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A Comparison of Univariate ARIMA and Multivariate to Estimate Absorption Pattern in Stronsium Tittanate Dop Variation

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ABSTRACT

ARIMA, VARIMA, and GSTARIMA are the models used to model the observation series and variable dop containing spatial dependence between its dop. More complex models do not guarantee the forecast result will be more accurate. Therefore, the aims of this study are to model and assess the accuracy of forecasting of the ARIMA, VARIMA, and GSTARIMA using space weight is normalization of cross correlation. It was applied to the absorption pattern in stronsium tittanate with variation of dop. Based on this study, the fitted model used were ARIMA, VARI, and GSTARI modeling using normalization of cross correlation with the order of observation series AR(2). In addition, the ARIMA model more accurate to forecast the absorption pattern in stronsium tittanate with variation of dop than VARI and GSTARI model.

Keywords: ARIMA, VARIMA, GSTARIMA, modeling, forecasting.

I. INTRODUCTION

Stronsium tittanate is one of the metal oxide materials that has a cubic perovkite structure. It has physical properties such as paraelektrictivity, superconductivity and fotokatalis also has good chemical and physical stability and superior optical properties. Based on Iriani (2007), it can be developed continuously for use in several applications one of them by injection a dop of rutheriun oxide.

Stronsium tittanate emitted wave length light in sequence. The percentage af absorption light is the observed. It is also given a dop injection of rutherium oxide with some kind of concentration.

The observational sequence of analysis is an analysis that focuss on behavioral studies in previous observation that implicitly assume that the behavior of the data in a particular observation will be repeated in subsequent observation. It can be classified into two, univariate model and multivariate model. One example of univariate model is Autoregressive Integrated Moving Average (ARIMA). This method uses an iterative approach in identifying the most appropriate model of all possible models. The multivariate model observed more than one observational sequence variable.

Sometimes the observational sequence data have interrelated rekationships between variable.

Multivariate analysis commonly used is Vector Autoregressive Integrated Moving Average (VARIMA). The use of multivariate methods such as VARIMA and others still can not explain the interrelationship between variables.

In this study the value of observation on objects performed sequentially so that it can follow the principles of observarion series by using ARIMA approach where the value of certain observation depends on the value of previous observation. Furthermore, the value of these observation will be given doping treatment. By studying the value of the object through the observational approach and the interrelationship between variables it can also be called Generalized Space Time Autoregressive Integrated Moving Average (GSTARIMA) with space is dop and time is sequence.

II. METHODS AND MATERIAL

A. Data

The data used in this study is secondary data generated from the experiment. This data is a series of observational data on the percentage of stronsium tittanate absorbed with various dop varieties ie dop 0%, dop 2%, dop 4%, and dop 6%. The data used amounts to 403 data with details 383 data for modeling and 20 data for validation.

B. Methods of Data Analysis

Steps in analyzing data:

1) Conducting data exploration and calculating correlation value for inter dop observation.
2) Calculates a weighted matrix by normalizing of cross doped cross line correlation.
3) Examine the data stationarity by using Augmented Dickey-Fuller test.
4) Divide data nto 2 sets of training data (383 first data) and data testing (last 20 data).
5) Establishment of ARIMA model with the following stages:
   a) Identification of temporary models.
   b) Estmation of parameters by using least squares method for autoregressive model.
   c) Testing the feasibility of the model by testing the residual whether it is whise noise.
6) Establishment of VARIMA model with the following stages:
   a) Model determination based on model order that has the smallest AICC value.
   b) Estimation of parameters by minimizing the residual using the least nonlinier least squares method with Gauss-Newton approach.
   c) Testing the feasibility of the model by testing the residual whether it is white noise using MACF plot.
7) Establishment of GSTARIMA model with the following stages:
   a) Determination of model based on orde identification model VARIMA.
   b) Estimation of model parameters by minimizing the residual using the nonlinier least squares method with Gauss-Newton approach.
   c) Testing the feasibility of the model by testing whether the residual is white noise using MACF plot.
8) Choosing the best model by looking at the accuracy of the forecast between model ARIMA, VARIMA, and GSTARIMA by looking at the smallest MAPE value.

III. RESULTS AND DISCUSSION

A. Weighted Normalization of Cross Correlation

The compilation of this weightes matrix is accomplished by normalizing cross dop correlation result in the corresponding observation lag. Then it will be normalized row to get normalization of cross correlation. Here is the result

TABLE I

WEIGHTED MATRIX CROSS DOP CORRELATION

Variable	Dop 0%	Dop 2%	Dop 4%	Dop 6%
Dop	0	0.262	0.24	0.49
Dop	0.16	0	0.46	0.36
Dop	0.15	0.472	0	0.36
Dop	0.30	0.350	0..34	0

B. Stationarity Test

The examination of the data stationarity can be seen from the plot between the percentage of stronsium tittanate with observation sequence. To futher convince this it can be tested Augmented Dickey-Fuller. The results show that each observation sequence data on each dop is stationary with an opportunity value < alfa (0.05) which means the data is stationary.

C. ARIMA Model

Identification of ARIMA model can be used plot ACF and PACF. After the ARIMA model is formed then the next will be predicted and testing the parameters of each model ARIMA formed from the selected model. The parameter estimation by using the least squares method by minimizing the sum of squares residual.

TABLE III. PARAMETER ESTIMATION OF ARIMA MODEL

*The parameters are not significan at the test level 5%

Variable	Model	Parameter	Estimation	SE Coef	t-value	p-value
Dop 0%	ARIMA (1,1,0)	μ	-0.001929	0.004452	-2.64	0.665*
		ϕ_1	-0.1309	0.0496	-0.43	0.009
Dop 2%	ARIMA (2,1,0)	μ	-0.0003596	0.0001338	-2.69	0.008
		ϕ_1	-0.0898	0.0497	-1.81	0.072
		ϕ_2	0.1065	0.0497	2.14	0.033
Dop 4%	ARIMA (1,1,0)	μ	-0.00078917	0.00007711	-10.23	0.000
		ϕ_1	0.1187	0.0497	-2.39	0.017
Dop 6%	ARIMA (1,1,0)	μ	-0.0001598	0.0001183	-1.35	0.177*
		ϕ_1	0.0885	0.0498	-1.78	0.076

D. VARIMA Model

Determination of VARIMA model is based on plot of MACF and MPACF. If not convincing, it can be seen from the smallest AICC value obtained. The parameter estimation for nonlinier equation requires an iteration process to obtain the minimum objective function of the estimation method. The best VARIMA model is VAR(2) because it has the smallest AICC value.

TABLE IIIII

PARAMETER ESTIMATION OF VARI (2) MODEL

Parameter	Estimation	SE Coef	t-value	p-value
ϕ_{10}^{1}	0.822465	0.0525	15.67	<.0001
ϕ_{11}^{1}	1.625366	1.1994	1.36	0.1762*
ϕ_{20}^{1}	0.012299	0.0524	0.23	0.8146*
ϕ_{21}^{1}	-1.08099	1.1879	-0.91	0.3634*
ϕ_{10}^{2}	1.057176	0.0516	20.49	<.0001
ϕ_{11}^{2}	-0.00078	0.00135	-0.58	0.5656*
ϕ_{20}^{2}	-0.20314	0.0517	-3.93	<.0001
ϕ_{21}^{2}	-0.00019	0.00134	-0.14	0.8877*
ϕ_{10}^{3}	0.894343	0.052	17.2	<.0001
ϕ_{11}^{3}	-0.00159	0.000804	-1.97	0.0494
ϕ_{20}^{3}	0.052262	0.0514	1.02	0.3102*
ϕ_{21}^{3}	0.000953	0.000802	1.19	0.2358*
ϕ_{10}^{4}	0.885476	0.0516	17.16	<.0001
ϕ_{11}^{4}	0.002786	0.00127	2.19	0.029
ϕ_{20}^{4}	0.08726	0.0515	0.36	0.7165*
ϕ_{21}^{4}	-0.00318	0.00126	-2.52	0.0123

*The parameters are not significan at the test level 5%

E. GSTARIMA Model

Determination of GSTARIMA model is based on the orde of the VARIMA model. The parameter estimation for nonlinier equation requires an iteration process to obtain the minimum objective function of the estimation method. The GSTARIMA model based on the best VARIMA model orde is VARI(2) has the smallest AICC value so that the best GSTARIMA model is GSTARI(2).

TABLE IVV

PARAMETER ESTIMATION OF GSTARI (2) MODEL

Parameter	Estimation	SE Coef	t-value	p-value
ϕ_{10}^{1}	0.826367	0.0513	16.1	<.0001
ϕ_{11}^{1}	3.569986	3.2759	1.09	0.2765*
ϕ_{20}^{1}	0.007195	0.0511	0.14	0.8882*
ϕ_{21}^{1}	-2.03149	3.2519	-0.62	0.5325*
ϕ_{10}^{2}	1.057487	0.0507	20.87	<.0001
ϕ_{11}^{2}	-0.00452	0.00787	-0.57	0.5663*
ϕ_{20}^{2}	-0.020382	0.0508	-4.01	<.0001
ϕ_{21}^{2}	-0.00062	0.00776	-0.08	0.9367*
ϕ_{10}^{3}	0.893341	0.0511	17.49	<.0001
ϕ_{11}^{3}	-0.0096	0.00491	-1.96	0.0513*
ϕ_{20}^{3}	0.054257	0.0505	1.07	0.2837*
ϕ_{21}^{3}	0.005931	0.00489	1.21	0.2262*
ϕ_{10}^{4}	0.884852	0.0506	17.5	<.0001
ϕ_{11}^{4}	0.009228	0.00414	2.23	0.0264
ϕ_{20}^{4}	0.019559	0.0505	0.39	0.6988*
ϕ_{21}^{4}	-0.01054	0.00411	-2.56	0.0107

*The parameters are not significan at the test level 5%

F. Choosing the Best Model

The best model is chosen based on the smallest forecasting error. The accuracy of ftrecasting can be seen based on the smallest MAPE value.

TABLE V

PARAMETER ESTIMATION OF GDSARI (2) MODEL

Dop	ARIMA	VARI(2)	GSTARI(2)
Dop 0%	0.024651	0.093135	0.098796
Dop 2%	0.020957	0.149801	0.157781
Dop 4%	0.186543	0.058388	0.55633
Dop 6%	0.001452	0.097551	0.102666
Average	0.058401	0.099719	0.228893

Based on the above table, it can be seen that the smallest MAPE value is ARIMA model compared to VARI(2) and GSTARI(2) model with normalization of cross correlation. So it can be said that the best model of the three models that have been obtained is the ARIMA model.

IV. CONCLUSION

Based on the aim of study, over all it can be concluded that the best model to estimate absoption pattern in stronsium tittanate with variation dop is ARIMA model compare to VARIMA and GSTARIMA model with normalization off cross correlation. ARIMA model has MAPE value smallest than VARI(2) and GSTARI(2) model.

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