73	11.60	10.44	10.08	11.40
	Ltrend	10.93	10.64	11.66	10.24	9.83	11.30
	Qtrend	10.86	10.52	11.69	9.87	9.42	11.03
	Ex.trend	11.05	10.76	11.77	10.31	9.90	11.37
Using log Normal price (LPI_t, LPE_t)	*No int*	11.36	11.15	11.88	10.69	10.37	11.54
	Const.	10.93	10.68	11.55	10.24	9.88	11.19
	Ltrend	10.90	10.60	11.62	10.02	9.62	11.08
	Qtrend	10.86	10.52	11.69	9.81	9.36	10.97
	Ex.trend	11.02	10.73	11.74	10.10	9.69	11.16

Source: This table was prepared by researchers

So the matrix of coefficients; $\mathbf{B} = (\boldsymbol{\beta}_1, \boldsymbol{\beta}_2, \boldsymbol{\beta}_3)$ for selection model above includes 33 parameters, where $vec(\boldsymbol{\beta}_i) = (\alpha_{i0}, \alpha_{i1}, \alpha_{i2}, \gamma_{1i1}, \gamma_{1i2}, \gamma_{1i3}, \gamma_{2i1}, \gamma_{2i2}, \gamma_{2i3}, \theta_{i1}, \theta_{i2})'$. The results of conditional least squares summarized in Table 3.

Table 3: The results of conditional least squares estimates

Independent Variables	**Production Quantity** QP_t			**Import Quantity** QI_t			**Export Quantity** QE_t		
	Estimate	*t Value*	*Pr > |t|*	*Estimate*	*t Value*	*Pr > |t|*	*Estimate*	*t Value*	*Pr > |t|*
Const.	208.7	1.63	0.125	492.5	1.47	0.164	17.52	0.67	0.513
Ltrend	-3.979	-2.24	0.042	8.406	1.80	0.093	-0.590	-1.63	0.126
Qtrend	0.279	2.52	0.025	-0.170	-0.58	0.568	0.053	2.34	0.035
QP_{t-1}	0.656	3.52	0.003	-0.983	-2.01	0.064	-0.033	-0.87	0.399
QI_{t-1}	0.008	0.09	0.931	0.384	1.62	0.127	0.020	1.10	0.289
QE_{t-1}	0.309	0.32	0.752	6.111	2.43	0.029	0.023	0.12	0.908
QP_{t-2}	0.255	1.35	0.200	0.579	1.16	0.264	0.105	2.71	0.017
QI_{t-2}	0.200	2.17	0.047	-0.619	-2.57	0.022	-0.042	-2.22	0.043
QE_{t-2}	-3.89	-2.95	0.011	2.551	0.74	0.472	-0.072	-0.27	0.792
LPI_t	-41.2	-2.70	0.017	-45.75	-1.14	0.272	2.663	0.85	0.407
LPE_t	13.57	1.240	0.237	-16.61	-0.58	0.573	-4.788	-2.14	0.051

From table 3 above we note that, production quantity at current time; QP_t has a significant negative linear trend but quantity of import; QI_t has a significant positive linear trend. Each of production quantity and export; QE_t has a significant positive quadratic trend. Production quantity lagged one period; QP_{t-1} has a significant positive affect on current production quantity and has significant negative affect on current import quantity. Import quantity lagged one period; QI_{t-1} has a significant positive affect on current import quantity at level 10%. Export quantity lagged one period; QE_{t-1} has a significant positive affect on current import quantity. Production quantity lagged two period; QP_{t-2} has a significant positive affect on current export quantity. Import quantity lagged two period; QI_{t-2} has a significant positive affect on current production quantity and has a significant negative affect on each of current import quantity and export. Export quantity lagged two period; QE_{t-2} has a significant negative affect on current production quantity. The relative increasing in current import prices; PI_t leads to a significant decrease in current production, also the relative increasing in current export prices; PE_t leads to a significant decrease in current export.

The negative effect of the linear trend on production is due to the lack of motivation of young people to work in the fishing profession, the absence of training institutes that contribute to the rehabilitation and rehabilitation of the fishing profession, and the absence of incentives that encourage young people to fish, including health insurance, sickness and disability insurance. As a result, production was weak, while fish imports tend to increase to meet growing of domestic demand.

The increase in fish production in the previous period has resulted in an increase in the financial return due to higher prices of local fish compared to the prices of imported fish. This revenue is therefore directed towards improving the productive factors of fish, financing projects related to the establishment and development of fishing scales and carrying out marine studies of fish stores. All this leads to increased domestic production in the current period. As a result of this productivity increase, the country is moving towards reducing fish imports in the current period to reduce the burden on the trade balance.

When the state increases exports in the previous period, it must take measures to maintain the level of domestic demand in the current period, which would increase imports in the current period.

Higher export prices would result in lower foreign demand for fish, which is measured by Saudi exports.

The estimation of empirical model represented as

$$\begin{bmatrix} QP_t \\ QI_t \\ QE_t \end{bmatrix} = \begin{bmatrix} 208.7 & -3.979 & 0.279 \\ 492.5 & 8.406 & -0.170 \\ 17.52 & -0.59 & 0.053 \end{bmatrix} \begin{bmatrix} 1 \\ t \\ t^2 \end{bmatrix} + \begin{bmatrix} 0.656 & 0.008 & 0.309 \\ -0.983 & 0.384 & 6.111 \\ -0.033 & 0.020 & 0.023 \end{bmatrix} \begin{bmatrix} QP_{t-1} \\ QI_{t-1} \\ QE_{t-1} \end{bmatrix}$$
$$+ \begin{bmatrix} 0.255 & 0.200 & -3.890 \\ 0.579 & -0.619 & 2.551 \\ 0.105 & -0.042 & -0.072 \end{bmatrix} \begin{bmatrix} QP_{t-2} \\ QI_{t-2} \\ QE_{t-2} \end{bmatrix} + \begin{bmatrix} -41.21 & 3.57 \\ -45.75 & -16.61 \\ 2.663 & -4.788 \end{bmatrix} \begin{bmatrix} LPI_t \\ LPE_t \end{bmatrix} \quad (2.8)$$

From equation above we note that the estimation of autoregressive coefficients matrices ; $\hat{\boldsymbol{\gamma}}_1$, $\hat{\boldsymbol{\gamma}}_2$ represented as

$$\hat{\boldsymbol{\gamma}}_1 = \begin{bmatrix} 0.656 & 0.008 & 0.309 \\ -0.983 & 0.384 & 6.111 \\ -0.033 & 0.020 & 0.023 \end{bmatrix}, \ \hat{\boldsymbol{\gamma}}_2 = \begin{bmatrix} 0.255 & 0.200 & -3.890 \\ 0.579 & -0.619 & 2.551 \\ 0.105 & -0.042 & -0.072 \end{bmatrix} \qquad (2.9)$$

and the eigenvalues of companion matrix; $\boldsymbol{\Gamma}$ are $(0.66, 0.88, 0.88, 0.26, 0.67, 0.67)$, where $\boldsymbol{\Gamma}$ denoted as

$$\boldsymbol{\Gamma} = \begin{bmatrix} \hat{\boldsymbol{\gamma}}_1 & \hat{\boldsymbol{\gamma}}_2 \\ \mathbf{I}_3 & \mathbf{0} \end{bmatrix}$$

then matrix $\boldsymbol{\Gamma}$ has modulus less than one, that is mean all the roots of $|\boldsymbol{\Gamma}(L)| = |\mathbf{I}_3 - \hat{\boldsymbol{\gamma}}_1 L^1 - \hat{\boldsymbol{\gamma}}_2 L^2| = 0$ fall outside the unit circle, and $\mathbf{Y}_t$ would be covariance-stationary.

From table 4, we note that, Addition each of endogenous vector; $(QP_{t-2}, QI_{t-2}, QE_{t-2})'$, endogenous vector; $(QP_{t-1}, QI_{t-1}, QE_{t-1})'$ and exogenous vector; $(LIP_t, LEP_t)'$ significantly improves the prediction.

Table 4: restrictions

Null Hypothesis	*Num DF*	*Den DF*	*F Value*	*Pr > F*
H_0: *Addition endogenous vector;* $(QP_{t-2}, QI_{t-2}, QE_{t-2})'$ non significance to improve prediction	9	42	4.42	0.0004
H_0: *Addition endogenous vector;* $(QP_{t-1}, QI_{t-1}, QE_{t-1})'$ non significance to improve prediction	9	42	4.13	0.0007
H_0: *Addition exogenous vector;* $(LIP_t, LEP_t)'$ non significance to improve prediction	6	42	4.46	0.0014
H_0: *Addition Quadratic Trend ;* t^2 non significance to improve prediction	3	42	2.97	0.0425
H_0: *Addition Linear Trend ;* t non significance to improve prediction	3	42	2.23	0.0989

As well addition of quadratic trend (t^2) significantly improves the prediction, but addition of linear trend (t) significantly improves the prediction at level 10%.

Prediction

According to criteria information $HQIC$, AIC, and $SBIC$, vector autoregressive model at lag length 2 with quadratic trend was selected to predict the values of exogenous variables; $(\tilde{LPI}, \ \tilde{LPE})$ during the period 2017 to 2030 (table 5), then $VARX(2)$ model (2.8) was used to predict quantities of production $(\hat{QP})$, import $(\hat{QI})$ and export $(\hat{QE})$

based on predicted values of exogenous variables above (table 5) by application form (2.5) as well standard error of prediction (2.6) during the study period (table 5).

Consumption was computed using equation; $(\hat{C} = \hat{Q}P + \hat{Q}I - \hat{Q}E)$ during the prediction period as well self-sufficiency ratio $[SSR = (\hat{Q}P / \hat{C}) \times 100]$ (table 5). When we expect a relative increase in import price and relative decrease in export prices in the period 2017-2030 as shown in table 5, we expect the following:

- The increase in production during that period with 1.2% annual growth rate, and the annual mean of production during the prediction period is estimated by 134.9 thousand tons, which is greater than the production mean during the study period (69.9 thousand tons- table 1).
- Domestic consumption is expected to increase with 3.7% annual growth rate, and the mean consumption for this period is estimated by 425.9 thousand tons, which is also greater than the mean during the study period (169.8 thousand tons – computed from table 1).
- Based on forecasted values of production and consumption, self-sufficiency ratio is expected to decrease with 2.4% annual growth rate, The mean of self-sufficiency ratio during that period will be 32.2%, which is less than the mean during the study period (41.2%- computed from table 1).
- From the above results, it is expected during the forecast period that the market gap (consumption - production) will be positive and narrow over time.
- In the coming period, the Ministry of Water and Fisheries will aim to increase production substantially and put control on imports to meet rising demand due to population growth in the coming period.

Year	*LPI*	*LPE*	Production Quantity *QP*		Import Quantity *QI*		Export Quantity *QE*		predicted Consumption Quantity QC	Predicted self-sufficiency ratio%
			predicted value	Standard error	predicted value	Standard error	predicted value	Standard error		
2017	8.0334	6.9035	123.91	5.39003	212.52	14.13	28.20	1.10	308.24	40.2
2018	8.1743	6.7904	132.16	6.49556	229.76	17.23	31.03	1.17	330.88	39.9
2019	8.2771	6.6946	128.55	7.85571	264.74	18.34	35.66	1.37	357.64	35.9
2020	8.3748	6.6151	129.27	8.24975	306.84	21.93	39.61	1.56	396.51	32.6
2021	8.4793	6.5432	126.64	8.59778	329.27	23.56	41.52	1.66	414.39	30.6
2022	8.5923	6.4724	126.36	8.79499	330.60	24.38	43.42	1.72	413.54	30.6
2023	8.7128	6.4000	130.84	8.82062	325.86	25.58	45.57	1.80	411.14	31.8
2024	8.8395	6.3253	135.15	8.83497	329.43	26.52	48.70	1.82	415.88	32.5
2025	8.9717	6.2482	139.08	8.87516	348.94	26.76	52.89	1.84	435.13	32.0
2026	9.1091	6.1690	141.32	8.89193	378.18	27.14	57.14	1.86	462.36	30.6
2027	9.2518	6.0878	141.81	8.91861	405.24	27.57	61.00	1.88	486.05	29.2
2028	9.3998	6.0047	142.62	8.94043	423.34	27.74	64.40	1.88	501.56	28.4
2029	9.5531	5.9196	144.40	8.94929	433.69	27.86	67.66	1.90	510.43	28.3
2030	9.7117	5.8326	147.08	8.95272	443.29	28.06	71.30	1.91	519.08	28.3
G.R			**0.012**		**0.052**		**0.069**		**0.037**	**-0.024**
Mean			**134.9**		**340.1**		**49.15**		**425.9**	**32.2**

6. Conclusions

The studies that aim to predict two time series or more, and some independent variables in the analysis are exogenous variables, the using of augmented vector autoregressive *VARX*(p) model is the appropriate model for forecasting these time series. So it was suggested in this research using *VARX* model to predict three time series, that are production, imports and exports of fish in Saudi Aribia. The empirical *VARX*(p) model with length lag periods; p, has constant and time trend terms, endogenous independent variables represented by quantities of production, imports and exports of fish at length lag periods $(1,2,\ldots, p)$ and exogenous independent variables denoted by prices of both imports and exports of fish.

Time series data from 1990 to 2016 was used for obtaining the results of application group of empirical models. According to information criteria (*AIC*, *HQIC*, *SBIC*), the appropriate empirical model of these group was *VARX*(2) model with length lag period (p =2), constant and quadratic trend. It was noted that all the eigenvalues of companion matrix were positive and less than one, this result was demonstrated that all the roots of companion matrix fall outside the unit circle, and the three time series (production, imports and exports) would be covariance-stationary.

From the results of conditional lest squares estimates, the statistical tests proved that the linear trend terms as well quadratic improved the predictive ability of the model. Also the quantity of both production, imports and exports lagged one and two period has significant effect, and their addition improves the predictive ability of the model. The prices of both imports and exports in their logarithmic form have a significant effect and improvement predictive ability of the model.

Empirical *VARX*(2) model was used to forecast quantity of both production, imports and exports of fish during period 2017-2030, From results of prediction quantity consumption as well self – sufficiency ratio computed, and the results showed that self-sufficiency ratio will decrease with 2.4% annual growth rate. We expect that the market gap will be positive and tend to narrow.

7. Recommendations

From the above results, the research recommend the following:

1- the expand in establishing of the specialized training institutes to train and qualify young people to practice fishing.
2- Supplying the incentives that encourage young people to fish, including attention to improving health insurance services and insurance against disease and disability.

3- The interest in improving the factors of fish production, financing the projects that related to establish and develop the fishing scales and conducting marine studies of fish stores.
4- Supplying the local production of fish at appropriate prices to consumers.
5- The study recommends that researchers in the future be interested in: the following
- conducting economic and econometrics studies on the production of fish and the factors affecting production, and studying the constraints of production.
- Study and analyze the impact of specific factors for Saudi fish consumption.
- Studying demand, supply and price analysis of fishery products.
- The need to use methods of statistical analysis suitable for studying the dynamic relationships between variables and prediction.

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Appendix 1: Data about quantity of fish production, Import and export in Saudi Arabia from 1990-2016.

Year	Quantity of production	Quantity of imports	Quantity of Eports	Imports prices	Exports prices
1990	42.618	33.387	0.773	1543.475	1825.356
1991	42.642	41.071	1.376	1714.762	2151.890
1992	48.111	27.405	1.827	1565.079	2053.093
1993	50.337	29.700	1.361	1385.657	1786.921
1994	56.812	31.532	0.927	1313.903	2935.484
1995	48.127	53.331	0.840	1455.757	2633.024
1996	50.511	45.902	1.204	1632.282	2330.565
1997	52.340	52.557	1.391	1605.057	2271.747
1998	53.226	59.643	2.205	1614.825	2414.966
1999	50.362	67.436	1.802	1511.033	2286.349
2000	54.680	66.611	1.705	1374.818	1985.924
2001	56.243	79.387	1.633	1402.572	2061.237
2002	56.601	77.490	1.718	1444.109	2040.745
2003	67.300	83.949	2.781	1359.444	1985.257
2004	66.591	112.109	4.837	1430.634	1449.452
2005	74.785	125.311	7.754	1415.901	1328.347
2006	81.004	138.360	8.188	1500.687	1450.171
2007	90.903	138.658	8.640	1518.109	1552.778
2008	93.495	102.889	10.639	2012.509	1420.122
2009	96.441	108.671	12.638	1823.016	1287.466
2010	100.471	181.828	13.863	1732.192	1505.663
2011	90.752	187.781	19.505	2194.514	1338.016
2012	89.999	211.546	16.561	2580.228	1347.986
2013	70.958	209.848	19.056	2587.835	1074.517
2014	91.865	216.349	24.152	2566.367	847.921
2015	103.652	212.109	20.687	2456.148	982.066
2016	106.818	212.591	22.996	2425.996	1091.929

Source: Ministry of environment, Water and Agriculture