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Innovation Performance in Saudi Arabia

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ABSTRACT

The reader, of this article, will find the past 8-years data for the GII score that measures the performance of innovation for Saudi Arabia which were hosted in reports published by the Global Innovation Index. These hosted data were, statistically, analyzed in order to forecast the future scores that Saudi Arabia can achieve during the next five years. The forecasting process passes through a systematic approach starting by checking the variation and distribution (using the descriptive statistics), checking the relationships (using the Person correlation coefficient) and finally developing a "regression equation" in order to be able to forecast the behavior of the GII for the next 5 years (using Box-Jenkins approach).

Keywords— *Innovation performance, Saudi Arabia, Global Innovation Index*

1. INTRODUCTION

The tempestuous economies of nations, the never trading off and additionally requesting nature of clients, and the changing pattern in workforce from metal work to cerebrum work leads, or rather power's an association to adjust to changes; every now and then. The sentence "Change Changes the Change on the off chance that you don't adjust Change" has a certifiable substitute nowadays where the world is going worldwide, computerized, home grown and profound. Advancement is a trendy expression, specialists can't survive without it; Innovation the executives has as of late got a lot of consideration from examine researchers, industry and the individual legislatures of the nation's due to its usefulness in continuing the associations and to give a serious edge. The more reasonable and serious firms are those which are pressed with advancement rehearses. The creative firms are increasingly adaptable and have a more prominent ability to adjust to changes. This implies they can spare themselves, when the earth is lopsided, thusly, can react quicker to changes, can make new open doors too misuse existing chances to a more noteworthy degree than the contenders. Development is a key capacity for a drawn-out supportability of organizations. The capacity to improve has been generally considered as one of the key achievement factor of business endurance and execution. [1]

Watchman (1980) recommended that the seriousness of countries relied upon the capacity of an industry to enhance and improve, and that organizations accomplish upper hand through advancement. Development is perceived to assume a focal job in making esteem and continuing upper hand. The advancement contains two exercises. The first is innovativeness which alludes to the advancement of thoughts that are both novel and helpful, either in the short or the long haul. The subsequent movement is thought execution which portrays the way toward changing over these thoughts into as good as ever items, administrations, or methods of getting things done. Hence, advancement can be conceptualized as enveloping two unique exercises: the improvement of novel, helpful thoughts and their execution. The term development has been utilized in the writing to depict both the procedure that utilizes new information, innovations and the procedures to create new items just as new or improved items themselves.[2]

The distinction from creation is that advancement additionally includes the factor of commercialization, deciding the organization achievement or disappointment. This gives off an impression of being the urgent point throughout the most recent couple of decades, as development has been distinguished by a few countries or intranational associations as the central point of monetary development and riches. Associations which work in today advertises, where worldwide rivalry, fast mechanical advances and asset inadequacy are squeezing issues, must advance so as to develop, to be successful and even to endure. For the endurance of associations, the associations need to put resources into various sorts of developments, on the grounds that the various kinds of advancement affect their results. [3]

Development is a multidisciplinary subject, this examination endeavored to recognize the regions which may be viewed as advancement rehearses precursors. There is no single model for advancement the board and a portion of the models are gotten from or follow the rationale of "Stage Gate" and "Channel" models. From now on, this examination researches the works on surfacing the human association in development rehearses in Saudi Arabian business associations [4,5]. The examination and

research approach utilized by the creators from the different investigations uncovers that advancement doesn't have a solidified or one of a kind model. Since advancement is exceptionally subject to nature, organization's destinations, system and culture. There were numerous examinations have been done so as to attempt to comprehend and discover a few different ways that can help in distinguishing the development the executive's models that better suit for every unique circumstance. [4]

This paper doesn't give an opinionated technique to associations to follow however it identifies what components are significant in rehearsing for an association to improve its development rehearses in Saudi Arabian setting. Emphasize that the motivation behind the paper is neither to contend for one best model of development rehearses nor to charm in a full methodological approval of an estimation scale. The point is somewhat constrained to investigating certain parts of advancement rehearses and propelling a scholastic conversation on their estimation during the time spent estimating great development rehearses which exists in Saudi Arabia.

Table 1: Specification table

Subject area	*Innovation*	
More specific subject area	Innovation performance	
Type of data	Table, graph	
How data was acquired	The data were hosted in reports published by the Global Innovation Index.	
Data format	Raw, analyzed and descriptive data	
Experimental factors	The dataset used in this article are a detailed metrics about the innovation performance collected for the last 8 years.	
Experimental features	At the beginning, "descriptive statistics" were conducted to test the variation and the distribution of the data; then Person's techniques were also used to check the relationships among the dependent and independent factors; lastly, "box-Jenkins" approached were used to develop "regression equation"	
Data source location	**Charts, graphs, tables & figures**.	**RAW DATA**
	Table 1	**2011** https://www.globalinnovationindex.org/userfiles/file/GII-2011_Report.pdf **2012** https://www.globalinnovationindex.org/userfiles/file/GII-2012-Report.pdf **2013** https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII-2013.pdf **2014** https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII-2014-v5.pdf **2015** https://www.globalinnovationindex.org/userfiles/file/reportpdf/gii-full-report-2015-v6.pdf **2016** https://www.globalinnovationindex.org/userfiles/file/reportpdf/gii-full-report-2016-v1.pdf **2017** https://www.globalinnovationindex.org/userfiles/file/reportpdf/gii-full-report-2017.pdf **2018** https://www.globalinnovationindex.org/userfiles/file/reportpdf/gii_2018-report-new.pdf
	Table 2 & 3	Table 1
	Table 4&5	2011 2012 2013 2014 2015 2016 2017 2018 **GII** **36.4** **39.3** **41.2** **41.6** **40.7** **37.8** **36.2** **34.27**
	Table 6	SAME RAW DATA FOR FIG 5
	Figure 1	http://www.m-hikari.com/ref/ref2019/ref1-2019/p/abonazelREF1-2019.pdf
	Figure 2&3	2011 2012 2013 2014 2015 2016 2017 2018 **GII** **36.4** **39.3** **41.2** **41.6** **40.7** **37.8** **36.2** **34.27**
	Figure 4	**Year** | **GII** (**Actual**, **Fitted**) | **Residuals of ARIMA (4, 0, 0) model** **2011** 36.4000 36.4246 -0.02456 **2012** 39.3000 39.2548 0.04520 **2013** 41.2000 41.1919 0.00810 **2014** 41.6000 41.6473 -0.04730 **2015** 40.7000 40.7520 -0.05203 **2016** 37.8000 37.7713 0.02872 **2017** 36.2000 36.1729 0.02709 **2018** 34.2700 34.2711 -0.00115
	Figure 5	**Year** | **Actual GII** | **Forecasted GII** **2011** 36.4 NA **2012** 39.3 NA **2013** 41.2 NA

		2014	41.6	NA
		2015	40.7	40.75203
		2016	37.8	37.74826
		2017	36.2	36.24278
		2018	34.3	34.18199
		2019	NA	35.93407
		2020	NA	36.96289
		2021	NA	40.51699
		2022	NA	41.12971
		2023	NA	41.86226
Data accessibility	Dataset is included in this article			
Related research articles	Dr. Ahmad Alkhaleefah, what to do to improve the international Saudi innovation rank/score, International Journal of Mechanical Engineering and Technology, 9(3), 2018, pp. 435-442			

1.1 Value of the data

- The data can be used as a benchmark to compare, yearly, the performance of Saudi Arabia in terms of innovation.
- The Inferential data, provides guidance for wide variety of stakeholders in the area of innovation; especially in Saudi Arabia
- The same dataset can be analyzed/forecasted using different techniques for comparison and assessment
- The Inferential data can be used by decision makers to drive their activities towards improving the score of the GII that in line with vision 2030
- The data shows how different pillars of the ecosystem can contribute to the performance in terms of innovation
- The Inferential data makes this research original with respect to the forecast for the future.

1.2 Data

The below

Table ***1*** showing the scores [GIIs] that Saudi Arabia have achieved during the last 8 years[6]. It also shows the values of the 7 sub pillars, through which the GII was calculated.

Table 1: Innovation performance of Saudi Arabia during last 8 Years

		2011	2012	2013	2014	2015	2016	2017	2018
Global innovation index	**GII**	**36.4**	**39.3**	**41.2**	**41.6**	**40.7**	**37.8**	**36.2**	**34.27**
Institution	X1	67.5	63.8	58.4	60	60.4	57.9	52.4	51.9
Human capital & research	X2	40.4	44.8	39.8	35.6	39.8	44.7	46.5	47.7
Infrastructure	X3	27.8	42.6	40.6	47	50.2	51.4	53.3	49.4
Market sophistication	X4	52.7	47.5	53.5	59	50.3	49.6	49.4	51.7
Business sophistication	X5	41.3	47.5	37.2	37.6	35.8	31.3	35	33.0
Knowledge and technology outputs	X6	18.3	15.3	24.8	25.7	25.1	22.4	21.6	20.2
Creative outputs	X7	35.6	43.4	48.2	45	42.9	34.6	28.4	23.4

1.3 Descriptive statistics

Before start analyzing a dataset. It is strongly recommend to check the "variation" and the "distribution" of this dataset. As shown below, the **Table 2** presents summary of "descriptive statistics" for the variables (dependent and independent variables) for eight years (2011 to 2018).

Table 2: Descriptive statistics of variables and test of normality

Variable	Mean	Max.	Min.	SD	Skewness	Kurtosis	Jarque-Bera	p-value
G11	38.434	41.600	34.270	2.684	-0.212	1.663	0.655	0.721
X1	59.038	67.500	51.900	5.261	0.063	2.170	0.235	0.889
X2	42.413	47.700	35.600	4.135	-0.255	1.889	0.498	0.779
X3	45.288	53.300	27.800	8.286	-1.217	3.480	2.053	0.358
X4	51.713	59.000	47.500	3.522	1.029	3.394	1.463	0.481
X5	37.338	47.500	31.300	5.101	0.913	3.045	1.112	0.573
X6	21.675	25.700	15.300	3.634	-0.523	2.137	0.614	0.736
X7	37.688	48.200	23.400	8.686	-0.437	1.896	0.661	0.719

It can be noted that the data does not have large "variation" and also it is normally "distributed" because the probability value (p-value) of Jarque-Bera (1980) test [7] is greater than 0.05.

1.4 Correlation matrix

As usual, it is important to investigate the relationships among the dependent and independent factors. To do so Pearson correlation coefficient have been used as seen below **Table 3**:

Table 3: Person's correlation matrix

	GII	X1	X2	X3	X4	X5	X6	X7
GII	1							
X1	0.370	1						
X2	-0.787	-0.536	1					
X3	-0.013	-0.783	0.354	1				
X4	0.389	0.078	-0.755	-0.197	1			
X5	0.259	0.711	-0.186	-0.597	-0.134	1		
X6	0.532	-0.315	-0.565	0.394	0.583	-0.621	1	
X7	0.952	0.576	-0.770	-0.282	0.312	0.466	0.318	1

The Table 3 presents Person's correlations between the different variables (dependent and independent variables). We found that X7 (creative outputs), X2 (human capital [3] and researc [7] h and X6 (knowledge and technology outputs) have high correlations with the dependent variable GII (Global Innovation Index).Moreover, some independent variables are correlated with each other.

Although the "correlation matrix" is an important indicator to understand the relationships between the variables, it is not enough to explain the effect of independent variables on the dependent variable, so that building a "regression model" is required.

1.5 Box–Jenkins approach [2]

Box–Jenkins approach for time series analysis is a common and widely used technique in many applications [8]. This approach is based on ARIMA models. Fig. ***1*** summaries the main iterative stages for modelling:

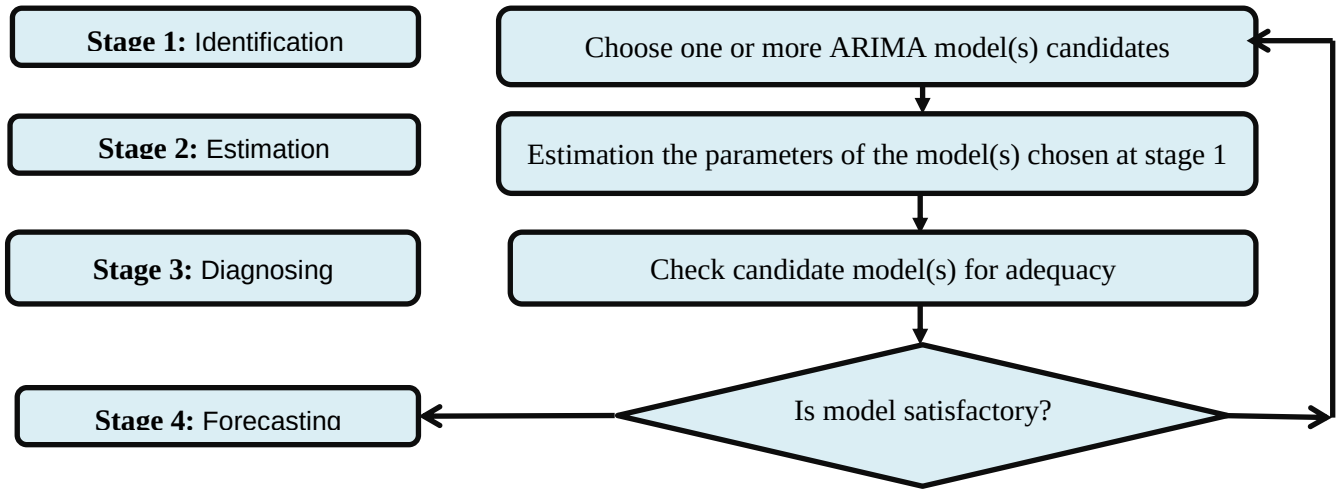

Fig. 1: Stages in the Box-Jenkins iterative approach
Source: Abonazel and Abd-Elftah (2019)

Appling this approach on GII data:

1st stage "identification" is checking the stationary of GII. Fig. ***2*** shows that GII is stationary because all p-values of Q-test are greater than 0.05. So that d=0 in ARIMA model. This means that the data is stationary:

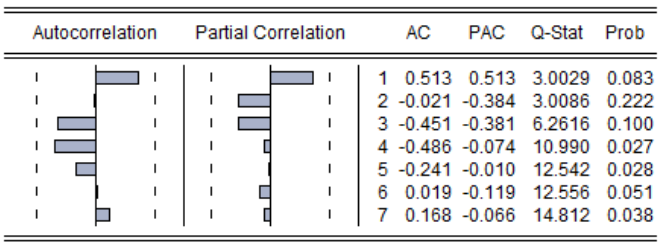

Fig. 2: ACF and PACF plots for GII

2nd stage "estimation" is to identify the value of the other two parameters p and q of ARIMA model, so that we check various ARIMA models to select the best model for the data. As seen in the below results in **Table 4**

Table 4: Evaluation of various ARIMA models

Model	Goodness-of-fit measure		
	AIC	BIC	MSE
ARIMA (1,0,0)	4.884	4.914	5.318
ARIMA (2,0,0)	3.810	3.850	1.098
ARIMA (3,0,0)	3.111	3.161	0.325
ARIMA (4,0,0)	1.075	1.135	0.005

ARIMA (4,0,1)	1.276	1.346	0.006
ARIMA (0,0,1)	4.794	4.824	4.060
ARIMA (0,0,2)	4.648	4.687	2.859
ARIMA (0,0,3)	4.564	4.614	2.241
ARIMA (0,0,4)	5.045	5.105	4.289
ARIMA (1,0,4)	4.978	5.078	5.968

The best model is ARIMA (4, 0, 0), because it has the minimum values of MSE, AIC, and BIC (goodness-of-fit measures). Modeling results of ARIMA (4, 0, 0) model have been estimated by maximum likelihood estimation method and are presented in the below Table 5.

Table 5 : The results of ARIMA (4, 0, 0) model

Variable	Coefficient	Std. Error	t-Statistic	p-value
C	38.22800	0.093543	408.6677	0.0000
AR(1)	-0.442457	0.001525	-290.1061	0.0000
AR(2)	0.903050	0.062040	14.55593	0.0047
AR(3)	-0.451819	0.001403	-322.1125	0.0000
AR(4)	-0.993697	0.000325	-3053.784	0.0000
Goodness-of-fit				
R-squared	0.999	Adj. R-squared		0.999
F-statistic	2188.263	p-value of F		0.000

The coefficient estimates of all parameters and the model overall are statistically significant at 1% level of significance. The estimated "regression equation" is:

$$GII_t = 38.23 - 0.44\, GII_{t-1} + 0.90\, GII_{t-2} + 0.45\, GII_{t-3} - 0.99\, GII_{t-4} + \varepsilon_t \quad (1)$$

Where ε_t is the error term in t, GII_t is the value of GII in t, and $GII_{t-s}; s = 1,2,3,4$ are the values of GII in different lags (s).

3rd stage "diagnosing". According to Box-Jenkins approach, the diagnostic tests of the model are checking the stationary and the normality of the residuals. Fig. ***3*** shows that the residuals are stationary because all p-values of Q-test are greater than 0.05.

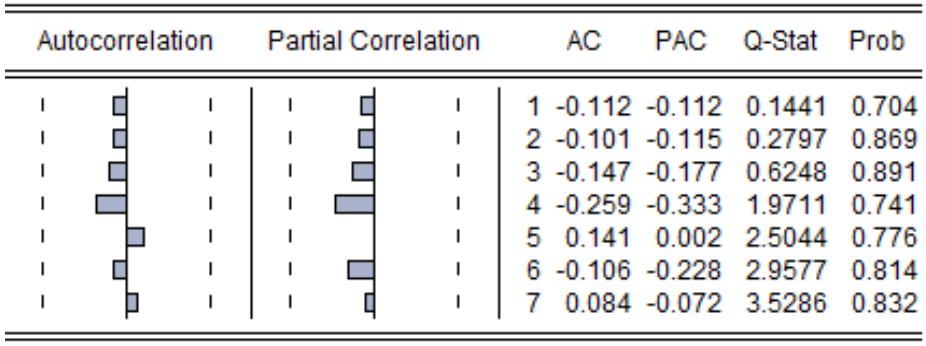

Fig. 3: ACF and PACF plots of ARIMA (4, 0, 0) residuals

And the values of residuals are distributed normally because the p-value of Jarque-Bera test is 0.711 and greater than 0.05 as in Fig. ***4***. So that this model can be used for forecasting GII from 2019 to 2023.

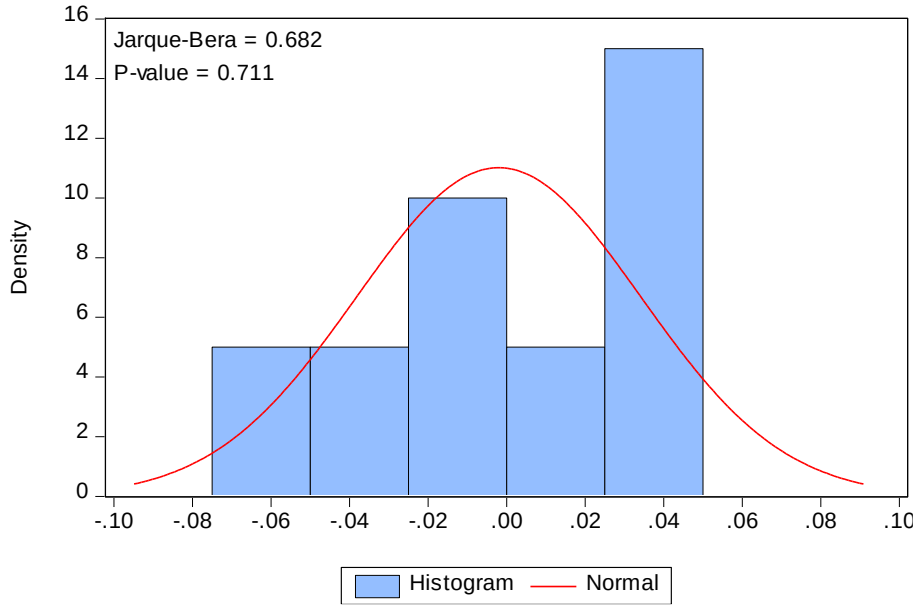

Fig. 4: The distribution of ARIMA (4, 0, 0) residuals

4th stage "forecasting". According to Box-Jenkins approach, we can use the final model given in equation (1) directly to forecast GII values from 2019 to 2023. The forecasted values of GII are given in the below **Table 6**:

Table 6: Forecasted values of GII with Box–Jenkins Approach

Years	Forecasted values
2019	35.93
2020	36.96
2021	40.52
2022	41.13
2023	41.86
Goodness-of-fit measures	
RMSE: Root Mean Squared Error	0.0612
MAE: Mean Absolute Error	0.0586
MAPE: Mean Abs. Percent Error	0.1599
Theil Inequality Coefficient	0.0008

Graphically, the above future performance can be depicted as the below graph (Fig. ***5***) which shows a positive performance:

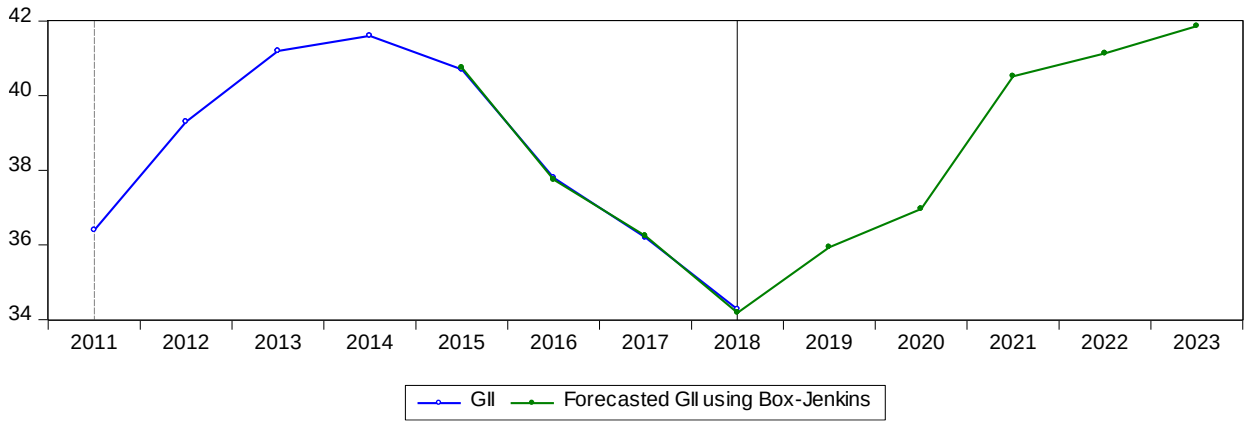

Fig. 5: Time series plot for actual and forecasted values with two approaches

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